GROWTH AND PRODUCTION RESPONSES OF BOSCHVELD CHICKENS TO BAKERS' YEAST SUPPLEMENTATION

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Abstract. The purpose of this study was to determine the impact of probiotic-yeast supplementation on growth and productivity of Boschveld chickens reared intensively from 1 - 91 days of age. Birds were raised on commercial starter mash (1 - 49 days) and grower mash (50 to 91 days). Six hundred unsexed Boschveld chicks with a mean live weight of 27.8 ± 1.07 g were allotted into six treatment groups. Each group was divided into five replicates of 20 chickens. Birds in each group were assigned to a diet containing 18 -20% crude protein and 3001.38 - 3009.98 Kcal/kg energy, but with increasing levels of bakers' yeast (TS) at 0 (TS0), 2.5 (TS2.5), 5.0 (TS5), 7.5 (TS7.5), 10.0 (TS10) and 12.5 g/kg feed (TS12.5). Experimental chickens were raised in a deep litter house; feed and water were given ad libitum. Data on growth performance indices, apparent metabolizable energy (AME) and nitrogen retention were collected and analysed statistically at $p < 0.05$. Treatment means where significant were separated using Duncan's test for multiple comparisons. Results revealed that dietary probiotic-yeast supplementation had no significant influence on feed intake and AME in Boschveld chickens. Chickens fed treatment diets had better final live weight (FLW), feed conversion efficiency (FCE), average daily gain (ADG) and nitrogen retention in comparison with chickens fed control diet. Our results demonstrated that probiotic-yeast supplementation at 5.0, 7.5 and 10.0 g/kg feed had a positive effect on performance indices of indigenous Boschveld chickens reared in a closed confinement from 1 up to 91 days of age.
Keywords: *indigenous chickens, probiotics, feed intake, feed conversion efficiency, live weight, nutrient digestibility*

Introduction

Indigenous chickens play an important socio-economic role in developing countries where they are reared for meat and eggs. They are an integral part of the poultry industry and are reared under a free-range system where they occasionally receive kitchen leftovers, damaged grains and insects among others. To the majority of resource-poor households, indigenous chickens serve as a quick source of income when money is needed for urgent family needs (FAO, 2010), and hence indigenous chickens are reared in most rural households because of their low requirements on labour, maintenance and production cost when compared with exotic chicken breeds. Furthermore, as suggested by Dessie and Ogle (2001) indigenous chickens have a slow growth rate and lay few eggs per clutch. Despite their low productivity and slow growth rates, indigenous chickens have good features such as hardiness, excellent meat quality, high disease-resistant ability, hardy eggshells and thermo-tolerance (Dessie and Ogle, 2001; Adesola et al., 2012). For many years, researchers have been investigating the possibility of increasing the productivity of indigenous chickens under an intensive production system through

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dietary manipulation without compromising their desirable features. Thus, it has become imperative to use some readily available probiotics to enhance the productivity of indigenous chickens.

Probiotics are live microorganisms which when administered in adequate amounts confer a beneficial health effects on the host (FAO/WHO, 2002). The mechanisms of action of probiotics include modulation of the gut microbial ecosystem in favor of the growth of beneficial microbes, stabilization of the gut barrier function, stimulation of immune response, enhanced enzymatic activity resulting in higher digestibility and nutrient utilization (Timmerman et al., 2005), culminating in improved chicken performance (Junaid et al., 2018; Ogbuewu et al., 2019). There is ample evidence that yeast (*Saccharomyces cerevisiae*), one of such probiotics, enhances digestibility and nutrient uptake in poultry (Ezema and Ugwu, 2014; Nath et al., 2016; Ogbuewu et al., 2019; Ogbuewu et al., 2020). Yeast is rich in crude protein (45%), phosphorus and potassium (Reed and Naodawithana, 1999). It also contains mannan and 1.3/1.6 β-glucans which stimulate the immune response (Abaza et al., 2008). Current feeding studies in our research station have shown that dietary yeast improves blood characteristics, carcass yield, cut-out part and organ weights in Boschveld chickens (Maoba et al., 2021a,b). The positive influence of dietary yeast on the production and health indices of exotic chicken breeds has been demonstrated (Ahmed et al., 2015; Ogbuewu et al., 2019; Ogbuewu and Mbajiorgu, 2020). However, little or no information exists on the growth and productivity of indigenous chicken breeds such as the Boschveld chickens fed diets supplemented with different yeast supplementation levels.

Historically, Boschveld chicken is a cross of three South African indigenous chicken breeds. The strain was developed by a white farmer (Mike Bosch) in the mid-1970s to assist in pests (ticks) control in his beef cattle farm. It is made up of 50, 25 and 25% of Venda, Ovambo and Matabele breed traits (Bosch, 2018). Boschveld chickens are reared both for meat and egg production, and according to Okoro et al. (2017), they weigh between 1.7 and 2.6 kg at 20 weeks of age. Boschveld chicken attains sexual maturity at 20 weeks of age (Okoro et al., 2017). It also has a pea-shaped comb and plumage colour ranging from red to light brown with white patches. The hens lay brown eggs and are broody with good mothering ability.

Currently, there is little or no information on dietary yeast supplementation as a nutritional approach for increasing the productivity of indigenous chicken. At the same time, it is assumed that such approach will help in ensuring optimal productivity in terms of body weight gain, feed efficiency, live weight, egg production and product quality. Also, as far as indigenous chicken production is concerned, it is very imperative to note that one important factor in intensive indigenous chicken farming is efficient nutrient utilization as feed solely contributes about 60-70% of the total cost of chicken production. Therefore, increasing feed efficiency and minimizing feed wastages could be the leading factor in profit maximization. Such information could be very helpful to rural farmers in South Africa and elsewhere. The purpose of this study, therefore, was to determine the effect of probiotic-yeast supplementation on growth and productivity of Boschveld chickens reared in a tropical environment from day-old up to 91 days of age.

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Materials and methods

Ethics statement and study location

The study adhered strictly to the guidelines of the University of South Africa's Animal Ethics Committee (2018/CAES/101). This experiment was done at Portion 22 of the farm Elandsfontein 334 IQ (26.3898 S 27.9235 E) in Gauteng Province, South Africa. The farm is situated about 30 km south of Johannesburg in the Midvaal Local Municipality within Sedibeng District Municipality. The study lasted from January to April 2019.

Preparation of poultry house and source of yeast

The poultry house had 30-floor pens with equal surface area (2 m^2/pen) and was divided into three rows of 10-floor pens. The floor of each pen was covered with a layer of wood shavings (7 cm deep). Baker's yeast (*S. cerevisiae*) used for the study was obtained from Anchor Yeast 22 Bunsen Street, Johannesburg, South Africa. Boschveld chicks were purchased at Boschveld Ranching (PTY) Limited, Limpopo, South Africa.

Experimental chickens, diets and design

600 day old unsexed Boschveld chicks with an average live weight of 27.8 ± 1.07 g were used for the study that lasted 91 days. Birds were raised on a commercial starter mash (1 to 49 d) and grower mash (50 to 91 d). Boschveld chicks were assigned to six dietary groups with five replications, each having 20 chicks in a completely randomized design. Experimental birds were fed mash diets (*Table 1*) mixed with different levels of baker's yeast designated: TS0 (0), TS2.5 (2.5), TS5 (5.0), TS7.5 (7.5), TS10 (10.0) and TS12.5 (12.5 g/kg feed). Diets and water were offered *ad libitum* throughout the feeding trial. Light was provided to the experimental chickens 24 hours daily. The vaccination program was implemented following the Boschveld chicken management guide (Bosch, 2018).

Table 1. *Proximate composition of the experimental diets*

Nutrients (g/kg)	**Starter feed (1 – 49 days)**	**Grower feed (50 - 91 days)**
Crude protein*	200.00	180.00
Lysine*	13.30	10.50
Methionine*	4.70	4.40
Moisture*	120.00	120.00
Crude fat*	25.00	25.00
Crude fibre*	50.00	60.00
Calcium*	10.50	9.50
Phosphorus*	6.00	4.52
Determined analysis		
Dry matter	914.63	912.53
Moisture	85.37	87.47
Crude protein	229.96	193.19
Ash	58.96	47.79
Nitrogen free extract	55.06	58.65
GE (MJ/kg)	17.74	17.17
ME (Kcal/kg)	3009.98	3001.38

* As illustrated in the feed label, Kcal – kilocalorie, GE –gross energy, ME - metabolisable energy

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Data collection

The initial live weights of chicks were weighed and recorded at the beginning of the feeding trial. Thereafter it was weighed at the end of each week of experiment to determine the weekly live weight and weight differences. FI was determined daily as the difference between the quantity of feed given and the leftover the following morning on the replicate basis. At the end of the feeding trial, the difference between the FLW and initial live weight (ILW) was determined and recorded as weight gain. The mean weight gained per replicate was further divided by the duration of study to determine ADG. FCE was calculated by dividing the feed intake (FI) by ADG.

Laboratory analysis

The feed samples were oven-dried at 105°C for 48 hours and finely ground (1-mm, Polymix PX-MFC 90 D) to pass through a 1-mm mesh sieve and thereafter analysed for ash, nitrogen, crude fibre (CF), ether extracts (EE) and nitrogen-free extract (NFE) content following the procedures outlined by AOAC (2008). The crude protein (CP) was calculated as N × 6.25. The GE of the diets and the fecal samples were determined by measuring the heat of combustion in the samples using a bomb calorimeter (Parr 6100, Moline, IL, USA). ME was calculated using the prediction equation of Pauzenga (1985) as follows: ME = 37 × CP % + 81.8 × EE % + 35.5 × NFE %.

A digestibility trial was conducted when chickens were aged between 42 and 49 days (starter phase) and between days 84 and 91 (grower phase). On days 42 and 84, two birds per replicate were transferred to a metabolic cage equipped with a drinker and feeder. The birds were stabilized for three days before droppings were collected from each chicken daily at 9:00 am following a standard procedure. AME and nitrogen retention were calculated using the methods of AOAC (2008).

Statistical analysis

Data were analysed for statistical differences between treatments using one-way analysis of variance and Pearson's product moment correlation following the General Linear Model procedure of the Statistical Analysis System (SAS 2010). The statistical model used was as described in *equation (1)*.

$$Y_{ijk} = \mu + T_1 + \Sigma_{ijk} \quad \text{(Eq.1)}$$

where: Y_{ijk} = the overall observation (FI, LW, FCE, ADG, AME and nitrogen retention), μ = the population means, T_1 = the effect of probiotic-yeast supplementation levels and Σ_{ijk} = the residual effect. Where significant ($p<0.05$), means were separated using Duncan's test for multiple comparisons to determine the significant differences among the treatment means due to dietary effect (SAS, 2010).

Results

The proximate biochemical composition of experimental diets is shown in *Table 1*. The analysis revealed that starter and grower diets contained a crude protein content of 229.96 and 193.19 g/kg, respectively. *Tables 2, 3 and 4* summarized the impact of probiotic-yeast supplementation on production variables of Boschveld chickens aged 1 - 49, 51 - 91 and 1 - 91 d. Probiotic-yeast had no effect ($p > 0.05$) on FI and AME.

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However, chickens offered TS5, TS7.5 and TS10 had higher ($p < 0.05$) than those diets TS0, TS2.5 and TS12.5, with the exception of chickens aged 1 - 49 d fed TS12.5, who had similar FLW to chickens fed TS5.0 and TS10.0. Boschveld chickens (51 - 91 and 1 - 91 d) fed diets TS5, TS7.5 and TS10.0 had significantly better ($p < 0.05$) FCE and ADG compared with those fed TS0, TS2.5 and TS12.5. However, no significant differences ($p > 0.05$) were found amongst the birds (51 - 91 and 1 - 91 d) fed TS5, TS7.5 and TS10.0 in terms of FCE and ADG. Similarly, chickens (51 - 91 and 1 - 91 d) fed TS0, TS2.5 and TS12.5 had comparable ($p > 0.05$) FCE and ADG values, whereas chickens (1- 49 d) fed TS5, TS7.5, TS10.0 and TS12.5 had better ($p < 0.05$) FCE and ADG than those fed TS0 and TS2.5. Boschveld chickens (50 - 91 d and 1 - 91 d) offered TS5, TS7.5, TS10.0 and TS12.5 retained more nitrogen than those fed TS0. A similar pattern was observed in Boschveld chickens aged 1 - 49 d, with the exception of birds fed TS2.5 that have the same nitrogen retention value as birds fed TS0.

Table 2. *Effect of probiotic-yeast on production indices of Boschveld chickens aged 1 to 49 days*

Diet (g/kg)	Production variables						
	ILW (g/b/d)	**FLW (g/b)**	**FI (g/b/d)**	**ADG (g/b/d)**	**FCE**	**AME (MJ ME/kg)**	**N-retention (g/b/d)**
TS0	28.4	540.5^{c}	38.1	10.5^{c}	3.7^{a}	11.3	1.84^{c}
TS2.5	26.4	548.3^{c}	36.8	10.7^{c}	3.5^{a}	10.7	1.90^{c}
TS5.0	27.7	633.3^{ab}	34.8	12.4^{ab}	2.8^{c}	11.9	2.26^{b}
TS7.5	27.0	646.9^{a}	37.2	12.7^{a}	2.9^{c}	11.7	2.54^{a}
TS10.0	29.4	634.6^{ab}	36.4	12.4^{ab}	3.0^{bc}	11.6	2.42^{ab}
TS12.5	27.5	583.7^{b}	37.3	11.4^{bc}	3.3^{ab}	10.8	2.26^{b}
Mean	27.8	597.9	36.8	11.7	3.2	11.3	2.20
SD	1.07	46.8	1.11	0.97	0.35	0.49	0.28
CV (%)	3.85	7.83	3.02	8.29	10.9	4.34	12.73
SEM	0.44	19.1	0.45	0.40	0.14	0.20	0.11
p-value	0.050	0.001	0.130	0.001	0.001	0.200	0.001

Means in the same column not sharing a common superscript are significant at $p < 0.05$. g – grams, b - bird, kg – kilograms, MJ – megajoules, ME – metabolisable energy, d - day, p - probability, ILW - initial live weight, FLW - final live weight, FI – feed intake, ADG – average daily gain, FCE – feed conversion efficiency, AME- - apparent metabolizable energy, N – nitrogen, SD - standard deviation, CV - coefficient of variation, SEM - standard error of the mean

The results of correlation coefficients among the production variables of Boschveld chickens aged 1 to 49 d and 51-91 d are shown in *Tables 5 and 6*. Positive and significant correlations existed between nitrogen retention and growth performance (ADG and FLW) in Boschveld chickens. In addition, significant ($p < 0.05$) and positive correlations were found between nitrogen retention and growth performance variables (ADG and FLW) in Boschveld chickens. However, negative and significant correlations existed between nitrogen retention and FCE ($p < 0.05$) in chickens aged 50 - 91 d. Nitrogen retention was not correlated ($p > 0.05$) to FI and AME in Boschveld chickens. On the other hand, significant and negative correlations were found between FCE, ADG and FLW. Similarly, AME was positively correlated with ADG ($p < 0.05$) in Boschveld chickens aged 51-91d.

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Table 3. *Effect of probiotic-yeast on production indices of Boschveld chickens aged 50 to 91 days*

Diet (g/kg)	Production variables					
	FLW (g/b)	FI (g//d)	ADG (g/b/d)	FCE	AME (MJ ME/kg)	N-retention (g/b/d)
TS0	1313.8^{d}	76.0	18.4^{b}	4.1^{a}	10.7	1.8^{c}
TS2.5	1388.6^{c}	75.7	20.0^{b}	3.9^{a}	11.0	2.2^{b}
TS5.0	1587.8^{b}	74.4	22.7^{a}	3.3^{b}	10.8	2.4^{a}
TS7.5	1634.6^{ab}	75.3	23.5^{a}	3.2^{b}	11.4	2.4^{a}
TS10.0	1685.6^{a}	74.4	25.0^{a}	3.0^{b}	11.9	2.5^{a}
TS12.5	1380.4^{c}	72.6	19.0^{b}	3.9^{a}	10.8	2.1^{b}
Mean	1498.5	74.7	21.4	3.56	11.1	2.2
SD	156.0	1.23	2.69	0.46	0.47	0.25
CV (%)	10.4	1.65	12.6	12.9	4.23	11.3
SEM	63.67	0.50	1.10	0.19	0.19	0.10
p-value	<.001	0.574	0.001	0.005	0.421	0.001

Means in the same column not sharing a common superscript are significant at p<0.05. g - gram, b - bird, d - day, p - probability, FLW - final live weight, FI - feed intake, ADG - average daily gain, FCE - feed conversion efficiency, AME - apparent metabolizable energy, kg – kilograms, MJ – megajoules, ME – metabolisable energy, SD - standard deviation, CV - coefficient of variation, SEM - standard error of the mean

Table 4. *Effect of probiotic-yeast on production indices of Boschveld chickens at 91 days of age*

Diet (g/kg)	Production variable					
	FLW (g/b)	FI (g/b/d)	FCE	ADG (g/b/d)	AME (MJ ME/kg)	N-retention (g/b/d)
TS0	1313.8^{d}	57.1	4.0^{a}	14.4^{c}	10.96	1.84^{d}
TS2.5	1388.6^{c}	56.2	3.7^{ab}	15.3^{c}	10.84	2.03^{c}
TS5	1587.8^{b}	54.6	3.1^{c}	17.6^{b}	11.35	2.34^{ab}
TS7.5	1634.6^{ab}	56.2	3.1^{c}	18.1^{ab}	11.56	2.48^{a}
TS10	1685.6^{a}	55.4	3.0^{c}	18.7^{a}	11.71	2.46^{a}
TS12.5	1380.4^{c}	54.9	3.6^{ab}	15.2^{c}	10.80	2.20^{bc}
Mean	1498.5	55.7	3.4	16.7	11.20	2.23
SD	156.0	0.92	0.4	1.79	0.397	0.25
CV (%)	10.4	1.65	0.11	10.7	3.54	11.2
SEM	63.67	0.376	0.16	0.73	0.162	0.10
P-value	0.001	0.455	0.001	0.001	0.230	0.001

^{a,b,c,d}: Means in the same column not sharing a common superscript are significant at p<0.05. g - gram, b - bird, d - day, p - probability, FLW - final live weight, FI - feed intake, FCE - feed conversion efficiency, ADG - average daily gain, AME - apparent metabolizable energy, kg – kilograms, MJ – megajoules, ME – metabolisable energy, SD - standard deviation, CV - coefficient of variation, SEM - standard error of the mean

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Table 5. *Correlation among the production variables of Boschveld chickens aged 1-49 days*

Variables	N-retention	Feed intake	ADG	FLW	FCE	AME
N-retention	1					
Feed intake	-0.3258	1				
ADG	0.9421**	-0.5638	1			
FLW	0.9407**	-0.5639	0.9998**	1		
FCE	-0.8029	0.7813	-0.9202**	-0.9155*	1	
AME	0.5625	-0.5095	0.7625	0.7694	-0.6387	1

*Correlation is significant at $p < 0.05$. N - Nitrogen, ADG - average daily gain, FLW - final live weight, FCE - feed conversion efficiency, AME - apparent metabolisable energy

Table 6. *Correlation among productive variables of Boschveld chickens aged 50 to 91 days*

Variables	N-retention	Feed intake	ADG	FLW	FCE	AME
N-retention	1					
Feed intake	-0.2173	1				
ADG	0.9246*	-0.0289	1			
FLW	0.9282*	-0.1072	0.9908*	1		
FCE	-0.9258*	0.1270	-0.9907*	-0.9992*	1	
AME	0.7167	0.0139	0.8334*	0.7836	0.7857	1

*Correlation is significant at $p < 0.05$. N – Nitrogen, ADG - average daily gain, FLW - final live weight, FCE - feed conversion efficiency, AME - apparent metabolizable energy

Discussion

This experiment assessed the impact of probiotic-yeast on growth and productivity of unsexed Boschveld chickens. The proximate composition indicated that yeast supplemented diets were rich in essential nutrients and met the nutrient requirements of Boschveld chickens (Bosch, 2018). ADG and FCE are important performance indicators in poultry production. Although, several variables should be considered for the ideal performance of the chickens such as its genetic potential, the composition of the diet, ecological condition and health of the chicken amongst others (Selvaggi et al., 2015; Sugiharto, 2016). Probiotic-yeast did not influence FI and AME in the present study. In agreement, Wulandari and Syahniar (2018) reported no effect of dietary yeast supplementation on feed intake in broiler chickens. However, contrary to the present findings, Ahmed et al. (2015) found that inclusion of yeast at 3% in the diet of broiler chickens aged 1-21 days increased feed intake. These differences could be attributed to genetic variation and growth potential of broiler chickens, since they are selected to reach market weight fast than the indigenous Boschveld chickens. The lack of significant changes in AME in the present investigation ruled out the likelihood of weight loss or muscle tissue alteration that occurs when animals use non-carbohydrate sources (amino acids and glycerol part of fat) to meet their body energy needs. Additionaly, the comparable AME values in all the dietary groups is an indication that diets were similar in terms of digestibility and energy utilization. However, no similar studies in Boschveld chickens were found in the literature to compare with the findings of the present study.

The FLW recorded in chickens fed treatment diets with the exception of chickens (1 - 49 d) fed TS2.5 diet were higher than those fed control diet, which is similar to the

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live weights recorded by Aluwong et al. (2012) in broiler chickens offered yeast at 5, 15 and 20 g/kg and Ding et al. (2019) in Chinese native chickens fed yeast beta-1, 3-1, 6-glucan at 0.5, 1.0 and 2.0 g/kg for 6 weeks. The improved FLW of chickens fed treatment diets when compared with control could be attributed to yeast's ability to improve digestibility and nutrient uptake in chickens (Ezema and Ugwu, 2014; Ogbuewu et al., 2019; Ogbuewu and Mbajiorgu, 2020). Another possible explanation for the increased live weights of chickens in treatment groups could be ascribed the capability of yeast to maintain a healthy gut through the production of lactic acid which makes the gastrointestinal tract acidic, thus reducing the population of pathogenic microbes (Ding et al., 2019; Ogbuewu et al., 2019). The FLW of chickens age 51- 91d and 1- 91 d fed probiotic-yeast at 5.0, 7.5 and 10.0 g/kg were higher than the value of 1555 g/bird/day as reported by Nherera (2018) in Boschveld chickens reared under improved management conditions for 17 weeks.

The significantly better FCE and ADG recorded in chickens fed probiotic-yeast at 5.0, 7.5 and 10.0 g/kg feed in the present study, when compared with those fed a diet without yeast supplementation, suggests the superiority of the diets in terms of digestibility and nutrient utilization. On the same hand, Shankar et al. (2017) found an improvement in ADG and FCE of broiler chickens offered yeast at a level (2 g/kg feed) below the values supplemented in the present study. Similar results were reported by Rafique et al. (2017) in broiler chickens fed diet incorporated with yeast at 1.5 g/kg feed, thus supporting Mabelebele et al. (2014), who found that broiler chickens have higher rate of small intestine development which is positively correlated with digestion and assimilation. The increased performance in terms of ADG and FCE in chickens offered 5.0, 7.5 and 10.0 g yeast/kg feed could be attributed to the yeast's ability to modulate intestinal microbial ecosystem in favor of the growth of lactic acid bacteria such as Lactobacillus species, stabilization of the gut epithelial function, improvement in gut immune system and digestive enzyme activity (Timmerman et al., 2005). However, the poor FCE and ADG recorded in chickens fed yeast at 2.5 g/kg feed in the present study could be attributed to the inability of yeast at this level to improve Boschveld chicken productivity. Contrary to the results of the improved performance of Boschveld chickens fed yeast at 5, 7.5 and 10 g/kg feed current study, Junaid et al. (2018) found that the addition of probiotics in the diets of broiler chickens did not affect ADG and FCE in broiler chickens aged 0 to 42 days. Similarly, Ahmed et al. (2015) reported poor ADG and FCE in chickens (0 - 3 weeks) fed yeast at 20 g/kg feed. The observed disparity could be ascribed to supplementation level reported to affect chicken performance (Ogbuewu et al., 2020). The ADG value of 21.4 g/bird/day recorded in chickens aged 51-91 days in the current study was higher than the value of 12.73 g/bird/day reported by Nherera (2018) in Boschveld chickens reared under improved feeding and health management for 17 weeks. This variation could be linked to differences in diet composition and health care. This result indicates that yeast has a growth-promoting effect in Boschveld chickens. The observed significant increase on ADG at a comparable feed intake in the present study is an indication that the chickens on treatment diets is gaining weight at a similar feed intake with the control.

The difference in quantity and nitrogen excretion routes has a strong influence in its retention, which is considered an index of protein status in animals, and has a direct consequence on animal performance (Chanjula et al., 2016). The significantly higher nitrogen retention in Boschveld chickens offered yeast at 5.0, 10.0 and 12.5 compared with the control, could in part be attributed to the quality of protein contained in the diets.

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Similar results were found in Indonesia's native chickens (Ma'rifah et al., 2013). The present findings show that nitrogen retention value increased progressively as the amount of yeast in the diet was increased, and thereafter declined, which is similar to the finding of Mbajiorgu et al. (2011) in South African unsexed Venda chickens. The significantly higher nitrogen retention recorded in birds fed treatment diets indicates the ability of the diets to support muscle development leading to better growth. This also suggests greater efficiency of the use of nitrogen in birds fed treatment diets over the control diet. Oyedeji et al. (2008) found a similar pattern in Ross 355 broiler chickens offered yeast culture at 0.2, 0.25 and 0.3 g/kg feed. Furthermore, the significant decline in nitrogen retention value of birds offered yeast at 12.5 g/kg feed in comparison with birds fed yeast at 7.5 g/kg indicates that 12.5 g yeast/kg feed could be higher than the level the Boschveld chickens could utilize.

Positive and significant correlations existed between nitrogen retention and ADG and FLW in Boschveld chickens aged 1 to 49 d and 51-91 d. This is expected because; at these stages there is greater nitrogen retention for protein tissue deposition in the muscles (Nery et al., 2007). The high and positive correlation found between nitrogen retention and ADG in chickens implies that as the nitrogen retention value increases, ADG and FLW also increase. The negative and strong correlations found between ADG and FCE suggest that a decrease in FCE increases ADG. These results are in harmony with Iji et al. (2001), who found that inclusion of yeast metabolites in chicken diets has a beneficial influence on digestive enzyme activity which leads to better digestion and nutrient utilization efficiency.

Conclusion

In conclusion, it can be inferred from the results of this study, that the range of yeast supplemented in the diet of chickens in the present study did not influence feed intake and apparent metabolizable energy intake of Boschveld chickens reared intensively from day old up 91 days. In fact, this implies that the type as well as the range of the yeast supplement used in the present study is acceptable by the birds. Also, given the fact that Boschveld chickens fed diets supplemented with yeast at 5.0, 7.5 and 10.0 g/kg feed had significantly higher final live weight, average daily gain, better nitrogen retention and feed conversion efficiency when compared to those offered a diet without yeast supplementation is a good indication that there is ample evidence that probiotic-yeast used in the present study has the ability to enhance digestibility and nutrient uptake in poultry as similarly observed by researchers (Ezema and Ugwu, 2014; Nath et al., 2016; Ogbuewu et al., 2019, 2020). Identifying the exact mechanism of action of probiotic-yeast that will allow the prediction of its ability to enhance digestibility and nutrient uptake in poultry remains a challenge.

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