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Research Article

Performance of Broiler Chickens Fed Different Cereal Based Diets Supplemented with *Saccharomyces cerevisiae*

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ABSTRACT

Introduction: Inefficient poultry production has been a serious challenge due to poor performance and scarcity of feed resources, which necessitate the exploration of alternatives. This study was conducted to assess the effect of *Saccharomyces cerevisiae* (SC) as a supplemental protein and growth promoter in different cereal-based diets on growth performance, serum biochemistry, characteristics of digesta, and nutrient digestibility of broiler chickens.
Materials and methods: A total of 324 day-old broiler chickens, comprising of mix sexes with an average weight of 45.36 ± 0.73, were randomly assigned to nine treatments, each consisting of three replicates with 12 birds per replicate. Three diets were formulated, each incorporating maize, sorghum, and wheat. The diets varied in the SC inclusion at levels of 0%, 5%, and 0.2% oxytetracycline (used as a growth promoter). The inclusion of oxytetracycline was to simulate the practice of in-feed antibiotics growth promoter, whereas yeast served as supplemental protein and growth promoter. Titanium dioxide was included in the feed at 0.2% on day 21 of the experiment to help estimate nutrient digestibility.
Results: Weight gain and feed conversion ratio were significantly lower in the groups fed sorghum with and without yeast. The groups fed maize with SC and oxytetracycline had the lowest blood glucose. Maize and sorghum without SC had the highest pH values. Protein digestibility was the lowest in the group fed sorghum with SC and wheat without SC.
Conclusion: Individual cereal diets performed competitively, supplementation of SC in different cereal-based diets did not influence their contribution and performance of the chickens. The inclusion of 5% SC reduced protein digestibility. Oxytetracycline yeast as a supplemental protein and growth promoter did not improve the performance of the chicks.

1. Introduction

Efficient poultry production has been challenging due to poor flock performance and escalating prices of conventional feedstuff[1]. The legislated withdrawal of antibiotics growth promoters, backed by growing consumer awareness, has not been without its attendant problems such as low animal performance, increased feed conversion, and rise in the incidence of certain sub-clinical gastroenteritis[2]. Farmers and researchers are all concerned, searching for ways of improving productive performance and attaining efficient production, especially through feed supplementation. Otherl researchers (Castagliuolo *et al.*[3], Grashorn[4], and Huyghebaert *et al.*[5]), have identified some alternative measures that have been tried as feed additives with the intent of improving poultry performance. However, expanded research has to be conducted to discover more efficient substitutes and their optimum use in enhancing poultry production.

Saccharomyces cerevisiae strains have been found to influence the intestinal environment by neutralizing bacterial toxins[6], and adherence of flagellate bacteria by the mannose receptors; these pathogens are eliminated through faeces[7]; reinforcement of mucosal integrity and

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intestinal cells[8]. Live yeasts have a documented efficacy on villi height and crypt depth, which enhances the assimilation of nutrients[9], and modulation of the immune system by stimulating IgA response to pathogens[10]. These enhance feed efficiency, growth, and livability of poultry species[11]. Yeast also has high proteins (40-45%) and low fats, a good source of vitamins particularly B-complex though low in sulfur amino acids. It has been successfully used in place of plant proteins in animal diets[12-13]. Mannan oligosaccharides (MOS) derived from yeast cell walls are polysaccharide-protein complexes that are indigestible to non-ruminant animals and provide favorable conditions for beneficial intestinal *Lactobacillus* spp.[14]. The main component of MOS is mannose, which is a sugar that many enteric bacteria with Type 1 fimbriae receptors can bind to mannose[15]. This binding leads to the elimination of undesirable bacteria through the gut without colonization; since bacteria must attach to the gut wall to colonize.

Nucleic acid content of yeast is one of the major concerns with its utilization in animal feed. Excessive intake of nucleic acid leads to uric acid precipitation, causing health disorders such as gout or kidney stone formation. Such problems were observed with nucleic acid concentration between (6-10%) which elevates serum uric acid levels[16]. Though yeast has been used as a protein supplement in other animal species, there is a lack of information on its efficacy and or otherwise in poultry production. Hence this study sought to evaluate the effect of *Saccharomyces cerevisiae* in different diet compositions (maize, wheat, and sorghum-based) on the productive performance and health of broiler chickens.

2. Materials and Methods

2.1. Ethical approval

The study was approved and conducted in line with the instructions of the Animal Care and Use Research Committee of the University of Ibadan, Nigeria. All animals were humanely handled during the experiment.

2.2. Experimental birds, housing, feeding and procedure

A total of 324 day-old, mixed-sex Arbor Acre broiler chickens weighing 45.36$\pm$0.73 were purchased from a reputable hatchery in Ibadan. The chicks were weighed, tagged, and randomly allotted to 9 treatments of 3 replicates with 12 birds per replicate in a completely randomized design. The birds were housed in open-sided pen units of 6 x 4 Ft on deep liter using wood shavings for 28 days. Feed and water were offered *ad libitum* throughout the period of the experiment, the chicks were vaccinated against Newcastle and infectious bursar disease.

2.3. Diets and feeding

Experimental diets were formulated according to NRC[17] to meet the nutrient requirement of broiler chickens using three different cereal grains (maize, sorghum, and wheat). The cereals were included to furnish 1500kcal/kg energy in each diet and the rest of the energy and nutrients were supplied by the other ingredients. Baker's yeast (STK Royal instant dry yeast, Foodlocker, Nigeria; 44.4%, cp, 3.23% Lysine, 0.7% Methionine, and 0.49%)[17] was included at 50g/kg of feed on dry matter basis as a protein supplement and growth promoter in each grain diet. A positive control diet containing oxytetracycline as a growth promoter for each diet was also prepared, nine experimental diets in all were formulated from the three selected grains. Diet 1 included maize based diet, Diet 2 was formed with maize based diet + 0.2% oxytetracycline (manufacturer's recommendation), Diet 3 entailed maize based diet + 5% *Saccharomyces cerevisiae;* Diet 4 had sorghum-based diet, Diet 5 was composed of sorghum based diet + 0.2% oxytetracycline, Diet 6 included sorghum based diet + 5% *Saccharomyces cerevisiae,* Diet 7 entailed wheat based diet, Diet 8 was made of wheat based diet + 0.2% oxytetracycline, and Diet 9 was formulated with wheat based diet + 5% *Saccharomyces cerevisiae.* The gross composition of the broiler starter diets is presented in Table 1.

2.4. Sample collection

Birds were housed in open-sided poultry pens with a stocking density of 5 birds per square meter on a deep liter floor with 4 cm thick wood shavings. Feed and water were offered *ad libitum,* birds were weighed weekly in the morning. Feed intake, weight gain, and feed conversion ratio were calculated at the end of the experiment.

$$Feed\ intake = Feed\ given - feed\ left\ (g)$$

$$Average\ weight\ gain = \frac{Weekly\ weight\ gain\ (g)}{7}$$

$$Feed\ conversion\ ratio = \frac{Feed\ intake\ (g)}{Weight\ gain\ (g)}$$

Two ml of blood were collected weekly in the morning from the jugular vein using needle and syringe into plain tubes. The coagulated samples were centrifuged immediately at 3,000 rpm for 10 min to harvest serum for the analysis of glucose, Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), and uric acid accumulation using standard kits (Randox, England) according to manufacturer's instruction.

Titanium dioxide was included at the rate of 2g/kg[18] as an indigestible marker on day 21 to help in the estimation of nutrient digestibility, and at 28 days old, two birds were selected at random from each replicate per treatment and euthanized by cervical dislocation. The small intestine was sectioned into duodenum, jejunum, and ileum, and intestinal content was collected from these sections into plastic cups with lids. Digesta collected from the two birds in each replicate were pooled, transported in an ice box and frozen pending evaluation of digesta viscosity, water holding capacity, and nutrient digestibility. All samples were collected in the morning.

2.5. Digesta pH, viscosity, and water retention

The intestinal pH from the duodenum, jejunum, and ileum was measured immediately using a portable digital pH meter (HI98103, Hanna instrument, Canada) at room temperature. Approximately 1 g of digesta was homogenized with 2 ml of distilled water in centrifuge tubes and centrifuged at 3,000 rpm for 10 min. The supernatant was withdrawn and viscosity (mPas) was determined at 28°C using a viscometer (model NDJ-8S, DRAWELL, Chongqing China) at a shear rate of 60 rpm. The sediments in the tubes after extraction of the supernatant were weighed with the tubes and then oven-dried and the dry weight was subtracted from the initial weight[19].

Water retention = [weight of residue + tube – weight of dry residue + tube] x 100

2.6. Determination of titanium dioxide and nutrient digestibility

Standard titanium dioxide solution was prepared by dissolving 0.25 g into 100 ml concentrated tetraoxosulphate (VI) acid, which was gently heated to dissolve. The content was transferred with about 200 ml of distilled water through filter paper into a 500 ml volumetric flask containing another 100 ml of the concentrated acid and the content made up to the mark.

0.2g of the ileal samples and diets were ashed in crucibles for 6 h at 505°C. 10 ml of 7.4M H_2SO_4 was added to the crucibles upon cooling and heated for 20 min to dissolve. The content was transferred with 15 ml distilled water into 50 ml beakers, the beaker content was then emptied through filter paper into 50 ml volumetric flask containing 10 m hydrogen peroxide (30% vol), and the content made up to mark with distilled water.

0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, and 5 ml of standard titanium dioxide solution were pipetted into individual 50 ml volumetric flask. 7.4M H_2SO_4 was added to the flasks to make a combined volume of 5ml i.e., 5, 4.5, 4, 3.5, 3, 2.5, 2, 1.5, 1, 0.5 and 10 ml of H_2O_2 were added to each flask and the content diluted to 50 ml with distilled water. Absorbance was read on a spectrophotometer at a wavelength of 410 nm. Nutrient digestibility was calculated using the formula below[20].

$$AID = [1 - (\frac{Marker\ in\ fedd}{Marker\ in\ digesta}) \times (\frac{Nutrient\ in\ digesta}{Nutrient\ in\ feed})] \times 100$$

AID means apparent ileal digestibility.

2.7. Statistical analysis

Data obtained from the study were analyzed using two-way ANOVA procedure in a general linear model of SAS. Means were separated with Duncan’s multiple range test at $p \leq 0.05$. The following statistical model was used: $y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$

Where, yijk signifies the amount of each observation for each trait, μ refers to mean, Ai is supplement effect, Bj determines feed effect, ABij stands for Supplement and feed interaction effect, and eijk is experimental error effect.

Table 1. Gross composition of experimental broiler starter diet (g/100gDM)

Ingredients	Control Diets			+ *Saccharomyces cerevisiae*			+ *Oxytetracycline*		
	Maize	Wheat	Sorghum	Maize	Wheat	Sorghum	Maize	Wheat	Sorghum
Maize starch	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Maize	43.7	-	-	43.7	-	-	43.7	-	-
Sorghum grain	-	-	46.1	-	-	46.1	-	-	46.1
Wheat grain	-	48.6	-	-	48.6	-	-	48.6	-
Soya oil	2.0	2.7	2.0	2.0	3.0	2.0	2.0	3.0	2.0
Soybean meal	39.7	34.1	37.3	34.7	28.8	32.3	34.7	28.8	32.3
Fish meal (72%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Baker’s yeast	-	-	-	5.0	5.0	5.0	5.0	5.0	5.0
DCP	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Vitamin Premix	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Salt	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
TOTAL	100	100	100	100	100	100	100	100	100
Calculated Nutrients									
Energy	3065.23	2988.52	3008.38	3039.232	2980.464	2982.384	3039.232	2980.464	2982.384
Crude protein	22.82	23.03	22.95	22.92	22.99	23.04	22.92	22.99	23.04
Calcium	1.08	1.09	1.09	1.08	1.09	1.09	1.08	1.09	1.09
Phosphorus	0.50	0.53	0.47	0.64	0.67	0.61	0.64	0.67	0.61
Methionine	0.57	0.51	0.51	0.59	0.53	0.53	0.59	0.53	0.53
Lysine	1.3	1.2	1.2	1.3	1.2	1.2	1.3	1.2	1.2
Crude Fibre	3.4	3.7	3.4	3.5	3.4	3.1	3.5	3.4	3.1

DCP: Dicalcium phosphate

3. Results and Discussion

No significant variations were observed in feed intake (FI) throughout the study. This differed from the report of Adejumo *et al.*[21] and Ahiwe *et al.*[22] Who reported an increase in feed intake with yeast inclusion. Weight gain was observed to differ significantly across the treatments, sorghum without SC had the lowest value (p = 0.045). This corresponds to the report of Adebiyi *et al.*[12] who did not observe increased weight gain with yeast supplementation. However, Shamala *et al.*[23] and Ahiwe *et al.*[22] reported that yeast caused an increase in weight gain in broiler chickens. The feed conversion ratio was lowest (p=0.038) in the group fed sorghum with oxytetracycline. This again showed that yeast inclusion did not influence FCR which is in line with Ahiwe *et al.*[22]. No significant differences were observed among treatment groups on the percentage livability (mortality rate) of the bird (Table 2). Dietary supplementation of yeast at 5% did not influence weight gain and feed conversion of broiler chickens, differences observed were based on feed sources rather than supplementation. These results agreed with Yalçinkaya *et al.*[16] and Yang *et al.*[24] who reported that *Saccharomyces cerevisiae* did not significantly improve growth performance in broilers chicken. on the other hand, Hooge *et al.*[25] and Rosen *et al.*[26] also reported that *Saccharomyces cerevisiae* supplementation increased weight gain and feed conversion of broiler chickens. It seems lower amounts of *yeast* exert more effect than higher amounts, studies of Ahiwe also revealed that the weight gain of chicks decreased with higher levels of yeast in the diet.

Serum parameters analyzed including ALT, AST, and glucose were not significantly affected by supplementation of *saccharomyces cerevisiae* but differed among the group. AST was lowest (p = 0.048) in the group fed maize without yeast (Table 3). This was similar to the findings of Line *et al.*[27] who reported no significant difference in ALT among the groups due to the inclusion of *Saccharomyces cerevisiae*. Shareef and Al-Dabbagh[28] also reported ALT and AST values to be normal for broilers in their studies. ALT and AST are enzymes that indicate the health status of the liver by their level in the blood, this result indicates that *saccharomyces cerevisiae* did not influence the liver enzyme levels. The results of serum glucose significantly reduced with yeast supplementation in maize diet (p = 0.032), and uric acid (mmol/L) evaluation showed that levels were higher in all the treatments at week one (Figure 1). However, at the third and fourth weeks, the levels significantly reduced across all the treatments which is an indication that 5% yeast inclusion in broiler chicken for up to four weeks did not lead to high uric acid accumulation.

Protein digestibility significantly (p = 0.037) reduced in sorghum with yeast. These differences were attributed to both the cereals and supplemental effect. Sorghum in other supplemental groups, performed better in protein digestibility. Dry matter digestibility was not significantly affected (p > 0.05, Table 3). Supplementation of yeast at 5% negatively influenced the protein digestibility of maize, sorghum, and wheat-based diets in broiler chicken. This was contrary to the study of Oyedeji *et al.*[29] who reported yeast to have increased protein retention in broiler chickens fed high-fiber diets. Fructo-oligosaccharide extracted from yeast cells was also reported to have increased mineral, starch, and protein utilization in broilers[30].

Digesta viscosity and water retention in the various sections of the intestine were not significantly (p > 0.05) affected by yeast supplementation (Table 4). This finding was similar to the results of Veldman and Vahl[31]; Yasar and

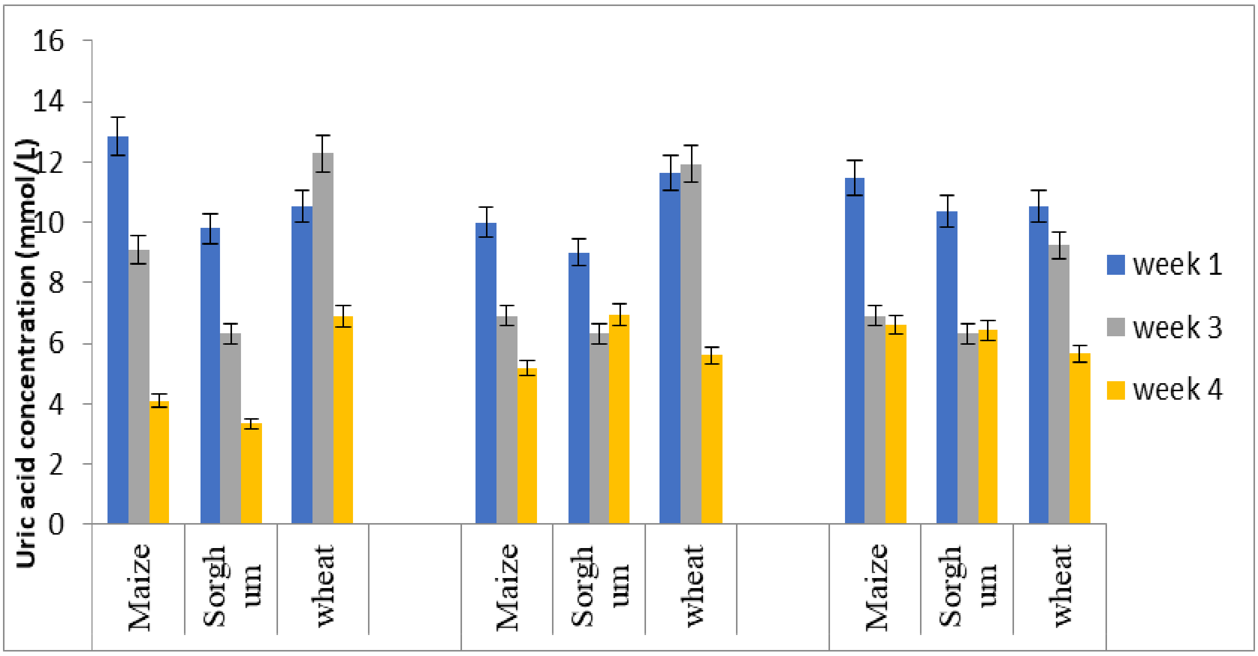

Figure 1. Uric acid concentration of broiler chickens fed different diets supplemented with yeast for four weeks

Table 2. Effects of *Saccharomyces cerevisiae* on growth performance of broiler chicks at four weeks of age

	+SC			-SC			AB Control			Two-way ANOVA			
	Maize	Sorghum	Wheat	Maize	Sorghum	Wheat	Maize	Sorghum	Wheat	p-value	Suppl	Diet	Suppl*Diet
Feed intake	1098.80	1009.00	985.30	980.23	926.76	991.18	882.55	897.42	959.98	0.110	NS	NS	NS
Weight gain	228.68^{a}	171.61^{b}	230.73^{a}	215.67^{a}	121.74^{b}	215.67^{a}	167.55^{c}	223.52^{b}	235.35^{a}	0.045	NS	*	NS
FCR	1.63^{a}	2.04^{a}	1.45^{c}	1.62^{a}	2.57^{a}	1.59^{b}	1.80^{a}	1.36^{c}	1.41^{b}	0.038	NS	*	NS
Livability (%)	100.00	93.33	97.22	100.00	91.66	96.92	100.00	96.97	97.23	0.075	NS	NS	NS

Values within a row with different superscript letters are significantly different ($p < 0.05$). NS: $p > 0.05$, *$p < 0.05$; SEM: p-value: probability, NS: Not Significant, FCR: Feed Conversion Ratio, Suppl: Supplement; Suppl*diet: Interaction between supplement and diet

Table 3. Serum biochemistry and nutrient digestibility of broiler chickens fed different diets with supplemental yeast for four weeks

Serum	+SC			-SC			AB Control			Two-way ANOVA^{2}			
	Maize	Sorghum	Wheat	Maize	Sorghum	Wheat	Maize	Sorghum	Wheat	p-value	Suppl	Diet	Suppl*Diet
ALT (IU/mol)	23.71	25.72	21.55	20.77	21.14	18.65	23.61	23.69	27.56	0.263	NS	NS	NS
AST (IU/mol)	270.75^{a}	200.42^{b}	214.54^{ab}	179.04^{b}	211.06^{ab}	203.48^{ab}	245.88^{ab}	246.59^{ab}	241.78^{ab}	0.048	*	*	NS
GLU (mg/dl)	199.50^{c}	284.67^{a}	219.83^{b}	213.83^{b}	215.17^{b}	234.33^{a}	200.00^{b}	225.00^{b}	213.17^{b}	0.051	*	*	NS
Digestibility													
Dry matter (%)	77.95	76.67	72.36	90.10	83.07	80.85	86.92	75.69	83.83	0.063	NS	NS	NS
Protein (%)	77.31^{a}	57.38^{c}	66.13^{b}	80.22^{a}	75.33^{a}	72.42^{ab}	77.89^{a}	73.57^{ab}	76.76^{a}	0.037	*	*	NS

Values within a row with different superscript letters are significantly different ($p < 0.05$). NS: $p > 0.05$; *: $p < 0.05$

AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, NS: No significant difference; +SC: Saccharomyces supplementation; -SC: without saccharomyces supplementation; AB: Antibiotics control; Suppl: Supplement; Suppl*diet: Interaction between supplement and diet; p-value: Probability

Table 4. Digesta characteristics of broiler chickens fed different diets containing yeast for four weeks

	+SC			-SC			AB Control			Two-way ANOVA^{2}			
	Maize	Sorghum	Wheat	Maize	Sorghum	Wheat	Maize	Sorghum	Wheat	p-value	Suppl	Diet	Suppl*Diet
VISCOSITY (mPas)													
Duodenum	0.22	0.08	0.09	0.16	0.29	0.08	0.14	0.11	0.04	0.272	NS	NS	NS
Jejunum	0.08	0.06	0.05	0.09	0.15	0.129	0.264	0.167	0.25	0.082	NS	NS	NS
Ileum	0.18	0.14	0.11	0.08	0.17	0.096	0.126	0.229	0.13	0.069	NS	NS	NS
pH													
Duodenum	6.09	6.05	6.17	6.21^{a}	6.29^{a}	5.67^{b}	6.18^{a}	6.08^{a}	5.69^{b}	0.032	NS	*	NS
Jejunum	5.90	5.63	5.74	5.94	5.72	5.80	6.07	5.82	5.89	0.132	NS	NS	NS
Ileum	5.97	5.85	6.30	5.99	6.08	6.19	6.84	6.09	6.13	0.150	NS	NS	NS
Caeca	7.48	7.10	6.53	7.17	7.07	6.88	7.59	7.17	7.07	0.253	NS	*	NS
WRC													
Duodenum	0.64	1.13	0.99	0.66	2.53	1.05	1.01	0.86	1.63	0.421	NS	NS	NS
Jejunum	2.25	2.07	1.59	2.09	2.43	2.25	2.67	4.24	2.45	0.098	NS	NS	NS
Ileum	2.06	2.56	1.81	2.12	1.52	2.51	1.87	1.45	2.07	0.324	NS	NS	NS

Values within a row with different superscript letters are significantly different ($p < 0.05$). NS: $p > 0.05$; *: $p < 0.05$

WRC: water retention capacity, +SC: With Saccharomyces cerevisiae, -SC: Without Saccharomyces cerevisiae, AB: Antibiotics, Suppl: Supplement, Suppl*diet: Interaction between supplement and diet, NS: No significant difference; p-value: Probability

Forbes[32] observed that differences in the viscosity of wheat grains were not reflected in broiler digesta viscosity. The intestinal pH from the various segments was not also significant ($p > 0.05$) except for duodenum in wheat without yeast and wheat with oxytetracycline ($p = 0.032$). Differences observed in duodenal, pH values were suggested to be a result of the diet source and not supplementation. Digesta viscosity is important to study because it can influence digesta transit as well as nutrient digestibility and absorption. Yeast supplementation and diet sources did not affect digesta viscosity in this study. pH influences intestinal environment leading to influenced digestibility and intestinal health[33]. The low intestinal pH seems to have contributed to the feed utilization and weight gain of the chicks in the corresponding groups.

4. Conclusion

Diet sources of this study had a significant effect on growth performance and digesta pH. Yeast supplementation did not influence diet sources as well as as growth performance of chicks. Yeast supplementation depressed protein digestibility and serum glucose. Yeast supplementation at 5% of broiler diet did not result in high uric acid accumulation in broiler chickens and no synergy was observed between supplementation and different diet sources. We recommend that the study be validated using different and lower levels of yeast, since most of the studies that reported positive impact used lower levels than 5%.

Declarations

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Adeleye O.O conceptualized the study, Kuka T.T. and Adetona performed the experiment under the supervision of Adeleye. All the authors contributed in analysis and writing. They have all read and approved the article before the submission.

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Availability of data and materials

The manuscript contains all datasets generated and/or analyzed in the current study.

Ethical considerations

The study was written originally and authors do not present any copy, false, or even fabricant data for presenting the methods or results of this study.

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