EFFECT OF DIETARY LYSINE TO ENERGY RATIO ON PRODUCTIVITY, CARCASS CHARACTERISTICS AND SENSORY ATTRIBUTES OF INDIGENOUS VENDA CHICKENS

Alabi, O.J
Department of Animal Production, School of Agriculture and Agricultural Technology,
Federal University of Technology,
P. M. B 65, Minna
Niger State, Nigeria.
shola.alabi@futminna.edu.ng
Phone number: 09030083008

ABSTRACT

A study was conducted to determine the effect of dietary lysine to energy ratio on productivity, carcass characteristics and sensory attributes of indigenous female Venda chickens aged 8 to 13 weeks. A total of 200 eight-weeks old female Venda chickens were fed isonitrogenous diets but with different lysine to energy ratios to form dietary lysine to energy ratio treatments of 0.57, 0.62, 0.67 and 0.73 g/MJ ME. A completely randomised design was used. Data on productivity, carcass and meat sensory attributes were determined. All data were analysed using a one way analysis of variance. Treatment means were separated using the least significant difference. A quadratic equation was used to determine dietary lysine to energy ratio for optimal response of production variables measured. Results show that feed intake, apparent metabolizable energy intake, growth rate, FCR and live weights were influenced ($P<0.05$) by dietary lysine to energy ratio. Carcass weight, dressing percentage, breast meat, drumstick, wing, drip loss, meat juiciness and flavour were also influenced ($P<0.05$) by dietary lysine to energy ratio. However, dietary lysine to energy ratio did not affect ($P>0.05$) thigh, fat pad, gizzard, liver and heart weights, and tenderness. Carcass weight, dressing percentage, breast meat, drumstick and wing weights were optimized at the same dietary lysine to energy ratio of 0.66. Drip loss, meat juiciness and flavour were optimized at dietary lysine to energy ratios of 0.63, 0.71 and 0.62, respectively. It was concluded that a single dietary lysine to energy ratio of 0.65 optimized growth rate, live weight and ME intake of Venda chickens. Similarly, a single dietary lysine to energy ratio of 0.66 optimized carcass weight and dressing percentage, while a ratio of 0.67 optimized feed intake, breast meat and drumstick weights. Feed conversion ratio, wing weight, meat drip loss, juiciness and flavour of Venda chickens were optimized at different ratios of 0.64, 0.60, 0.63, 0.71 and 0.62, respectively. These results have implications on ration formulation for indigenous Venda chickens.

Keywords: Optimization, lysine, growth, breast meat juiciness and breast meat tenderness.

INTRODUCTION

Poultry accounts for more than 30 % of all the animal protein consumption worldwide (Permin *et al.*, 2000). It is estimated that by the year 2015, poultry will account for 40 % of all animal protein consumed by people (Permin *et al.*, 2000). This figure is expected to be higher in rural areas where indigenous chickens account for more than 80 % of poultry production (Guèye, 2003). However, indigenous chickens have low growth rates and high mortality rates (King'ori *et al.*, 2003). Causes of low growth rates and high mortality rates include poor nutrition, poor genetic potential, problem of diseases and poor management skills (King'ori *et al.*, 2010). There is evidence that dietary lysine and energy levels are important in poultry production and health (Chen *et al.*, 2003; Priyankarage *et al.*, 2008). Some research studies have already been done at the University of Limpopo on optimal nutrient requirements for indigenous chickens (Mbajiorgu 2010; Mbajiorgu *et al.*, 2011). However, the effects of the relationship between dietary lysine and energy levels on productivity of indigenous chickens have not been extensively explored and results are not conclusive. This is particularly true with indigenous Venda chickens found in South Africa. Thus, this work was conducted to determine the effect of dietary lysine to energy ratio on productivity, carcass characteristics and sensory attributes of indigenous female Venda chickens aged 8 to 13 weeks.

MATERIALS AND METHODS

This study was conducted at the Animal Unit of the University of Limpopo, South Africa. The ambient temperatures around the study area ranged between 20 and 36 °C during summer and between 10 and 25 °C in winter. University of Limpopo lies at latitude 27.55 S and longitude 24.77 E. It receives a mean annual rainfall of less than 400 mm (Kutu and Asiwe, 2010).

This experiment was done to determine the effect of dietary lysine to energy ratio on productivity, carcass characteristics and sensory attributes of indigenous female Venda chickens aged 8 to 13 weeks. A total of 200 eight-weeks old female Venda chickens were fed isonitrogenous diets but with different lysine to energy ratios to form four dietary lysine to energy ratio treatments of 0.57, 0.62, 0.67 and 0.73 g/MJ ME (Table 1). Each treatment was replicated five times in a completely randomized design. Each replicate had ten chicks, thus, 20 floor pens measuring 2.5 m^2 in area were used. The birds were offered feed and fresh water *ad libitum*. Twenty three hours of light were available per day. The experiment was terminated when the birds were 91 days old. Prior to this experiment, the chickens were fed a 180 g CP/kg DM and 12.14 MJ ME/kg DM diet to meet their nutritional requirements according to NRC (1994). The initial live weights of the birds were taken at the beginning of experiment and at weekly intervals thereafter. Feed intake, growth rate, feed conversion ratio and digestibility were determined according to the procedures of McDonald *et al.* (2011).At 91 days of age, all remaining birds in each pen were slaughtered by cervical dislocation as recommended by the University of Limpopo Committee on Animal Ethics. Carcass weight, breast meat, drumstick, thigh and wing weights were determined. Meat samples from each breast part of the slaughtered bird were taken and stored in the refrigerator for sensory evaluation.

Meat samples which had been frozen at -20 °C were thawed for 24 hours at room temperature for sensory evaluation. The samples were broiled (grilled) on the oven rack set at 160 °C. The oven was allowed to preheat for 20 minutes. The meat samples were grilled for approximately 50 minutes and turned every 25 minutes. Tongs were used for turning to avoid piercing which could let the moisture to escape. The samples were cut into smaller pieces of 1.5 cm thick according to their treatments and replicates. A taste panel of assessors evaluated the meat for tenderness, juiciness and flavour (American Meat Science Association, 1995). The sensory evaluation panel consisted of members of staff and students of the University of Limpopo (Turfloop Campus). Panellists rated the samples on a *point hedonic scale* ranging from 1 = dislike it very much to 5 = like it very much Dry matter contents of the diets, refusals and faecal samples were determined as described by AOAC (2008). The gross energy of the diets and faecal samples were determined (AOAC, 2008) using a bomb calorimeter. The apparent metabolizable energy contents of the diets were determined according to AOAC (2008) official methods. Data on feed intake, growth rate, FCR, live weight, ME, nitrogen retention, carcass characteristics and sensory attributes were analysed by one-way analysis of variance (SAS, 2010). Treatment means were separated using the least significant difference (95 % confidence level). The responses in feed intake, growth rate, FCR, live weight, ME, carcass, breast meat yield, drumstick, wing weights, drip loss, breast meat juiciness and flavour to energy levels were modelled using the following quadratic equation (SAS, 2010):

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

Where Y is optimal feed intake, growth rate, FCR, live weight, ME, carcass, breast meat yield, drumstick, wing weights drip loss, breast meat juiciness and flavour; a = intercept; b = coefficients of quadratic equation; x = dietary energy level 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, 2010). The quadratic model was used because it gave the best fit.

RESULTS

The effects of dietary lysine to energy ratio on feed intake, growth rate, feed conversion ratio (FCR), live weight, apparent metabolizable energy, nitrogen (N) retention and mortality of female Venda chickens aged eight to thirteen weeks are presented in Table 2. Dietary lysine to energy ratio had effect ($P<0.05$) on feed intake, apparent metabolizable energy, growth rate, FCR and live weights of the chickens. 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 ($P>0.05$) feed intakes. Chickens on diets having lysine to energy ratios of 0.62 or 0.67 had similar ($P>0.05$) growth rates. Similarly, chickens offered diets having lysine to energy ratios of 0.73 or 0.57 had the same ($P>0.05$) 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 having 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 birds on diets having lysine to energy ratios of 0.67, 0.57or 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 ($P>0.05$) FCR values. Chickens on a diet having a lysine to energy ratio of 0.62 had higher ($P<0.05$) ME intakes than those on diets having lysine to energy ratios of 0.67, 0.73 or 0.57. Chickens on a diet having a lysine to energy ratio of 0.67 had higher ($P<0.05$) ME intakes than those offered diets having lysine to energy ratios of 0.73 or 0.57. However, chickens on diets having lysine to energy ratios of 0.73 and 0.57 had similar (P>0.05) ME intakes. Nitrogen retention and mortality of the chickens were not influenced (P>0.05) by the dietary treatments.

Results of the effect of lysine to energy ratio on carcass characteristics of female indigenous Venda chickens aged 91 days are presented in Table 3. Dietary lysine to energy ratio did not have effect (P>0.05) on thigh, fat pad, gizzard, liver and heart weights. However, carcass weight, dressing percentage, breast meat, drumstick and wing weights were influenced (P<0.05) by dietary lysine to energy ratio. Carcass weight and dressing percentage values of chickens offered diets having lysine to energy ratios of 0.62 or 0.67 were higher (P<0.05) than those of birds on diets having lysine to energy ratios of 0.57 or 0.73. Similarly, chickens on a diet having a lysine to energy ratio of 0.73 had higher (P<0.05) carcass weight and dressing percentage values than those on a diet having a lysine to energy ratio of 0.57. Female chickens offered diets having lysine to energy ratios of 0.62 or 0.67 had similar (P>0.05) carcass weights and dressing percentages. Female Venda chickens offered diets having lysine to energy ratios of 0.62, 0.67 and 0.73 had similar (P>0.05) breast meat weights; their weights were, however, higher (P<0.05) than those of birds on a diet having a lysine to energy ratio of 0.57. Chickens offered diets having lysine to energy ratios of 0.62 or 0.67 had similar (P>0.05) drumstick and wing weights. Similarly, chickens offered diets having lysine to energy ratios of 0.62 or 0.73 had the same (P>0.05) drumstick and wing weights. However, chickens offered a diet having a lysine to energy ratio of 0.67 had higher (P<0.05) drumstick and wing weights than those on diets having 0.57 and 0.73 lysine to energy ratios. Similarly, chickens on a diet having a lysine to energy ratio of 0.73 had higher (0<0.05) drumstick and wing weights than those on a diet having a lysine to energy ratio of 0.57. Venda chicken breast meat was not affected (P>0.05) by dietary treatments. Feed intake, growth rate, FCR, live weight and apparent metabolizable energy of female Venda chickens were optimized at dietary lysine to energy ratios of 0.67 (r^2 = 0.58), 0.65 (r^2 = 0.97), 0.64 (r^2 = 0.88), 0.65 (r^2 = 0.91) and 0.65 (r^2 = 0.76) (Table 4). Also, presented in Table 4 are the optimal response ratios for carcass weight, dressing percentage, breast meat, drumstick weight and wing weight. These parameters were optimized at dietary lysine to energy ratios of 0.66 (r^2 = 0.99), 0.66 (r^2 = 0.99), 0.67 (r^2 = 0.99), 0.67 (r^2 = 0.99) and 0.60 (r^2 = 0.99), respectively.

Results of the effect of lysine to energy ratio on drip loss, tenderness, juiciness and flavour of meat of indigenous female Venda chickens aged 91 days are presented in Table 3. Dietary lysine to energy ratio affected (P<0.05) meat drip loss, juiciness and flavour. Chickens offered a diet having a lysine to energy ratio of 0.67 produced meat with a higher (P<0.05) drip loss than those of meat from chickens on diets having lysine to energy ratios of 0.57 and 0.73. However, female Venda chickens offered diets having lysine to energy ratios of 0.62 or 0.67 produced meat with similar (P>0.05) drip losses. Similarly, chickens offered diets having 0.57, 0.62 or 0.73 lysine to energy ratios produced meat with the same (P>0.05) drip losses. Chickens offered a diet having a lysine to energy ratio of 0.67 produced breast meat with higher (P<0.05) juiciness scores than those of meat from chickens offered a diet having a lysine to energy ratio of 0.62. However, female Venda chickens offered diets having lysine to energy ratios of 0.57, 0.67 or 0.73 produced breast meat with similar (P>0.05) juiciness scores. Similarly, chickens offered diets having lysine to energy ratios of 0.57, 0.62 or 0.73 produced breast meat having the same (P>0.05) juiciness scores. Chickens offered diets containing lysine to energy ratios of 0.57, 0.62 or 0.67 produced breast meat with better (P<0.05) flavour scores than those offered a diet having a lysine to energy ratio of 0.73. However, female Venda chickens fed diets having lysine to energy ratios of 0.57, 0.62 or 0.67 produced breast meat with similar (P>0.05) flavour. Drip loss at slaughtering, breast meat juiciness and flavour were optimized at dietary lysine to energy ratios of 0.63 (r^2 = 0.67), 0.71 (r^2 = 0.604) and 0.62 (r^2 = 1.00), respectively (Table 4).

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 seven to thirteen 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, live weight, ME intake and nitrogen retention of female Venda chickens aged eight 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 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 three to six 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 ratio of 0.646 for optimal 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 three to six weeks. Similarly, the ratio of 0.65 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 are heavier and hence require higher lysine for their growth (NRC, 1994).

Results of the present study indicate that a dietary lysine to energy ratio of 0.64 optimized FCR. This ratio is lower than the ratio of 0.89 and 1.84 reported by Sinurat and Balnave (1985) and Araujo *et al.* (2005), respectively, for broiler chickens. Apparent metabolisable energy intake was optimized at a dietary lysine to energy ratio of 0.66. Thereafter, an increase in the dietary lysine to energy ratio resulted in a decrease in ME intake. It can, thus, be noted that in a diet containing 8 g of lysine per kg DM, 12.31 MJ of ME/kg DM and 150 g of CP/kg DM, ME intake of female indigenous Venda chickens aged eight to thirteen weeks was optimized at a dietary lysine to energy ratio of 0.66. This ratio is lower than the lysine to energy ratio of 0.71 observed by Araujo *et al.* (2005) for broiler chickens aged three to six weeks. Thus, broiler chickens seem to require higher lysine to energy ratio in their diets for optimal ME intake than indigenous female Venda chickens. Results of the effect of dietary lysine to energy ratio on carcass characteristics of female Venda chickens aged 91 days indicated that dietary treatment had effect on carcass weight, dressing percentage, breast meat, and drumstick and wing weights. Ajaujo *et al.* (2005) reported that dietary energy and lysine levels influenced slaughter, carcass, breast meat and leg meat weights, and abdominal fat percentages of broiler chickens aged 44 to 55 days. Tang *et al.* (2007) found that dietary lysine and energy levels influenced live weight, dressing percentage and breast meat, however, the authors reported that breast meat was not influenced by dietary lysine and energy levels. Quadratic analysis of the present results indicated that carcass, dressing percentage, thigh and wing weights were optimized at an approximately dietary lysine to energy ratio of 0.66. The ratio observed in the present study is lower than ratios of 0.84 for carcass weight, 1.11 for dressing percentage, 0.57 for breast meat weight and 0.80 for leg meat weight reported by Araujo *et al.* (2005) in broiler chickens aged 55 days. A dietary lysine to energy ratio of approximately 0.67 optimized breast meat, drumstick, gizzard and liver weights. Tang *et al.* (2007) reported a lower dietary lysine to energy ratio of 0.56 for optimal breast meat yield in broiler chickens. However, NRC (1994) reported a higher lysine to energy ratio of 0.74 for optimal breast meat yield in broiler chickens. Araujo *et al.* (2005) observed that leg weight of broiler chickens was optimized at a dietary lysine to energy ratio of 0.80. The differences observed could be attributed to differences in the breeds used. Broiler chickens require higher dietary lysine for breast meat production than do indigenous chickens (Kerr *et al.*, 1999). Dietary lysine to energy ratio affected breast meat drip loss, juiciness and flavour. Breast meat drip loss increased until it was optimized at a dietary lysine to energy ratio of 0.631. This is similar to the results obtained by Tang *et al.* (2007) in broiler chickens. However, the authors did not determine the level for optimal drip loss. Drip loss affects the meat juiciness and flavour. Similar results were reported by Tang (2007) in broiler chickens.

CONCLUSION

It is concluded that a single dietary lysine to energy ratio of 0.65 optimized growth rate, live weight and ME of Venda chickens. Similarly, a single dietary lysine to energy ratio of 0.66 optimized carcass weight and dressing percentage, while a ratio of 0.67 optimized feed intake, breast meat and drumstick weights. The feed conversion ratio, wing weight, meat drip loss, juiciness and flavour of Venda chickens were optimized at different ratios of 0.64, 0.60, 0.63, 0.71 and 0.62, respectively. These results have implications on ration formulation for indigenous Venda chickens. Thus, the lysine to energy ratio for optimal productivity will depend on the production parameter in question.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the VLIR-UL and National Research Foundation (NRF) for financial support.

REFERENCES

American Meat Science Association, 1995. Research Guidelines for Cookery, Sensory Evaluation and Instrumental Measurements of Fresh Meat. American Meat Science Association, Cicago, IL., USA.

AOAC 2008. Official Method of Analysis of Association of Official Analytical Chemists, International (18th ed.), Washington D.C.

Araujo L.F., Junqueira O.F., Stringhini J.H., 2005. Energy and lysine for broilers from 44 to 55 days of age. *Bra. J. of Poult. Sci.* 77(4), 237-241

Chen C., Sander J.E., Dale N.M., 2003. The effect of dietary lysine deficiency on immune response to Newcastle disease vaccination in chicken. *Avian Disease* 47, 1341–1351.

Guèye E.F., 2003. Production and consumption trends in Africa. *W. Poult. Sci.* 19 (11), 12-14.

Hind A.A,, Elagib H.A.A., Elzubeir E.A., 2012. The effect of feeding different levels of lysine and energy on broiler performance under high environmental temperature. *J. of Agric. and Vet. Sci.*. 5 (2), 121-131

Kerr B.J., Kidd M.T., Halpin K.M.G., McWard W., Quarles C.L., 1999. Lysine level increases live performance and breast yield in male broilers. *J. of Appl. Poult. Res.* 8, 381-390.

King'ori A.M., Tuitoek J.K., Muiruri H.K., Wachira A.M., 2003. Protein requirements of growing indigenous chickens during the 14-21 weeks growing period. *S. Afr. J. Ani. Sci.* 33 (2), 78-82.

King'ori A.M., Wachira A.M., Tuitoek J.K., 2010. Indigenous chicken production in Kenya: A review. *Int'l of Poult. Sci.* 9 (4), 309-316

Kutu F.R., Asiwe J.A.N., 2010. Assessment of maize and dry bean productivity under different intercrop systems and fertilization regimes. *Afr. J. of Agric. Res.*5 (13), 1627-1631

Labadan M.C. (JR), Hsu K.N. Austic R.E., 2001. Lysine and arginine requirements of broiler chickens at two to three week intervals to 18 weeks of age. *Poult. Sci.* 80, 599-606.

Mbajiorgu C.A., 2010. Effect of dietary energy to protein ratio levels on growth and productivity of indigenous Venda chickens raised in closed confinement from one day up to 13 weeks of age. PhD Thesis, Animal Production Department, University of Limpopo.

Mbajiorgu C.A., Ngambi J.W., Norris D., Alabi O.J., 2011. Effect of dietary lysine to energy to ratio on performance of unsexed indigenous Venda chickens. *Asian J. of Ani.and Vet. Adv.* 6 (5), 517-524.

McDonald P., Edwards R.A., Greenhalgh J.F.D., Morgan C.A., Sinclair L.A., Wilkinson R.G., 2011. Animal Nutrition. Seventh edition. Prentice Hall. London pp 214-280

Nasr J., Kheiri F., 2012. Effects of lysine levels of diets formulated based on total or digestible amino acids on broiler carcass composition. *Bra. J. of Poult. Sci.* 14(4), 233–304.

NRC, 1994. Nutrient Requirements of Poultry. 9th Revised edition. National Academy Press: Washington, DC.

Permin A., Pedersen G., Riise J.C., 2000. Poultry as a tool for poverty alleviation: Opportunities and problems related to poultry production at village level. Network for Smallholder Poultry Development, The Royal Veterinary and Agricultural University, Bulowsuej 17, 1870 Frederiksberg, Denmark.

Priyankarage, N., Ross, S.P., Silva, S.S.P. and N.R. Pirgozliev. 2008. The efficiency of energy retention of broiler chickens and turkeys fed on diets with different lysine concentration. *British Poultry Science* 48(6): 721–730.

SAS, 2010. Statistical Analysis System. SAS User Guide: Release 9.2. SAS Institute Inc, Cary NC, USA.

Sinurat, A.P., Balnave D., 1985. Effect of dietary amino acids and metabolisable energy on the performance of broilers kept at high temperature. *Bri. Poult. Sci.* 26, 117–128.

Tang M.Y., Ma Q.G., Chen Z.D., Ji C., 2007. Effects of dietary metabolizable energy and lysine on carcass characteristics and meat quality in Arbor acres broilers. *Asian-Aust. J. Ani. Sci.* 20, 1865-1873.

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

Ingredient (%)	Experimental diet			
	0.57	0.62	0.67	0.73
Maize	43.16	43.16	43.16	43.16
Wheat Bran	28.11	28.11	28.11	28.11
Full fat Soya	2.00	2.00	2.00	2.00
Hipro Soya	22.89	22.89	22.89	22.89
Limestone	2.64	2.70	2.72	2.74
Salt	0.44	0.44	0.44	0.44
Methionine	0.20	0.20	0.20	0.20
Lysine	0.15	0.11	0.09	0.07
Threonine	0.05	0.03	0.03	0.03
Choline	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 fiber	3.37	3.40	3.38	3.27
Methionine	0.61	0.59	0.62	0.62
Lysine	1.40	1.40	1.41	1.41
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
Lysine to energy ratios	0.57	0.62	0.67	0.73

Vit/Min Premix ; Vitamin/mineral premix

Table 2: Effect of dietary lysine to energy ratio (g/MJ ME) 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 eight to thirteen weeks

Variable	Dietary lysine to energy ratio (g/MJ ME)				
	0.57	0.62	0.67	0.73	SE
Feed intake	99.92^{b}	101.58^{b}	114.75^{a}	104.73^{b}	2.05
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}	0.29
Live weight	1259.3^{c}	1361.7^{b}	1443.0^{a}	1229.7^{c}	23.69
ME	9.54^{c}	11.58^{a}	10.80^{b}	10.18^{c}	0.21
N-retention	1.18	1.46	1.65	1.54	0.05
Mortality	0.01	0.00	0.00	0.00	0.01

a,b,c,d: Means in the row not sharing a common superscript are significantly different ($P<0.05$)

Table 3: Effect of lysine to energy ratio (g/MJ ME) on carcass characteristics (g), breast meat drip loss and sensory attributes of female Venda chickens aged 91 days

Variable	Dietary lysine to energy ratio (g/MJ ME) 0.57	0.62	0.67	0.73	SE
Carcass characteristics					
Carcass weight	911.00[c]	1197.30[a]	1203.30[a]	1009.30[b]	33.28
Dressing %	72.40[c]	87.90[a]	89.90[a]	82.10[b]	1.865
Breast meat	182.3[b]	204.7[a]	209.3[a]	200.0[a]	3.132
Drumstick	110.3[c]	127.1[ab]	129.0[a]	121.3[b]	2.093
Thigh	122.7	148.7	143.7	134.3	2.857
Wing	97.3[c]	116.7[ab]	118.7[a]	108.7[b]	2.433
Fat pad	2.70	2.70	2.60	2.60	0.018
Gizzard	52.00	56.70	60.30	55.70	1.496
Liver	25.70	29.00	27.70	28.30	0.710
Heart	5.00	7.00	5.70	6.30	0.276
Drip loss	3.33[b]	3.45[ab]	3.53[a]	3.35[b]	0.030
Sensory attributes					
Tenderness	3.55	3.40	3.33	3.33	0.042
Juiciness	3.48[ab]	3.38[b]	3.58[a]	3.50[ab]	0.029
Flavour	4.08[a]	4.08[a]	4.10[a]	3.80[b]	0.042

a,b,c,d :Means in the row not sharing a common superscript are significantly different ($P<0.05$)

SE : Standard error

Table 4: Dietary lysine to energy ratios for optimal carcass characteristics (g) and sensory attributes of female Venda chickens aged 91 days

Variable	Formula	r^2	L:E ratio	Optimal Y-level
Feed intake	$Y = -402.856 + 1526.121x - 1135.502x^2$	0.58	0.67	109.90
Growth rate	$Y = -309.454 + 1013.112x - 783.877x^2$	0.97	0.65	17.89
FCR	$Y = 125.072 - 372.623x + 291.648x^2$	0.88	0.64	6.05
Live weight	$Y = -10349.76 + 36268.02x - 7935.36x^2$	0.91	0.65	1421.80
ME	$Y = -85.298 + 295.263x - 225.556x^2$	0.76	0.65	11.33
Carcass wt	$Y = -16826.60 + 55024.08x - 41916.50x^2$	0.99	0.66	1231.03
Dressing %	$Y = -819.33 + 2742.36 - 2065.58x^2$	0.99	0.66	90.89
Breast meat	$Y = -1055.15 + 3784.23x - 2829.04x^2$	0.99	0.67	210.33
Drumstick	$Y = -826.36 + 2877.80x - 2164.45x^2$	0.99	0.67	130.21
Wing	$Y = -1016.98 + 3431.45x + 2588.97x^2$	0.99	0.60	120.04
Drip loss	$Y = -2.139 + 17.899x - 14.193x^2$	0.67	0.63	3.50
Juiciness	$Y = -0.956 + 12.660x - 8.943x^2$	0.60	0.71	3.52
Flavour	$Y = -8.720 + 41.373x - 33.184x^2$	1.00	0.62	4.18

L:E ratio: Lysine to energy ratio for optimal variable

wt : Weight