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Growth and haematological response of indigenous Venda chickens aged 8 to 13 weeks to varying dietary lysine to energy ratios

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Summary

The effect of feeding varying dietary lysine to energy levels on growth and haematological values of indigenous Venda chickens aged 8 – 13 weeks was evaluated. Four hundred and twenty Venda chickens (BW 362 ± 10 g) were allocated to four dietary treatments in a completely randomized design. Each treatment was replicated seven times, and each replicate had fifteen chickens. Four maize–soya beans-based diets were formulated. Each diet had similar CP (150 g/kg DM) and lysine (8 g lysine/kg DM) but varying energy levels (11, 12, 13 and 14 MJ ME/kg DM). The birds were reared in a deep litter house; feed and water were provided *ad libitum*. Data on growth and haematological values were collected and analysed using one-way analysis of variance. Duncan's test for multiple comparisons was used to test the significant difference between treatment means ($p < 0.05$). A quadratic equation was used to determine dietary lysine to energy ratios for optimum parameters which were significant difference. Results showed that dietary energy level influenced ($p < 0.05$) feed intake, feed conversion ratio, live weight, haemoglobin and pack cell volume values of chickens. Dry matter digestibility, metabolizable energy and nitrogen retention not influenced by dietary lysine to energy ratio. Also, white blood cell, red blood cell, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration in female Venda chickens aged 91 days were not influenced by dietary lysine to energy ratio. It is concluded that dietary lysine to energy ratios of 0.672, 0.646, 0.639 and 0.649 optimized feed intake, growth rate, FCR and live weight in indigenous female Venda chickens fed diets containing 8 g of lysine/kg DM, 150 g of CP/kg DM and 11 MJ of ME/kg DM. This has implications in diet formulation for indigenous female Venda chickens.

Keywords optimization, haematological, lysine to energy ratio, Venda chicken

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Introduction

Poultry, particularly chickens, are the most widely kept livestock species and the most numerous in the whole world (Moreki et al., 2010). The contribution of local poultry production to the nutritional and economic status of rural households is well recognized (Norris and Ng'ambi, 2006). However, there have been declines in the number of indigenous chickens, mainly due to their poor productive and reproductive performances (Ben Larbi et al., 2013) and an increase in commercially produced poultry meat and eggs from exotic poultry breeds (Guèye, 2003). This increased production of exotic chicken breeds was achieved because of improved intensive management strategies and research into nutrition and growth of the exotic chicken breeds. On the contrary, development of indigenous chickens in terms of nutrition, management and disease control has not been duly attended to (King'ori et al., 2007). Most studies aimed at improving the performance of indigenous chickens have been carried out, mainly, on male (Magala et al., 2012; Mbajiorgu, 2010), under scavenging conditions (Sonaiya et al., 1999; Alders et al., 2001) and crossbreeding (Zaman et al., 2004). However, it has been shown that their productivity under scavenging conditions is very low (Alders et al., 2001). For chickens to be productive, they need feeds that will give them the necessary nutrients for body function, growth and meat production. It is, however, unlikely that nutrients in the feed under scavenging conditions, especially lysine and energy, will be present in the same ratio as required by these chickens for improved productivity. When there is imbalance in the nutrient intake, heavy nutritional burden is placed on the chickens; thus, poor growth and development is to be expected. To attain a balanced diet in order to improve productivity of indigenous chicken, intensive rearing conditions seem to be the most viable options (Mbajiorgu, 2010). Mohammad and Sohail (2008) stated that balanced nutrition is an important factor in determining performance and productivity of chickens. Numerous authors indicated that dietary lysine to energy ratio improved production parameters in broiler chickens (Araujo et al., 2005; Mbajiorgu et al., 2011; Hind et al., 2012). Mbajiorgu et al. (2011) indicated that varying lysine to energy ratio in the diets has effect on productivity of Venda chickens. The Venda chickens are multicoloured with white, black and red; they have rose-coloured combs, and most are five-toed feet. The hens are broody and have good motherly ability. However, not much research on the subject has been carried out.

Haematological and biochemical indices may also give some insight on production performance potential (Orheruata and Akhuomobhogbe, 2006). Several factors, such as nutrition, age, gender, breed, health and physiological status, may influence the normal blood values of various species (Jain, 1993). The effect of feeding varying dietary lysine to energy ratio on growth of indigenous chickens is not conclusive, and their impact on haematological indices has not been established. Therefore, the objective of the study was to determine the effect of feeding varying dietary lysine to energy ratios on growth and haematological values of indigenous Venda chickens aged 8 to 13 weeks.

Materials and methods

Study site, experimental design, animals and measurements

This study was conducted at the University of Limpopo in South Africa. A total of 420 female indigenous Venda chickens aged 40 days (BW 362 ± 10 g) were randomly allocated to four dietary treatments in a completely randomized design. Each treatment was replicated seven times with fifteen birds per replicate. Four maize–soya beans-based mash diets were formulated. Ingredients and nutrient composition of the experimental diets are presented in Table 1. Each treatment had similar digestible lysine (8 g lysine/kg DM) contents but varying energy levels of 11, 12, 13 and 14 MJ ME/kg DM, thus forming lysine to energy ratios of 0.73 (FL_8E_{11}), 0.67 (FL_8E_{12}), 0.62 (FL_8E_{13}) and 0.57 (FL_8E_{14}) for treatment 1 to 4 respectively. The birds were reared in a deep litter house; feed and water were provided *ad libitum*. Prior to this experiment, the chickens had been fed 180 g of CP/kg DM and 12.14 MJ of ME/kg DM diet to meet their nutritional requirements according to NRC (1994). A 10-day acclimation period was given before data collection. The experiments were carried out between January and March 2013.

Average live weight per bird was measured when the experiment commenced. Thereafter, average live weight per bird was measured at weekly intervals by weighing the chickens in each pen, and the total live weight was divided by the total number of birds in the pen to obtain the average live weight of the chickens. These live weights were used to calculate growth rate. Feed conversion ratio per pen was calculated as total feed consumed divided by the weight of live birds plus

Table 1 Ingredients and nutrient composition of the experimental diets (%)

	Experimental diet code			
Ingredients	0.73 (FL_8E_{11})	0.67 (FL_8E_{12})	0.62 (FL_8E_{13})	0.57 (FL_8E_{14})
Yellow Maize	58.49	58.59	58.84	58.86
Full-fat Soya	30.08	30.18	30.22	30.28
Hi-pro Soya (46%+)	3.12	3.12	3.12	3.12
Soya oil	3.22	3.42	3.62	3.70
Wheat Bran	1.05	1.95	0.16	0.00
Limestone Powder	2.40	1.10	2.40	2.40
Monocalcium phosphate	0.54	0.54	0.54	0.54
Salt Fine	0.44	0.44	0.44	0.44
Methionine DL Powder	0.18	0.18	0.18	0.18
Lysine HCL Powder	0.10	0.10	0.10	0.10
Threonine	0.02	0.02	0.02	0.02
Choline Chloride	0.07	0.07	0.07	0.07
Vit/Min PMX	0.29	0.29	0.29	0.29
Determined analysis				
Dry matter	88.48	88.21	88.64	88.55
Ash	6.43	6.57	6.52	6.45
Crude protein	17.99	17.96	17.81	17.88
Ether extract	3.49	3.44	3.51	3.64
Crude fibre	3.37	3.40	3.38	3.27
Methionine	0.61	0.59	0.62	0.62
Lysine	0.96	0.96	0.94	0.95
Calcium	10.05	10.06	10.08	10.08
Phosphorus	5.50	5.50	5.50	5.50
ME (MJ/kg)	10.79	11.79	12.78	13.98

the weight of birds that died or were culled minus weight of all birds in the pen at the start of the experiment. Digestibility was performed between ages of 84 and 91 days. Digestibility was conducted in specially designed metabolic cages having separated watering and feeding troughs. Four birds were randomly selected from each replicate and transferred to metabolic cages for the measurement of apparent digestibility. A 3-day acclimatization period was allowed prior to a 3-day collection period. Droppings voided by each bird were collected on a daily basis at 09.00H and kept frozen. Daily excreta collections were pooled for each bird and stored at −20 °C until further processing. Care was taken to avoid contamination from feathers, scales, debris and feeds. Subsamples of daily feed offered, refusals and faeces voided per animal were collected and weighed using a 0.1-g sensitive-level electronic scale (RADWEG). At the end of collection period, faeces collected from each animal over the trial period were thoroughly mixed, and two subsamples were taken. One of the samples was used for estimating DM by oven-drying at 105 °C for 24 h, while the second sample was oven-dried at 60 °C for 72 h for chemical analysis. Apparent nutrient digestibility was calculated according to the formula given by Mc Donald et al. (2011). At 91 days of age, blood samples were collected from jugular vein during slaughtering. The blood was received in a 10-ml test tube containing ETDA. Haematological parameters (red blood cells, white blood cells, haemoglobin, packed volume cells, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration) were measured using a Beckman Coulter AcT Diff Haematology Analyzer (Beckman Coulter, Fullerton, CA, USA).

Chemical analysis

Dry matter of the diets, refusals, faeces samples was determined as described by AOAC (2005). The gross energy of the diets, refusals, faeces and meat samples was determined using a bomb calorimeter (AOAC, 2005). Diets and excreta were assayed for total N using a Leco FP-428 nitrogen analyser (Leco Instruments, Stockport, Cheshire, UK). Nitrogen retention was calculated as the difference between N intake and N in the excreta.

Statistical analysis

Data on feed intake, digestibility, growth rate, feed conversion ratio, metabolizable energy, nitrogen retention, live weight and haematological parameters were analysed using General Linear Model procedure of the statistical analysis system of SAS Institute (SAS, 2008) using one-way analysis of variance (SAS, 2008). Where there were significant differences ($p < 0.05$), Duncan's test for multiple comparisons was used to test the significance of differences between treatment means (SAS, 2008). The responses in feed intake, growth rate, feed conversion ratio and live weight to dietary lysine to energy ratios were modelled using the following quadratic equation (SAS, 2008):

$$Y = a + b_1x + b_2x^2 + \epsilon$$

where Y = optimum feed intake, growth rate, feed conversion ratio and live weight; a = intercept; b = coefficients of quadratic equation; x = dietary lysine to energy ratio; and $-b_1/2b_2 = x$ value for optimum response. The quadratic model was fitted to the experimental data by means of the NLIN procedure of SAS (SAS, 2008). The quadratic model was used because it gave the best fit.

Results

Results showed that dietary lysine to energy ratio had effect ($p < 0.05$) on feed intake, growth rate, FCR and live weights of female Venda chickens aged 50 to 91 days (Table 2). Indigenous female Venda chickens offered a diet having a lysine to energy ratio of 0.67 had a higher ($p < 0.05$) feed intake than those on diets having lysine to energy ratios of 0.73, 0.62 or 0.57 which had similar feed intakes. Chickens on diets having lysine to energy

Table 2 Effect of dietary lysine to energy ratio (g/MJ of ME/DM) on feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g feed/g live weight gain), live weight (g/bird aged 91 days), apparent metabolizable energy (MJ/kg DM), nitrogen retention (g/bird/day) and mortality (%) of female Venda chickens aged 8 to 13 weeks

	Dietary lysine to energy ratio (g/MJ ME)				
Variable	0.57	0.62	0.67	0.73	SEM
Feed intake	99.92^{b}	101.58^{b}	114.75^{a}	104.73^{b}	2.049
Growth rate	13.1^{b}	17.9^{a}	16.9^{a}	12.5^{b}	0.68
FCR	7.60^{ab}	5.76^{c}	6.79^{b}	8.37^{a}	0.292
Live weight	1259.3^{c}	1361.7^{b}	1443.0^{a}	1229.7^{c}	23.68
Mortality	0.01	0.00	0.00	0.00	0.001

ME, metabolizable energy; N-retention, nitrogen retention; SEM, standard error of the mean.
Means in the row not sharing a common superscript are significantly different ($p < 0.05$).

ratios of 0.62 or 0.67 had similar growth rates. Similarly, chickens offered diets having lysine to energy ratios of 0.73 or 0.57 had the similar growth rates. However, chickens on diets having lysine to energy ratios of 0.62 or 0.67 had higher ($p < 0.05$) growth rates than those offered diets containing lysine to energy ratios of 0.57 or 0.73.

Female Venda chickens offered a diet having a lysine to energy ratio of 0.62 had better ($p < 0.05$) FCR values than those of birds on diets having lysine to energy ratios of 0.67, 0.57 or 0.73. Similarly, chickens offered a diet having a lysine to energy ratio of 0.67 had a better ($p < 0.05$) FCR than those on a diet having a lysine to energy ratio of 0.73. However, chickens on diets having lysine to energy ratios of 0.73 or 0.57 had similar FCR values.

Mortality of the chickens was not influenced by the dietary treatments. Similarly, dry matter digestibility, metabolizable energy intake and nitrogen retention of the chickens were not influenced by dietary lysine to energy ratio (Table 3).

Results of the effect of dietary lysine to energy ratio on haematological values of female Venda chickens aged 91 days are presented in Table 4. Dietary lysine to energy ratio had no effect on all the haematological parameters measured except haemoglobin (Hb) and pack cell volume (PCV) ($p < 0.05$) values. Female Venda chickens on a diet having a lysine to energy ratio of 0.67 had higher ($p < 0.05$) Hb values than those from chickens on diets having lysine to energy ratios of 0.57, 0.62 or 0.73. However, chickens offered diets having lysine to energy ratios of 0.62, 0.57 or 0.73 had similar Hb values. Venda chickens offered a diet containing a lysine to energy ratio of 0.73 had higher ($p < 0.05$) PCV values than those from chickens on diets containing lysine to energy ratios of 0.67, 0.62 or 0.57. However, chickens on diets containing lysine to energy ratios of 0.67, 0.62 or 0.57 had similar PCV values.

Table 3 Effect of dietary lysine to energy ratio (g/MJ of ME/DM) on dry matter digestibility (%), metabolizable energy intake (ME) (MJ/kg DM) and nitrogen retention (g feed/g live weight gain) of unsexed Venda chickens aged 7 weeks

	Dietary lysine to energy ratio (g/MJ ME)				
Variable	0.57	0.62	0.67	0.73	SEM
Dry matter digestibility	66.1	70.5	70.1	70.8	0.60
Metabolizable energy	11.1	12.6	11.8	11.1	0.21
Nitrogen retention	1.0	1.2	1.3	1.1	0.04

ME, metabolizable energy; SE, standard error of the mean.

Table 4 Effect of dietary lysine to energy (g/MJ of ME/DM) on white blood cell (WBC), red blood cell (RBC), haemoglobin (Hb), pack cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) in female Venda chickens aged 91 days

	Dietary lysine to energy ratio (g/MJ ME)				
Variable	0.57	0.62	0.67	0.73	SE
WBC $(10)^3$ μl	23.52	25.63	26.59	26.48	0.430
RBC $(10)^4$ μl	2.62	2.65	2.74	2.67	0.039
Hb (g/dl)	9.62^b	9.77^b	10.52^a	9.58^b	0.039
PCV (%)	29.99^b	30.16^b	30.33^b	33.85^a	0.495
MCV (fl)	136.17	144.85	145.84	143.51	1.193
MCH (pg)	46.11	48.00	46.57	44.24	0.362
MCHC (g/dl)	24.81	26.77	30.72	31.56	0.741

ME, metabolizable energy; SEM, standard error of the mean.
Means in the row not sharing a common superscript are significantly different ($p < 0.05$).

Feed intake, growth rate, FCR and live weight of female Venda chickens were optimized at dietary lysine to energy ratios of 0.672, 0.646, 0.639 and 0.649 respectively (Table 5).

Discussion

The results show that feed intake, growth rate, feed conversion ratio, live weight and ME intake were influenced by dietary lysine to energy ratio. Mbajiorgu et al. (2011), also, reported that dietary lysine to energy ratio had effect on growth rate and FCR of male indigenous Venda chickens aged 7 to 13 weeks. Similarly, Hind et al. (2012) observed that feeding different lysine and energy diets to broiler chickens influenced their feed intake and FCR.

As the dietary lysine to energy ratio increased, feed intake, growth rate and live weight of female Venda chicken aged 8 to 13 weeks also increased until they were optimized at different dietary lysine to energy ratios. Feed intake was optimized at a dietary lysine to energy ratio of 0.672. This ratio is lower than the dietary lysine to energy ratios of 1.09 and 0.74 reported by Hind et al. (2012) and Araujo et al. (2005), respectively, for broiler chickens aged 3 to 6 weeks. The difference might be attributed to different breeds used. Broiler chickens require higher lysine levels as they are bred for fast growth (Nasr and Kheiri, 2012), thus requiring higher lysine to energy ratio in their diets.

In the present study, dietary lysine to energy ratios of 0.646 and 0.649 optimized growth rate and live weight of the chickens respectively. The optimal ratio

Table 5 Dietary energy (MJ of ME/DM) for optimal feed intake (g/bird/day), growth rate (g/bird/day), FCR (g feed/g live weight gain), live weight (g/bird aged 91 days) and apparent metabolizable energy (MJ/kg DM) of female Venda chickens aged 8 to 13 weeks

Trait	Formula	r^2	L:E ratio	Optimal *Y*-level
Feed intake	$Y = -402.856 + 1526.121x - 1135.502x^2$	0.575	0.672	109.9
Growth rate	$Y = -309.454 + 1013.112x - 783.877x^2$	0.969	0.646	17.89
FCR	$Y = 125.072 - 372.623x + 291.648x^2$	0.880	0.639	6.05
Live weight	$Y = -10349.76 + 36268.02x - 7935.36x^2$	0.906	0.649	1421.8
ME	$Y = -85.298 + 295.263x - 225.556x^2$	0.760	0.655	11.33

L:E ratio, lysine to energy ratio for optimal variables; ME, metabolizable energy.

of 0.646 for growth rate, in the present study, is lower than the ratios of 1.05 (Hind et al., 2012), 0.75 (NRC, 1994) and 0.74 (Labadan et al., 2001) for broiler chickens aged 3 to 6 weeks. Similarly, the ratio of 0.649 for optimal live weight in the present study is lower than a dietary lysine to energy ratio of 0.85 reported by Mbajiorgu et al. (2011) for male Venda chickens. It is possible that the difference between the two experiments in dietary lysine to energy ratios for optimal growth rates of Venda chickens may be due to differences in lysine requirements for male and female chickens. Male chickens require higher lysine for their growth (NRC, 1994; Zaghari et al., 2002).

Results of the present study indicate that a dietary lysine to energy ratio of 0.639 optimized FCR of female Venda chickens. This ratio is lower than 0.89 and 1.84 reported by Sinurat and Balnave (1985) and Araujo et al. (2005), respectively, for broiler chickens. This might be because the broiler chickens are fast-growing chickens and, thus, require a higher dietary lysine to energy ratio.

The haematological parameters observed in the present study were within the range reported in the literature for indigenous chickens (Islam et al., 2004; Elagib and Ahmed, 2011). Dietary lysine to energy ratio did not have statistically significant influence on the haematological parameters measured except the Hb and PCV. Egbunike et al. (2009) reported that different dietary protein sources did not influence the haematological parameters.

Results of the effect of dietary lysine to energy ratio on the haemoglobin showed that as the dietary lysine to energy ratio increased, the Hb values increased until they were optimized at a dietary lysine to energy ratio of 0.566. Dairo et al. (2010) observed that as the energy levels of the diets of broiler chickens increased, the Hb values also increased. Adequate quantities of lysine are essential for normal haemoglobin (Hb) formation in animals. Haemoglobin carries oxygen from lungs to tissues. Low amino acid intake may alter the absorption, retention and/or utilization of substances which are essential for normal haematopoiesis, thus affecting the iron absorption in intestines (Lönnerdal and Chen, 1990). Thus, low Hb concentration might affect oxygen carrying ability of the blood. Low-amino acid-fed animals have subnormal Hb compared to adequately fed animals (Rincker et al., 2005). Optimum Hb synthesis increases the availability of oxygen for anabolic activities leading to increased production of energy for muscle mass accretion.

The PCV values, in the present study, increased as the dietary lysine to energy ratio increased, and they were optimized at a ratio of 0.609. The results indicate that at low dietary lysine to energy ratio, the PCV values are low. This is in agreement with the results of E-dozien and Switzer (1977). The authors stated that PCV are very responsive to amino acid deficiency. Orheruata and Akhuomobhogbe (2006) reported that haematological and biochemical indices may also give some insight on production performance potential. Thus, a sufficient amino acid profile is necessary for maintaining optimal concentrations of blood constituents.

It is concluded that in the present study, dietary lysine to energy ratios of 0.672, 0.646, 0.639, and 0.649 optimized feed intake, growth rate, FCR and live weight, respectively, in indigenous female Venda chickens fed diets containing 8 g of lysine/kg DM, 150 g of CP/kg DM and 11, 12, 13 and 14 MJ of ME/kg DM. This means that dietary lysine to energy ratio levels for optimal productivity will depend on the parameter of interest. This has more implications in diet formulation for indigenous female Venda chickens.

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