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Full Length Research Paper

Effect of ascorbic acid supplementation level to diets of indigenous Venda hens on egg production, hatchability and subsequent productivity of chicks

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An experiment was conducted to determine the effect of ascorbic acid supplementation level to the diets of indigenous Venda hens on egg production, hatchability and subsequent productivity of the chicks. The first part of the study determined the effect of ascorbic acid supplementation level to the diets of Venda hens on feed intake, egg production, egg weight, egg content, hatchability and chick hatch-weight. Seventy five Venda hens were randomly assigned to five dietary ascorbic acid treatment levels with three replications, each having five hens. A complete randomized design was used. The treatments were A_0 (0 ascorbic acid/kg DM feed), A_{200} (200 mg ascorbic acid/kg DM feed), A_{500} (500 mg ascorbic acid/kg DM feed), A_{1000} (1000 mg ascorbic acid/kg DM feed), A_{1500} (1500 mg ascorbic acid/kg DM feed). Ascorbic acid supplementation to the diets of indigenous Venda hens improved (P<0.05) egg weight, egg contents and hatchability. The second part of the study determined the effect of ascorbic acid supplementation level to the diets of Venda hens on performance of chicks between one and seven weeks of age. A total of 104 unsexed day-old chicks that hatched from the first part of the study were used according to the treatments and replicates from which they hatched. All the birds were offered the same grower feed and fresh water *ad libitum*. Indigenous Venda hens supplemented with ascorbic acid produced chicks with improved (P<0.05) feed intake, feed conversion ratio, growth rate and live weight at 7 weeks of age. However, ascorbic acid supplementation to the diets of indigenous Venda hens did not have any effect (P>0.05) on diet digestibility, metabolisable energy, nitrogen retention and mortality of their chickens. These results have implications on ration formulation for indigenous Venda hens.

Key words: Indigenous Venda chickens, ascorbic acid supplementation, optimum feed intake, feed conversion ratio, growth rate, live weight, mortalit.

INTRODUCTION

The majority of households in the rural areas of South Africa keep indigenous chicken breeds. Theses indigenous chickens are very important to rural people for their income and nutrition (FAO, 2010). However, they have low productivity and high mortality rates. Thus, they produce few eggs with low hatchability (Dessie and Ogle, 2001). The possibility of improving productivity of the chickens by means of manipulation of the diets of parent stock has been the subject of research for many years, with the aim of finding ways of influencing the productivity of their offsprings. There is is evidence that chicks whose parents were supplemented with ascorbic acid tend to have high growth and low mortality rates.

There is some indication that dietary ascorbic acid supplementation has a positive effect on productivity of broiler chickens (Whitehead and Keller, 2003). However, limited information was found concerning the effect of supplementation of ascorbic acid to the hens on productivity of the chicks. In fact, no such information was found on indigenous chicken. It is, therefore, important to determine and ascertain such responses in indigenous chicken. The objective of this study was to determine the effect of ascorbic acid supplementation level to the diets of indigenous Venda hens on egg production, hatchability

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Table 1. Composition of layers diet ingredient.

Ingredient	Quantity (%)
Maize	64.00
Maize gluten meal	11.67
Fish meal	5.00
Soya Hi Pro	4.37
Full fat soya	4.91
Di-Sodium phosphate	1.33
DL-Methionine	0.20
L-Lysine_HCl	0.20
Vit. Trace El. Premix	0.15

and subsequent productivity of the chicks from day-old up to 7 weeks of age.

MATERIALS AND METHODS

This study was conducted at the experimental farm of the University of Limpopo in South Africa. The first part of this study determined the effect of ascorbic acid supplementation level to the diets of indigenous Venda hens on feed intake, egg production, egg weight, egg content, hatchability and chick hatch-weight. A total of 75 Venda laying hens, aged 33 weeks were randomly assigned to five dietary ascorbic acid treatment levels with three replications, each having five hens. Thus, 15 laying pens were used in total. A complete randomized design (SAS, 2008) was used. Thus, the treatments were as follows:

A_0 - Venda hens fed layers mash *ad libitum* with no ascorbic acid supplementation.
A_{200} - Venda hens fed layers mash *ad libitum* and supplemented with 200 mg ascorbic acid per kg DM feed.
A_{500} - Venda hens fed layers mash *ad libitum* and supplemented with 500 mg ascorbic acid per kg DM feed.
A_{1000} - Venda hens fed layers mash *ad libitum* and supplemented with 1000 mg ascorbic acid per kg DM feed.
A_{1500} - Venda hens fed layers mash *ad libitum* and supplemented with 1500 mg ascorbic acid per kg DM feed.

The composition of layers diet ingredient are presented in Table 1. Nutrient compositions of the diets for the hens are presented in Table 2. The diets were isocaloric (13.5 MJ energy/kg DM) and isonitrogenous (150 g CP/kg DM) but with different supplementation levels of ascorbic acid, ranging between 17.1 and 1517.1 mg per kg DM feed. Levels of other nutrients in the diets were similar. All the hens were inseminated weekly with semen from the same cock. The hens were on the aforementioned diets for 33 days. Feed and water were offered on *ad libitum* basis. Eggs collected during the last 10 days from each replicate were set in a commercial multi-stage incubator. This was done in December, 2008. The ambient temperature during the experimentation period ranged between 25 and 32°C.

The second part of the study determined the effect of ascorbic acid supplementation levels to the diets of Venda hens on performance of unsexed indigenous Venda chicks between 1 and 7 weeks of age. A total of 104 unsexed day-old chicks that hatched from the first part of the study were allocated into 15 floor pens according to the number of chicks that hatched from each replicate. Chicks from each replicate had an initial weight of 34.9 ± 2 g per bird. The diet for the chicks was a commercial standard grower diet fed up to 7 weeks old. The grower diet contained 880 g DM/kg, 15.5 MJ energy/kg DM, 137.5 g crude protein/kg DM, 10 g calcium/kg DM, 5.5 g phosphorus/kg 17.1 mg ascorbic acid/kg DM. All the birds were offered the same grower feed and fresh water *ad libitum*. A complete randomized design (SAS, 2008) was used.

The average voluntary feed intake per bird was measured daily by subtracting the weight of leftovers from that of the feed offered per day and the difference was divided by the total number of birds in the pen. Total egg production was determined by collecting eggs laid in each replicate everyday and pooling together for the period of 10 days. The daily mean number of eggs produced in each replicate was calculated. Mean egg weight per replicate was determined. Representative egg albumen, yolk and shell contents were carefully separated and weighed on an electronic weighing scale. The contents were then used for the determination of nutrients contained in them. Growth rate and feed conversion ratio per chicken were calculated (Lehmann et al., 1996). Mortality rate of the chickens in each pen was calculated as the total number of deaths divided by the total number of chickens per pen then multiplied by a hundred.

Digestibility was carried out when the birds were 7 weeks of age. Digestibility was conducted in specially designed metabolic cages having separated watering and feeding troughs. Two birds were randomly selected from each replicate and transferred to metabolic cages for apparent digestibility. A three-day acclimatization period was allowed prior to a three day collection period. Droppings voided by each bird were collected on a daily basis at 9.00 h. Dry matter contents of eggs, feeds, feed refusals and faeces were determined by drying the sample at 105°C for 24 h. Calcium and phosphorus in egg shells and feeds were determined using an inductively coupled plasma emission (ICP) Perkin–Elmer spectrometer (University of Limpopo Laboratory, South Africa). Gross energy values for feeds and faeces were determined using an adiabatic bomb calorimeter (University of Limpopo Laboratory, South Africa). The nitrogen contents of the eggs, diets, feed refusals and faeces were determined (AOAC, 2002).

High performance liquid chromatography (HPLC) was used to determine the quantity of ascorbic acid contained in the experimental feeds (LATS, University of Limpopo, South Africa). Data on egg production, egg weight, egg content, egg hatchability, chick hatch-weight, feed intake, feed digestibility, growth rate, live weight, feed conversion ratio and mortality of indigenous Venda chickens were analyzed using the general linear model procedure of the statistical analysis of variance (SAS, 2008). The Duncan's multiple range test was used to test the significance of differences between treatment means ($P<0.05$) (SAS, 2008). Optimal responses in feed intake, egg production, egg content, egg weight, growth rate, live weight, feed conversion ratio and mortality to the dietary ascorbic acid supplementation level for the chickens were modeled using the following quadratic equation (SAS, 2008):

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

Where, Y is the feed intake, egg production, egg weight, egg content, egg hatchability, chick hatch-weight, growth rate, live weight, feed conversion ratio and mortality; a is the intercept; b_1 and b_2 are coefficients of the quadratic equation; x is the dietary ascorbic acid supplementation level and $-b_1/2b_2$ is the x value for optimum response. The quadratic model was fitted to the experimental data by means of NLIN procedure of SAS (SAS 2008). The quadratic model was used because it gave the best fit.

RESULTS

Results of the effect of ascorbic acid supplementation level to the diets of indigenous Venda hens on feed intake, egg production, egg weight, hatchability and chick

Table 2. Nutrient composition of the diets for Venda hens (the units are in g/kg for dry matter, g/kg DM feed for calcium protein and phosphorus, mg/kg DM feed for ascorbic acid and MJ ME* feed for energy.

Diet	Nutrient						
	DM	Energy	Protein	Calcium	P	Vitamin C	Vitamin C_1
A_0	900	13.5	150	10.64	5.5	17.1	0
A_{200}	900	13.5	150	10.64	5.5	17.1	200
A_{500}	900	13.5	150	10.64	5.5	17.1	500
A_{1000}	900	13.5	150	10.64	5.5	17.1	1000
A_{1500}	900	13.5	150	10.64	5.5	17.1	1500

Vitamin C (ascorbic acid) in the diet. Vit C_1: Vitamin C (ascorbic acid) supplementation. Laboratory determined total energy (NIRA).

Table 3. Effect of ascorbic acid supplementation level to the diets of Venda hens on feed intake (g/bird/day), egg production (eggs/hen/10 days), egg weight (g/egg), egg hatchability (%) and chick hatch-weight (g/bird).

Diet	Variable				
	Feed intake	Number of eggs	Egg weight	Hatchability	Hatch-weight
A_0	115	5.9	49.1^{d}	31^{c}	33.8
A_{200}	117	6.3	51^{a}	64^{a}	34.4
A_{500}	118	6.2	51^{a}	57^{ab}	37.3
A_{1000}	116	6.1	50^{b}	61^{ab}	33.7
A_{1500}	115	6.0	49^{c}	40^{bc}	35.4
SE	2.08	0.06	0.00	6.70	1.35

^{a,b,c,d}: Means in the same column not sharing a common superscript are significantly different P<0.05) SE : standard error.

Table 4. Effect of ascorbic acid supplementation level to the diets of Venda hens on egg albumen weight (g), yolk weight (g) and shell weight (g).

Diet	Albumen weight	Yolk weight	Shell weight
A_0	25.78^{e}	15.00^{d}	6.05^{e}
A_{200}	28.26^{a}	15.58^{c}	6.44^{b}
A_{500}	26.36^{d}	16.99^{a}	6.93^{a}
A_{1000}	27.26^{c}	15.90^{b}	6.30^{d}
A_{1500}	27.55^{b}	14.47^{e}	6.41^{c}
SE	0.00000257	0.00000122	0.00000121

^{a,b,c,d,e}: Means in the same column not sharing a common superscript are significantly different (P<0.05). SE: standard error.

hatch-weight are presented in Table 3. Dietary ascorbic acid supplementation had no effect (P>0.05) on feed intake, number of eggs produced and chick hatch-weight. However, eggs from hens supplemented with 200 and 500 mg of ascorbic acid per kg DM feed were heavier (P<0.05) than those from hens supplemented with 1000 and 1500 mg of ascorbic acid per kg DM feed. Venda hens supplemented with 200, 500 and 1000 mg of ascorbic acid per kg DM feed produced eggs with higher (P<0.05) hatchability than eggs from hens on unsupplemented diets. Ascorbic acid supplementation level to the diets of indigenous Venda hens on egg albumen, yolk and shell weights are presented in Table 4. Indigenous Venda hens offered a diet supplemented with 200 mg of ascorbic acid per kg DM feed had higher (P<0.05) egg albumen weight than those from hens on unsupplemented diets and those from hens supplemented with 500, 1000 and 1500 mg of ascorbic acid per kg DM feed. However, indigenous Venda hens offered a diet not supplemented with ascorbic acid produced eggs with a lower (P<0.05) egg albumen weight than those of other treatments. Indigenous Venda hens offered a diet supplemented with 500 mg of ascorbic acid per kg DM feed produced eggs with higher (P<0.05) egg yolk and egg shell weights than those on unsupplemented diets and those supplemented with 200,

Table 5. Effect of ascorbic acid supplementation level to the diets of Venda hens on optimal feed intake (g/bird/day), egg production (egg/hen/10 days), egg weight (g/egg), hatchability (%) and chick hatch-weight (g/bird).

Trait	Formula	AA	Y- value	r^2	P
Intake	$Y= 115.583 + 0.005x + 0.00000402x^2$	621	117.2	0.681	0.319
Eggs	$Y= 6.022 + 0.00006x + -0.0000004x^2$	700	6.22	0.439	0.561
Egg weight	$Y= 49.600 + 0.004x + 0.000002928x^2$	683	50.9	0.694	0.306
Hatchability	$Y = 38.727 + 0.07x + -0.00004663x^2$	750	65	0.670	0.330
Hatch-wt	$Y = 34.25 + 0.003x + 0.000001786x^2$	840	35.4	0.115	0.885

r^2 :Regression coefficient. P: probability. AA: ascorbic acid supplementation level (mg/kg DM feed) for optimum variable. Y-value Optimum variable.

Table 6. Effect of ascorbic acid supplementation level to the diets of Venda hens on optimal egg albumen weight, yolk weight and shell weight (g).

Trait	Formula	AA	Y-value	r^2	P
Albumen weight	$Y= 26.575 + 0.001x + -0.000000349x^2$	1438	27.3	0.144	0.856
Yolk weight	$Y = 15.008 + 0.005x + -0.000003411x^2$	733	16.8	0.753	0.124
Shell weight	$Y = 6.185 + 0.001x + -0.0000007x^2$	648.5	6.63	0.379	0.621

r^2 : Regression coefficient. P: probability .AA: ascorbic acid supplementation level (mg/kg DM feed) for optimum variable. Y- value: optimum variable.

Table 7. Effect of ascorbic acid supplementation level to the diets of Venda hens on live weight at 7 weeks of age (g/bird), feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g feed/g live weight gain), mortality (%) and intake as % of live weight (%) of chicks from a day old up to 7 weeks of age.

Diet	Variable					
	Intake	Growth rate	Live weight	FCR	Mortality	Intake as % of Lwt
A_0	40^{c}	5.3^{b}	498^{b}	4.2^{b}	0	8.2^{ab}
A_{200}	43^{ab}	7.1^{a}	530^{ab}	4.3^{a}	6.7	8.1^{ab}
A_{500}	44^{a}	7.2^{a}	501^{b}	3.4^{d}	0	9.0^{a}
A_{1000}	41^{bc}	5.4^{b}	623^{a}	4.1^{c}	0	6.5^{b}
A_{1500}	39^{c}	5.5^{b}	499^{b}	4.0^{c}	0	7.8^{ab}
SE	0.73	0.17	33.8	0.002	2.98	0.5

^{a,b,c,}:Means in the same column not sharing a common superscript are ssignificantly different P<0.05). SE: standard error.

1000 and 1500 mg of ascorbic acid per kg DM feed. Ascorbic acid supplementation increased (P<0.05) egg shell weight. Feed intake, egg production, egg weight, egg hatchability and chick hatch-weight were optimized at ascorbic acid supplementation levels to the diets of Venda hens of 621, 700, 683, 750 and 840 mg/kg DM feed, respectively (Table 5). Egg albumen, egg yolk and egg shell were optimized at ascorbic acid supplementation levels to the diets of Venda hens of 1432.6, 733.0 and 648.5 mg/kg DM feed, respectively (Table 6).

Effect of ascorbic acid supplementation level to the diets of indigenous Venda hens on feed intake, intake as percentage of live weight, growth rate, feed conversion ratio and mortality of the chicks from a day old up to 7 weeks of age and live weight at 7 weeks old are presented in Table 7. Dietary ascorbic acid supplementation to the diets of indigenous Venda hens had no effect (P>0.05) on mortality of Venda chicks. Venda hens supplemented with 500 mg of ascorbic acid per kg DM feed produced chicks which ate more (P<0.05) feed than those from hens not supplemented and those from hens supplemented with 1000 and 1500 mg of ascorbic acid per kg DM feed. However, chicks from hens supplemented with 200 and 500 mg of ascorbic acid per kg DM feed had similar (P<0.05) intakes. Hens supplemented with 500 mg of ascorbic acid per kg DM feed produced chicks which had a higher (P<0.05) intake as percentage of live weight than those from hens supplemented with 1000 mg of ascorbic acid per kg DM

Table 8. Effect of ascorbic acid supplementation level to the diets of Venda hens on diet dry matter digestibility (%), metabolisable energy (ME) (MJ/kgDM) and nitrogen retention (g/bird/day) of chicks between 42 and 49 days of age.

Diet	Variable		
	DM digestibility	Metabolisable energy	Nitrogen retention
A0	56.9	9.58	0.53
A_{200}	55.4	9.61	0.63
A_{500}	54.4	9.23	0.64
A_{1000}	57.7	9.72	0.57
A_{1500}	57.2	9.59	0.62
SE	1.39	0.21	0.073

SE: Standard error.

Table 9. Effect of ascorbic acid supplementation level to the diets of Venda hens on optimal live weight at 7 weeks of age (g/bird), feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (g DM feed/g live weight gain) and intake as percentage of live weight (intake %) between a day old and 7 weeks of age.

Trait	Formula	AA	Y- Value	r^2	P
Lwt	$Y = 484.421 + 0.212x + -0.0001273x^2$	833	573	0.411	0.589
Intake	$Y = 41.094 + 0.007x + -0.000005978x^2$	585	43	0.784	0.216
Growth	$Y = 6.000 + 0.002x + -0.000001829x^2$	547	6.546	0.357	0.643
FCR	$Y = 7.014 + -0.001x + 0.000001058x^2$	723	6.7	0.158	0.842
Intake (%)	$Y = 8.108 + 0.002x + -0.000002087x^2$	479	8.6	0.897	0.103

r^2: Regression coefficient. P: probability. AA:ascorbic acid supplementation level (mg/kg DM feed) for optimum variable. Y -Value: optimum variable.

feed. Hens supplemented with 200 and 500 mg of ascorbic acid per kg DM feed produced chicks with higher ($P<0.05$) growth rates than those from hens not supplemented and those from hens supplemented with 1000 and 1500 mg of ascorbic acid per kg DM feed.

Similarly, chicks from hens supplemented with 1000 mg of ascorbic acid per kg DM feed were heavier ($P<0.05$) than those from hens not supplemented and those from hens supplemented with 500 and 1500 mg of ascorbic acid per kg DM feed. However, chicks from hens supplemented with 200 and 1000 mg of ascorbic acid per kg DM feed had similar ($P>0.05$) live weights. Hens supplemented with 500 mg of ascorbic acid per kg DM feed produced chicks which had better ($P<0.05$) feed conversion ratios than those from hens not supplemented and those from hens supplemented with 200, 1000 and 1500 mg of ascorbic acid per kg DM feed. Ascorbic acid supplementation to the diets of hens had no effect ($P>0.05$) on diet dry matter digestibility, apparent metabolisable energy and nitrogen retention of Venda chicks between 42 and 49 days of age (Table 8). Live weight, feed intake, growth rate, feed conversion ratio and intake as percentage of live weight of indigenous Venda chicks between a day old and 7 weeks of age were optimized at dietary ascorbic acid supplementation levels for the hens of 833, 585, 547, 723 and 479 mg/kg DM feed, respectively (Table 9).

DISCUSSION

The experiment revealed that ascorbic acid supplementation had no effect on the number of eggs produced by indigenous Venda hens at 36 weeks of age. However, ascorbic acid supplementation in the diets of indigenous Venda hens improved egg weights and hatchability. There was a strong and positive relationship between egg weight and hatchability values. Eggs with higher weights tended to produce higher hatchability values. These results are consistent with the findings of Lin et al. (2000) who reported that ascorbic acid supplementation increased egg hatchability in broiler chicken breeders. In this study, ascorbic acid supplementation to the diets of indigenous Venda hens increased egg albumen, yolk and shell weights. This is expected since ascorbic acid is necessary for the maintenance of normal collagen metabolism which is required for normal structure of egg shells (McDonald et al., 2003). Dietary ascorbic acid supplementation in the diets of indigenous Venda improved dry matter, nitrogen and calcium contents of egg albumen, yolk and shell. This view supports Orban et al. (1993), who reported that supplementation of ascorbic acid in the diets of broiler chickens improved calcium metabolism and egg shell mineralization. However, these results are contrary to those of Creel et al. (2001) who did not find any

relationship between ascorbic acid supplementation to the diets and productive parameters of the produced eggs of broiler hens.

Feed intake, egg production, egg weight, egg hatchability and chick hatch-weight were optimized at different ascorbic acid supplementation levels of 621, 700, 683, 750 and 840 mg/kg DM feed, respectively. These results have implications when formulating diets for chickens. Thus, dietary ascorbic acid supplementation level for optimal productivity will depend on the variable in question. Indigenous Venda hens supplemented with ascorbic acid produced chicks having higher feed intake, better feed conversion ratio, improved growth rates and higher live weights at seven weeks of age than those from hens not supplemented with ascorbic acid. There were no studies found on the performance of chicks from indigenous hens supplemented with dietary ascorbic acid. However, Atencio et al. (2005) found that the progeny hatched from hens supplemented with high doses of vitamin D_3 showed better performance in broiler chickens.

As revealed in the present study, ascorbic acid supplementation in the diets of indigenous Venda hens had no effect on mortality of the chicks. However, mortality was reduced from 6.7 to 0% with increased levels of ascorbic acid. No previous studies were found on the effect of ascorbic acid supplementation to the diets of indigenous hens on the mortality of their chicks. However, Hossain et al. (1998) indicated that high concentrations of vitamin E in the diets of broiler chicken hens increased the immune responses in the chicks. This reduced mortality of the chicks. Live weight, feed intake, growth rate, feed conversion ratio and intake as percentage of live weight of Venda chickens between a day old and seven weeks of age were optimized at different ascorbic acid supplementation levels to the diets of hens of 833, 585, 547, 723 and 479 mg/kg DM feed, respectively. This indicates that ascorbic acid requirements of indigenous Venda hens for optimal productivity of their chicks will depend on the production variable in question. No reports were found on the effect of ascorbic acid supplementation level to the diets of indigenous hens on optimum productivity of the chicks.

Conclusion

This study demonstrated that ascorbic acid supplementation to the diets of indigenous Venda hens has positive effects on egg weight, egg content, hatchability and growth of chicks up to 7 weeks. Ascorbic acid requirements of indigenous Venda hens for optimal productivity were variable and depended on the production parameter in question. These results have a lot of implication on ration formation for indigenous Venda hens. However, more research should be done to ascertain these responses.

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