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Serum biochemical values of indigenous Boschveld chickens in response to baker's yeast (*Saccharomyces cerevisiae*) supplementation

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Abstract The use of eco-friendly feed additives such as probiotics to improve ~~of~~ chicken performance has been highlighted. However, the effect of baker's yeast, one of such probiotics on serum biochemical characteristics of unsexed indigenous Boschveld chickens has not been investigated. This study revealed that indigenous Boschveld chickens aged day 1 to 90 offered diets containing baker's yeast at 5, 7.5 and 10 g/kg feed had significantly higher ($p<0.05$) serum total protein and significantly lower ($p<0.05$) serum cholesterol, when compared to the chickens fed diets containing baker's yeast at 0, 2.5 and 12.5 g/kg feed. Unsexed indigenous Boschveld chickens offered diets having baker's yeast at 5.0 and 7.5 g/kg feed had significantly reduced ($p<0.05$) serum triglycerides than indigenous Boschveld chickens offered baker's yeast at 0, 2.5, 10 and 12.5 g/kg feed. In addition, chickens fed diets supplemented with baker's yeast at 5.0, 7.5 and 10 g/kg feed had significantly higher ($p<0.05$) serum globulin than those offered baker's yeast at 0, 2.5 and 12.5 g/kg feed. Conversely, no significant difference was found in the serum albumin, glucose and uric acid between the control and the yeast groups. Quadratic calculation indicated that serum total protein, globulin, cholesterol and triglycerides were optimised at 7.3, 3.7, 6.9 and 7.0 g bakers yeast/kg feed, respectively. Results indicate that inclusion of yeast at 7.3, 3.7, 6.9 and 7.0 g/kg supported optimal serum total protein, globulin, cholesterol and triglycerides formation in indigenous chickens aged from 1 to 91 days fed 0, 2.5, 5.0, 7.5, 10.0 and 12.5 g bakers yeast/kg feed.

Keywords: Probiotics, Serum chemistry, Indigenous chicken, Quadratic function

Introduction

Like other developing nations, the poultry sector in South Africa is divided into two sub-sectors, comprising industrial and traditional sub-sectors. Each sub-sector has its uniqueness that makes its contribution to national food security crucial. The industrial sub-sector comprised exotic chicken breeds (layers and broilers, respectively) reared for meat and egg production. They are raised in urban and pre-urban areas where there is infrastructure and trained manpower for production and market for products exist. In contrast, the traditional sub-sector is comprised of local chickens such as Boschveld chickens and is reared extensively in the rural areas. They play a vital role in improving household nutrition and revenue of most rural households (Iqbal *et al.*, 2016). Local

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birds are self-reliant and strong chickens with the potential to adapt to adverse environmental conditions (Ilo and Egu, 2018).

Despite these good attributes of local chickens under the extensive system of production, their productivity is still low. This low productivity is primarily attributed to the high cost of feed linked to the rising cost of feed ingredients. This has compelled researchers to develop strategies to improve chicken productivity using probiotics. Probiotics are live microorganisms which when given in the right doses improves the performance of host animal by maintaining intestinal microbial balance (Lee and Salminen, 2009). Yeast, one of such probiotics is a single-celled microorganism (Hoffman *et al*., 2015) that measures between 3 and 4 micrometres in size. It possesses nuclear membrane and cell walls but lacks chloroplasts (Shurson, 2018). Yeast is characterised by high concentrations of protein (45%), phosphorus and potassium (Reed and Naodawithana, 1999). Besides its nutritional values, yeast has been shown to improve chicken performance via one or more of the following mechanisms of action: 1. modulates the gut microbial ecosystem via pathogen inhibition, 2) enhance digestive enzyme activity, 3) increase feed consumption, 4) activate gut immune response and, 5) reduce gut pH by encouraging the growth of lactic acid-producing bacteria (Ezema and Ugwu, 2014).

Various reports involving avian species other than indigenous chickens indicate that birds fed standard diets supplemented with probiotic-yeast performed better than the controls in terms of growth, nutrient digestibility, intestinal health, meat quality and blood characteristics (Zhang *et al*., 2005; Yang *et al*., 2008; Ahmed *et al*., 2015; Hassan *et al*., 2016; Nabila *et al*., 2017). Yeast supplementation has been shown to improve feed efficiency (Ahmed *et al*., 2015), reduce serum total lipid concentration (Kurtoglu *et al*., 2004), and abdominal fat content (Ezema and Ugwu, 2014) in exotic chicken breeds. Similarly, yeast and its product contain mannan and 1.3/1.6 β-glucans which improve the immune response, serum protein and immunoglobulin concentrations (Abdollahi *et al*., 2002; Abaza *et al*., 2008). Enhanced performance in indigenous Boschveld chickens fed standard poultry feed supplemented with baker's yeast up to 12.5 g/kg has been demonstrated (Maoba *et al*., 2021a, b).

Boschveld chicken is a cross of three local South African chicken breeds, which weighs approximately 1.7 to 2.6 kg at 5 months of age (Okoro *et al*., 2017; Bosch, 2018). They have light brown coloured feathers mixed with white, and egg weights of about 50 g at 32 weeks of age have been recorded (Okoro *et al*., 2017). Under scavenging conditions, Boschveld hens produce about 200 eggs per bird per year. They begin to lay at 6 months and have a laying lifespan of 3 years. They lay brown eggs, have good meat quality, and the hens are broody with good mothering ability. However, there is little research on the influence of yeast inclusion on the blood chemistry of indigenous Boschveld chickens. There is growing interest on the use of quadratic function to determine the levels of feed supplements that supports optimal productivity in chickens (Mbajiorgu *et al*., 2011; Okoro *et al*., 2017). The study was assessed the serum biochemical indices of indigenous Boschveld chicken on dietary baker's yeast supplementation on serum biochemical indices of unsexed indigenous Boschveld chickens managed intensively.

Materials and methods

The study was approved (2018/CAES/101) by the Animal Ethics Committee of the University of South Africa. It was conducted at a farm situated at Midvaal local municipality in Guateng province, South Africa. A total of 600-day-old Boschveld chicks with average weight of 27.8 ± 1.07 g were randomly allotted to six treatments (T0, T1, T2, T3, T4 and T5) of 100 animals per group and 20 animals per replicate. Birds were fed a diet (Table 1) supplemented with baker's yeast at 0, 2.5, 5.0, 7.5, 10.0, or 12.5 g/kg feed. The experiment lasted for 91 days. Metabolisable energy (ME) was calculated following standard protocols (Pauzenga, 1985; AOAC, 2008). Feed and water were offered at free choice.

Table 1. Biochemical composition of experimental diets

Nutrients (%)*	Starter feed (1 to 49 d)	Grower feed (50 to 91 d)
Crude protein	20.0	18.0
Crude fat	2.50	2.50
Crude fibre	5.00	6.00
Lysine	1.33	1.05
Methionine	0.47	0.44
Moisture	12.0	12.0
Calcium	1.05	0.95
Phosphorus	0.60	0.45
Determined analysis		
Dry matter	91.46	91.25
Moisture	8.54	8.75
Crude protein	22.98	19.32
Ash	5.90	4.78
NFE	55.06	58.65
ME (Kcal/kg)**	3009.98	3001.38

* As shown in feed label, ** calculated value, NFE nitrogen free extract, ME metabolisable energy

On the day 91, live weight of an individual chicken was measured using an electronic weighing scale. Thereafter, fifteen chickens from each treatment were selected, and 3 ml of blood was drawn from the brachial vein of each of the selected chicken using syringes and needles and transferred into a non-EDTA treated collection tubes. Thereafter, they were taken to the laboratory in ice block container within 3 hours of collection for analysis. Serum glucose, cholesterol, triglyceride, albumin, total protein and uric acid were measured using Anision-3000 auto-analyser system. Serum globulin was calculated by subtracting serum albumin from serum total protein.

Data were analysed using a one-way analysis of variance (SAS, 2010). Duncan's test for multiple comparisons was used to test the significant difference between treatment means ($p < 0.05$). A quadratic model was used to determine dietary probiotic-yeast levels for optimum parameters which were significantly different. The responses in optimum serum biochemical parameters to baker's yeast inclusion were modeled using quadratic equation (SAS, 2010) as described by Maoba *et al.* (2021b):

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

Where, Y is the serum biochemical variables; a is the intercept on Y-axis; b_1 and b_2 are coefficients of the quadratic equation; x is the yeast inclusion level and $-b_1/2b_2$ is the x value for optimum serum biochemical response. The quadratic model was fitted to the experimental data using the non-linear model (NLIN) procedure of SAS (2010). The quadratic model was used because it gave the best fit.

Results

The results showed the effect of yeast supplementation on live weight, serum total proteins, albumin, glucose, cholesterol, triglyceride and uric acid of experimental birds are shown in Table 2. Boschveld chickens on diets T1 - T5 had higher ($p < 0.05$) live weight than chickens on diet T0. Boschveld chickens on diets T1 –T5 had similar ($p > 0.05$) serum albumin, glucose and uric acid to chickens on diet T0. In converse, birds on diets T2, T3 and T4 recorded higher ($p < 0.05$) serum total proteins compared to chickens on diets T0, T1 and T5. On the other hand, Boschveld chickens offered diets T2, T3 and T4 had higher ($p < 0.05$) serum globulin values than those fed diets T0, T1 and T5. However, chickens offered diets T0, T1 and T5 had similar ($p > 0.05$) serum globulin values. Birds offered diets T2 and T3 had significantly lower ($p < 0.05$) serum cholesterol and triglycerides compared to chickens on the other four diets.

Table 2. Body weight and serum chemistry of Boschveld chickens on yeast intervention

Parameters	**Treatments (g/kg)**						**SEM**
	T0 (0)	T1(2.5)	T2 (5.0)	T3 (7.5)	T4(10.0)	T5 (12.5)	
Live weight (g)	1313.8^d	1388.6^c	1587.8^b	1634.6^{ab}	1685.6^a	1380.4^c	63.64
Total protein (g/dl)	3.96^b	4.20^b	5.32^a	5.30^a	5.46^a	4.26^b	0.277
Albumin (g/dl)	1.44	1.42	1.54	1.62	1.64	1.44	0.040
Globulin (g/dl)	2.52^b	2.98^b	3.78^a	4.68^a	3.82^a	2.82^b	0.026
Glucose (mmol/L)	12.89	14.12	14.42	13.84	14.26	14.53	0.245
Cholesterol (mmol/L)	4.74^a	4.56^a	3.11^b	3.34^b	3.59^b	4.47^a	0.287
Triglyceride (mmol/L)	0.60^a	0.53^{ab}	0.27^c	0.29^c	0.42^b	0.49^{ab}	0.053
Uric acid (mmol/L)	0.45	0.49	0.42	0.47	0.45	0.48	0.011

a, b, c: Means in the same row not sharing a common superscript are significant at p<0.05. SEM = standard error of the mean, dl = decilitre, mmol = millimoles.

Data on the impact of yeast on blood chemistry variables of experimental birds are shown in Table 3 and Figures 1 to 4. The serum total protein content of Boschveld chickens was optimised at 7.3 g yeast/kg feed with a coefficient of determination (r^2) value of 79% (Table 3 and Figure 1). Serum globulin was optimised at probiotic-yeast inclusion level of 3.7 g/kg feed with r^2 value of 82% (Table 3 and Figure 2). Serum cholesterol was optimised at 6.9 g yeast/kg feed with r^2 value of 77% (Table 3 and Figure 3). Similarly, serum triglyceride of Boschveld chickens was optimised at at 7.0 g yeast/kg feed (Table 3 and Figure 4).

Table 3. Effect of yeast for optimal blood chemistry variables of Boschveld chickens

Parameters	Equation	X	Y	r^2	P-value
Serum total protein (g/dl)	$Y = 3.75 + 0.4403x - 0.0303x^2$	7.3	5.3	0.79	0.001
Serum globulin (g/dl)	$Y = 0.618 + 1.831x - 0.2489x^2$	3.7	4.0	0.82	0.023
Cholesterol (mmol/L)	$Y= 4.9643 - 0.4791x + 0.0349x^2$	6.9	3.3	0.77	0.001
Triglyceride (mmol/L)	$Y = 0.6214 - 0.0877x + 0.0063x^2$	7.0	0.3	0.91	0.001

X = yeast inclusion level for optimal Y value; r^2 = Coefficient of determination

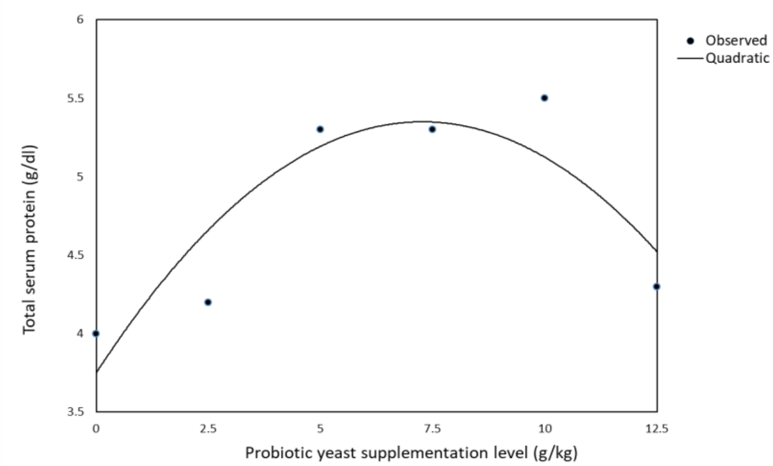

Figure 1. Serum total protein of indigenous Boschveld chickens on yeast enriched diets

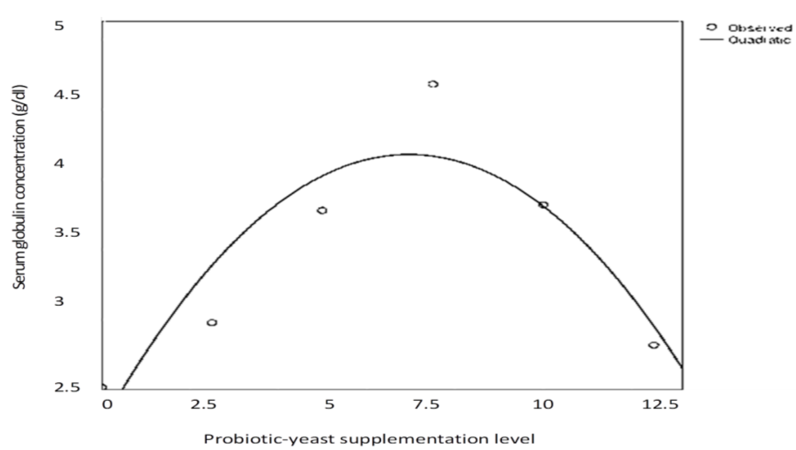

Figure 2. Serum globulin values of Boschveld chickens fed yeast

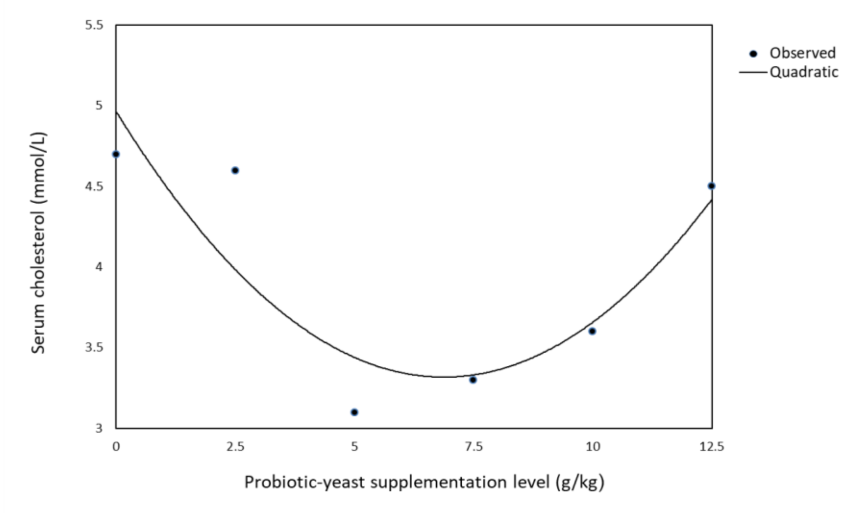

Figure 3. Serum cholesterol of Boschveld chickensfed yeast

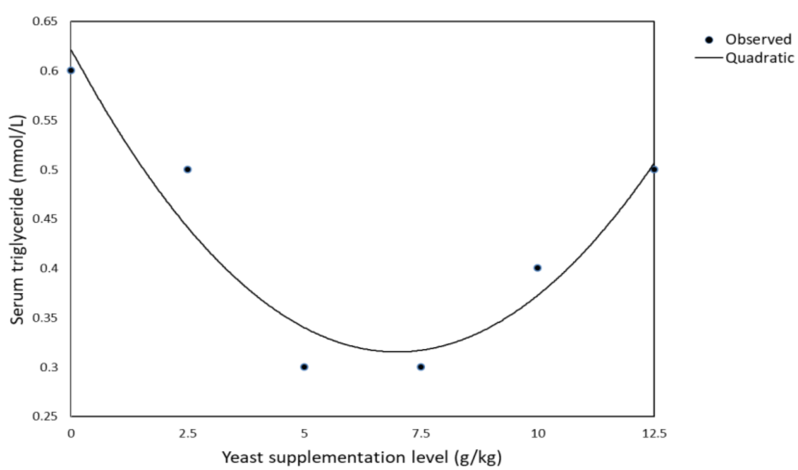

Figure 4. Serum triglycerides of Boschveld chickens administered yeast

Discussion

The higher live body weights found in chickens fed probiotic-yeast agrees with Ahmed *et al.* (2015), who reported higher body weight gain in broiler chickens fed yeast supplemented diets. The significantly high live body weight of chickens offered diets T2 – T4 when compared to birds fed control diet could be related to yeast ability to enhance gut immune responses and increased digestive enzyme secretion and activity which may consequently lead to higher protein digestion and uptake from the gut as corroborated by Rinttila and Apajalahti (2013), leading to improve in growth performance.

The concentrations of serum total protein, globulin, cholesterol and triglyceride of unsexed Boschveld chickens were influenced by the inclusion of yeast in the diets. Although, yeast had no effect on serum uric acid, albumin, glucose and total protein levels of 3.96 - 5.46 g/dl obtained in this investigation was within the normative value of 4.0 - 6.0 g/dl reported for chickens (Simaraks *et al*., 2004). The similarity in serum glucose values among the chickens fed baker's yeast in the study indicated that inclusion of up to 12.5 g yeast/kg feed in the diet of indigenous Boschveld chickens had no negative on the production of blood glucose . The highest level of serum total protein was observed in chickens offered 10.0 g yeast kg^{-1} DM feed and the lowest value was observed in the group offered control diet. The better the quality of protein contained in the diet, the higher the value of serum total protein (Hawkey *et al*., 2000; Akinfola *et al*., 2007). The significantly higher serum total protein and globulin levels in Boschveld chickens fed yeast-based diet at the levels of 5.0 - 10.0 g/kg is in agreement with El-Naga (2012) and Paryad and Mahmoudi (2008), who found signifcantly higher serum total protein in chickens fed 5 and 15 g yeast/kg feed, respectively. In contrast to this finding, Ahmed *et al.* (2015) found that broiler chickens fed yeast had similar serum globulin levels. This disparity could be attributed to genetics and the quantity of yeast added to the feed. A similar result has been reported in broiler chickens (Shankar *et al*., 2018). Serum globulin is essential in fighting disease and it is also used as an indicator of immune response in animals (Abdel - Fattah *et al*., 2008). Derivatives of yeast cell walls have been found to activate the immune system, and boost globulin protein levels (Abaza *et al*., 2008) and improve leukocyte count in chickens (Abdollahi *et al*., 2002). The significantly higher serum globulin values in groups of chickens fed diets T2, T3 and T4 could be due to increased immune response as probiotics have been reported to increase antibody production in chickens (Kabir *et al*., 2004; Abaza *et al*., 2008). In addition, the likely effect of enhanced vaccination on serum globulin values cannot be ruled out in the current investigation.

The serum concentration of cholesterol level (3.11 - 4.74 mmol/L) observed in the present investigation was slightly below the range of 7.2 – 13.3 mmol/L reported for native chickens (Simaraks *et al*., 2004). The variation may partially be attributed to breed and genotype variations. The serum concentration of triglyceride level ranged from 0.27 to 0.60 mmol/L with the highest level observed in the control group and lowest in group fed diet T2. The significantly low serum cholesterol and triglyceride value recorded in chickens fed diets T2, T3 and T4 indicate the ability of yeast at these supplementation levels to reduce blood cholesterol and triglyceride value of Boschveld chickens. This corroborates the findings of Maoba *et al.* (2021a), who noticed lower abdominal fat in birds fed yeast-based diets. The observed significantly lower serum lipid in chickens on diets T2, T3 and T4 is in agreement with Ahmed *et al.* (2015), who found reduced serum cholesterol in birds offered yeast diets. There are negative correlations between serum protein and serum lipid levels in the present study. The potential of yeast to increase serum proteins and decrease serum lipid levels in chickens has been pointed out (Shahir *et al*., 2014; Premavalli *et al*., 2018) and this effect has been attributed to the ability of yeast to inhibit hydroxymethylglutaryl coenzyme A, an enzyme involved in the cholesterol synthesis pathway thereby decrease cholesterol synthesis (Fukushima and Nakano, 1995). Uric acid is the main end product of protein metabolism in poultry. Ogunwole *et al.* (2017) associated elevated blood urea with poor dietary protein quality. The uric acid levels (0.42 – 0.49 mmol/L) recorded in this investigation were within the value of 0.3 – 0.7 mmol/L found in native birds (Simaraks *et al*., 2004). The similarity in serum urea levels in the current study is an indication of a better quality of protein in the control and yeast diets. The comparable uric acid value among the birds offered yeast supplemented diets ruled out the possibility of muscular wastage due to protein inadequacy (Adewale *et al*., 2018).

The results of the present study showed that yeast supplementation had a quadratic effect on serum total protein, globulin, triglyceride and cholesterol. The serum concentrations of total protein, globulin, triglyceride and cholesterol of unsexed indigenous Boschveld chickens were optimised at 7.3, 3.7, 7.0 and 6.9 g yeast/kg feed. The coefficient of determination value of 77% to 91% observed in this study suggest that there is a high strength of relationships between yeast supplementation levels and serum total protein, globulin, triglyceride and cholesterol in unsexed indigenous Boschveld chickens using quadratic optimization function. The serum total protein, globulin, triglyceride and cholesterol were observed to be optimized at different supplementation levels and the reason for the difference is not known. However, it may be that these serum parameters require different dietary components and yeast levels for their production. Thus, this is in agreement with Mbajiorgu *et al*. (2011), who stated that optimum supplementation response value of feed supplements inclusion levels for optimizing different parameters in animals, is dynamic.

In summary, our results indicated that up to 12.5 g/kg feed of yeast supported the production of serum biochemical variables in Boschveld chickens. The findings of this study also indicated that yeast dose levels of 7.3, 3.7, 6.9 and 7.0 g/kg feed optimised serum total protein, globulin, cholesterol and triglycerides. Our quadratic results showed that optimum supplementation response value of yeast for optimising serum biochemical variables in indigenous birds is dynamic. Therefore yeast supplementation level above 7.3 g/ kg feed may not be recommended for the best serum biochemical variables in Boschveld chickens.

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