DRIED YEAST (*Saccharomyces cerevisiae*) IMPROVED PRODUCTIVE PERFORMANCE AND TESTICULAR WEIGHT OF COCKERELS.

*Olobatoke, R.Y.,[1]Akanni, S.,[1] and Olaniyan, O.[1]
[1]College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, P.M.B. 205, Kabba, Nigeria
*Corresponding author: yemisirose205@yahoo.com

ABSTRACT

This experiment was conducted to evaluate the effects of supplementing drinking water with dried yeast on growth, organ and testes weights and haematological parameters of cockerels. A total of 100 day- old cockerel chicks were randomly allotted to 4 treatments, each treatment consisting of 5 replicates with 5 birds per replicate in a completely randomized experimental design. The treatments consisted of dried yeast added to drinking water at 0g/mL, 0.5g/mL, 1g/mL and 1.5g/mL, respectively. The experiment lasted for 8 weeks including a one-week acclimatization period. At the end of the 8th week, blood samples were taken in heparinized bottles from 10 birds from each treatment after which the birds were sacrificed for organ assessment. Traits measured were feed consumption, body weight, feed conversion ratio (FCR), testicular weights, organ weights and hematological indices. Adding dried yeast in drinking water of cockerels resulted in increased feed intake as the level of yeast increased. The greatest body and testicular weights and feed conversion efficiency were obtained at the inclusion level of 0.5g yeast/mL. Treatments had no detectable effect on heart, spleen and hematological indices. Dried yeast can be supplemented in drinking water of cockerels for the purpose of improving growth and reproductive performance

Keywords: Body weight, feed conversion ratio, haematological indices, internal organs, testes size

INTRODUCTION

Cocks are an important component of a poultry breeder enterprise, where their major role is egg fertilization rather than meat production. On a breeding farm, proper management of males positively influences fertility. Stress, which may cause either weight loss or reduced water intake, can lead to a complete shutdown of testes function particularly when it is experienced during early stages (1 - 3 weeks) of development (Moyle *et al*., 2012). This is because testicular weights are closely associated with body size and there is a direct relationship between testicular size and sperm production (Sarabia *et al.*, 2013; Allaoui *et al*., 2014). Cockerels are male chickens of pre-pubertal age. The testes are quite small prior to maturity, but accelerate in growth from 15 to 20 weeks of age reaching up to 0.5 - 2 g (Powley, 2008). Faster growing males are therefore likely to have relatively larger testes; hence the importance of ensuring proper growth and development of the males. Use of synthetic antibiotics as growth promoters in poultry has been very helpful in alleviating some disease challenges and ensuring good performance (Wati *et al*., 2015). Recent public health concerns over development of antibiotic-resistant bacteria, which has been linked with accumulation of antibiotic residues in poultry products, has led to a ban on the use of antibiotic growth promoters in many countries (Dhama *et al*., 2014). Subsequently, various researchers have focused on natural herbs as alternatives to antibiotics. Yasar and Akinci (2014) reported that selected probiotics increased growth rate of quails, with *Saccharomyces cereviae* giving a better result than other organic products. Supplementation with yeast cell wall has suppressed inflammatory response, promoted immunoglobin generation and increased the production of short chain fatty acids in broilers with subclinical necrotic enteritis (Xue *et al*., 2017). This suggests that yeast cell wall has health beneficial effects. This was evidenced by the work of Zhen *et al*. (2019) who reported that yeast culture positively influenced fecal bacterial density and diversity in broiler chickens. Hatab *et al*. (2016) similarly noted that biological supplementation with probiotics had a significant positive effect on final body weight, feed conversion ratio and antibody titre against Newcastle disease in broiler chickens. In another study carried out on Japanese quails, Sharif *et al.* (2018) also observed that the inclusion of distiller's yeast sludge, up to 3% to the diet of the birds, improved bird performance and economic efficacy. However, Olnood *et al*. (2015) reported that the addition of probiotic Lactobacillus did not improve weight gain, feed intake and feed conversion rate of broiler chickens raised in cages for 6 weeks. Dried yeast (*Saccharomyces cereviae*), which is rich in crude protein and vitamin B, has also been recognized as a natural growth promoter and has thus been explored for its beneficial effects (Shankar *et al*., 2017). There are several additional reports of positive effects of dried yeast on productive performance, thyroid hormone metabolism, serum enzyme activities and behavioural performance of broilers (El-Iraqi and Fayed, 2012; Aluwong *et al*., 2013; Mohammed *et al*., 2015). Bortoluzzi *et al*. (2018) reported that supplementing broiler diets with autolyzed yeast improved the performance of the birds vaccinated against coccidiosis. This, they said, is partially explained by the modulation of intestinal microbiota and the immune system by the yeast. This report was corroborated by the work of Bushwereb *et al*. (2019) who noted that baker's yeast ameliorated the negative effects of aflatoxin-contaminated diet fed to broiler birds. Bolacali and Irak (2017) assessed the effect of dietary yeast autolysate on performance, carcass characteristics and blood parameters of Japanese quails, and concluded that addition of 2% yeast autolysate to the diets could enhance their performance through 42 days of age. Özsoy *et al*. (2018) similarly observed significant increase in egg production and egg weight as well as improved feed efficiency when layer diets were supplemented with cultured yeast. However, there is a paucity of information on effects of dried yeast on the productive performance and reproductive organs of cockerels Therefore, the effects of dried yeast provided as a water additive on growth performance, internal organs, testicular weights, and haematological indices of cockerels were investigated in this study.

MATERIALS AND METHODS

The experiment was conducted at the Poultry unit of Kabba College of Agriculture, which is located in the Southern Guinea Savannah ecological zone of Nigeria, between latitude 07^{o}5^{o}N and longitude 6^{o}4^{o}E of the equator (DMS Coordinates) with elevation of 424m above the sea level. The mean annual rainfall is about 1570mm per annum with annual temperature range of 18-32^{o}C.

The housing and management of experimental birds were in accordance with the guidelines of Ahmadu Bello University on animal research. One day-old Bovans goldline cockerel chicks (N = 100) were used for the experiment. The chicks, which were housed in deep litter pens at stocking density of15 birds/m^2, were provided with adequate lighting as well as feed and water ad *libitum*. The brooding temperature was initially at 35 - 36°C and gradually decreased to 25°C at 21 days of age. The birds were randomly allotted to four treatments in a completely randomized design experiment. Each treatment was replicated five times, with five birds in a pen as one replicate. Each pen was therefore considered as an experimental unit. The treatments included the addition of dried yeast to the drinking water of birds as follows: 0g/ml (Control); 0.5g/ml; 1g/ml and 1.5g/ml. Using 4-litre capacity fountain drinker, the total quantity of dried yeast to be administered per unit/day was first mixed with a small quantity (200 – 400 ml) of water and served to the birds. Normal water was provided to the birds after the treated water was completely consumed. The birds were fed commercial chick mash (Hybrid®,Hybrid feeds Ltd, Kaduna, Nigeria) throughout the period of the experiment, which lasted for 8 weeks including a one week acclimatization period. Routine vaccinations were administered. Initial body weights of the chicks were recorded on day 8. Thereafter, body weight was recorded weekly and feed intake was recorded daily. Daily feed intake was aggregated weekly for the data analysis. Feed conversion ratio was calculated as ratio of feed intake to body weight gain. Performance index (PI) of the birds was obtained using the formula of North (1984) as follows:

$$\text{PI} = \frac{\text{Live body weight (kg) x 100}}{\text{FCR}}$$

Where PI = performance index; FCR = feed conversion ratio

At week 8, blood samples were collected from 2 randomly selected birds per replicate (10 birds/per treatment) in each treatment group, via the brachial vein, into heparinized bottles and immediately transported to the laboratory for hematological analysis. The birds were then slaughtered and the liver, heart, spleen, gizzard and testes of each slaughtered bird were harvested, weighed using a 350-g capacity electronic scale (Citizen Scale, Model-CY 320, Germany). Percentage packed cell volume (PCV) was determined using the microhaematocrit centrifugation technique (Dacie and Lewis, 1991). This was achieved by filling heparinised capillary tube with blood up to three quarter of its length, with the other end of the tube heat-sealed. The tubes were then centrifuged in Hawksley® microhaematocrit centrifuge at 13,000 rpm for 5 min. The tubes were removed from the centrifuge and the PCV value was read using haematocrit reader. Erythrocyte and leucocyte counts were obtained using haemocytometer with Neubauer grid. Blood sample dilution of 1:20 and 1:200 (diluent was distilled water) were made for white blood cell (WBC) and erythrocyte counts respectively, Cover slips were placed on top of the grid area of the Neubauer chamber, after which samples were loaded in the loading area of the chamber. Cells in the 4 large squares were counted for WBC whereas cells in the centre area marked 'R' were counted for erythrocytes using X10 microscope magnification. Cell counts were multiplied by the dilution factor. The haemoglobin concentration was measured by spectrophotometer using the Cyanmethahaemoglobin method according to Hall and Malia (1991). About 0.02 ml of well mixed blood was added to 4 ml of modified Drabkin solution. The mixture was allowed to stand for 3 min and the haemoglobin concentration was read using spectrophotometer. Performance data were collected longitudinally.

Data Analysis

Performance data were subjected to repeated measures ANOVA (mixed model), while data measured once such as blood parameters and internal organs were analysed in single factor ANOVA, using the General Linear Model procedure of SAS (2001), as respectively shown in the models below:

$$y_{ijk} = \mu + t_i + \delta_{ij} + p_k + (t * p)_{ik} + \epsilon_{ijk}$$

Where y_{ijk} = observation ijk; μ = overall mean, t_i= the effect of treatment i, p_k= effect of period k, $(t * p)_{ik}$= the effect of interaction between treatment i and period k,δ_{ij}= random error with mean 0 and variance σ_δ^2 , the variance between pens within a treatment or covariance between repeated measurements within pens, ϵ_{ijk} = random error with mean 0 and variance, σ_{ϵ}^{2} ,the variance between measurements within pens.

$$Yij = \mu + \alpha i + Eij$$

Where Yij = observed response; μ = overall mean; αi= treatment effect; Eij= random error

Treatment differences were considered significant at $P < 0.05$. Tukey's procedure was used to separate treatment mean difference of each response variable.

RESULTS AND DISCUSSION

The effects of including dried yeast in drinking water of cockerel chicks on growth performance of birds are shown in Table 1. Feed consumption of the control birds was significantly lower than those treated with dried yeast. In the treated group, feed intake increased steadily in a dose-dependent manner as the level of inclusion of the yeast increased. This is an indication that dried yeast in drinking water may have a positive effect on the digestive system of the birds, and perhaps help to trigger appetite. This is contrary to the observations of Özsoy and Yalcin (2011) who reported that yeast culture included in broiler turkey diets at levels 1, 2 and 3mg/kg, had no significant effect on performance of the birds. Wondifraw and Tamir (2014) similarly observed that there was no significant difference in feed intake between treatments, when birds were fed up to 30% of brewer's dried grain yeast mixture. Aluwong *et al*. (2013a) however reported that broilers administered 1.5 and 2.0 ml yeast probiotic had reduced feed intake compared with the control. The form of yeast used and the route of administration may be responsible for the disparity in results.

Table 1 Effect of dried yeast on performance parameters of cockerel chicks

Parameters	Treatment (Dried Yeast in g/ml)				SEM
	C	0.5	1	1.5	
Cum. Feed consumption (g)	1942^{b}	2377^{ab}	2390^{ab}	2439^{a}	75
Body weight (g)	360.0^{b}	540.5^{a}	456.5^{ab}	425.5^{b}	9.32
Feed conversion ratio	5.39	4.41	5.23	5.75	0.57
Performance index	6.68^{b}	12.26^{a}	8.73^{ab}	7.40^{b}	2.48

^{a,b}Means within same row with different superscripts are significantly different (P≤0.05). C = control; SEM = standard error of means

Dried yeast added to the drinking water of cockerels, significantly improved the body weight of the birds over the control group all through the period of the experiment. Body weight within the treated group however decreased as the concentration of dried yeast increased, with the highest body weight recorded in the group gavaged with 0.5g/mL. Improvement in body weight confirms the reports of previous researches when yeast was administered to broilers either as feed supplements or water additives (Aluwong *et al*., 2013b; Buba *et al*., 2016; Shankar *et al*., 2017), whereas highest body weight at 0.5g/mL is in agreement with the observation of Onwurah *et al*. (2013). Furthermore, feed conversion ratio (FCR) improved and the performance index (PI) was significantly increased by the inclusion of dried yeast in water, particularly at 0.5g/mL. However, with greater levels of yeast being provided FCR became poorer and the PI was reduced (Table 1). This suggests that high rate of yeast administered to cockerels may hamper effective feed utilization. This observation agrees with the report of Ozório *et al*. (2012) when dried yeast was used as substitute for fishmeal in Nile Tilapia diets. They also noted that daily growth coefficient decreased with increasing level of dried yeast. The linear depression on growth performance of birds in the current study may be attributed to the β-glucans content of dried yeast, which in avian species, may negatively affect nutrient absorption thus playing the role of antinutritional factor (Ozório *et al*., 2012). Improved feed conversion ratio of the 0.5g/ml yeast-supplemented group is an indication that they had increased feed utilization than the other groups and this may be due to efficient nutrient digestibility. Yasar and Yegen (2017) similarly observed significant growth-promoting effect of yeast fermented additives when supplemented in broiler diets at 5 and 10 g/kg. Improved performance indices observed in the current study are all in agreement with the reports of Mulatu *et al*. (2019).

Table 2 shows the effect of adding dried yeast in the drinking water of cockerel chicks on the internal organ weights of the birds. Gizzard weights of the control birds were significantly lower than those treated with dried yeast. Gizzard weight within the treated group however decreased as the concentration of dried yeast increased, following the trend observed in body weight. This may suggest a relationship between body weight and gizzard size. However, although correlation analysis showed a positive relationship between both parameters, the relationship was not significant (r = 0.85; p = 0.15), indicating that improvement in body weight may not be solely responsible for the trend observed in gizzard size. Liver weight increased linearly, though non-significantly, as the level of dried yeast in the drinking water increased. Treatment however, appear to have no effect on heart and spleen weights. Birds in the control group generally had the lowest organ weights. This accord with the reports of Mohammed *et al.* (2015) although they observed a significant decrease in relative weight of liver compared with the control.

Addition of dried yeast to the drinking water of cockerels significantly increased the testicular weight of birds particularly when added at the rate of 0.5g/ml (Fig. 1). Birds in the control group had the lowest testis index, followed by birds treated with 1 and 1.5 g/ml, respectively. Pearson correlation analysis showed a positive relationship between body weight and testicular size ($r = 0.95$, $p = 0.05$). Thus improvement in body weight which was also significant at 0.5g/ml (Table 1) could be responsible for the observed improvement in testicular weight. The close relationship between body weight and testis size has been reported in previous researches (Allaoui *et al.*, 2014). In addition, higher testis index could also mean improvement in fertility as a direct relationship between testis size and sperm production has been noted in previous researches (Sarabia *et al.*, 2013).

Table 2 Effect of dried yeast on internal organ weights of cockerel chicks

Parameters	Treatment (Dried Yeast in g/ml)				SEM
	C	0.5	1	1.5	
Gizzard (g)	11.75^{b}	28.25^{a}	26.00^{a}	25.75^{a}	2.54
Liver (g)	12.25	16.75	17.75	19.50	1.09
Heart (g)	1.00	3.50	2.75	3.25	0.41
Spleen (g)	1.00^{b}	2.25^{a}	2.25^{a}	2.25^{a}	0.23

[a,b]Means within same row with different superscripts are significantly different (P≤0.05). C = control; SEM = standard error of means

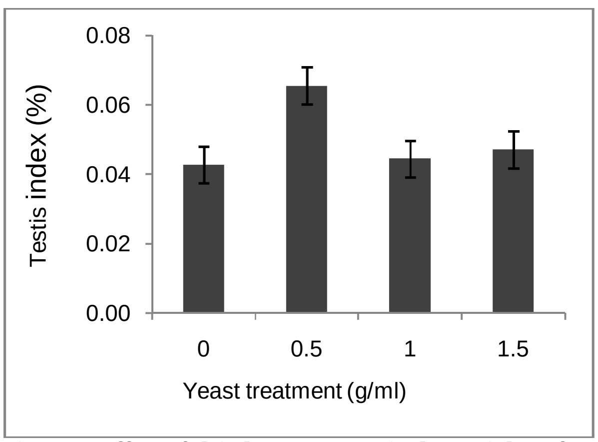

Figure 1 Effect of dried yeast on testicular weights of cockerels. Bars indicate the standard errors of means

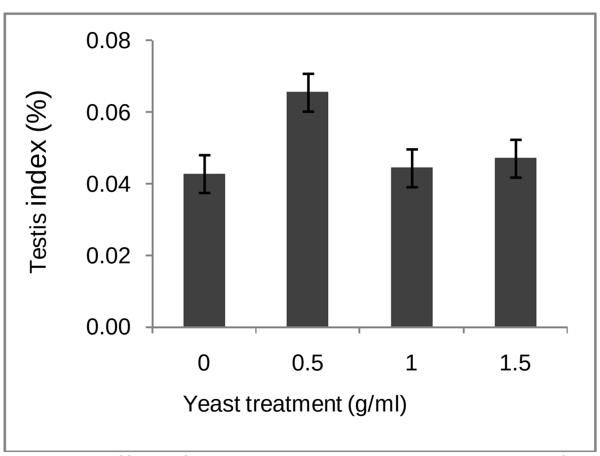

Figure 1 Effect of dried yeast on testicular weights of cockerels. Bars indicate the standard errors of means

Similar observations were reported by Heng *et al*. (2017) who administered soyabean isoflavonoids to young male breeders at the rate of 5 mg/kg. They suggested that soyabean isoflavonoids promote testicular growth by increasing reproductive hormone secretion since the isoflavonoids had no significant effect on body weight of the birds. The haematological indices also seem not to be affected by treatment with dried yeast in the current study (Table 3). This is in partial agreement with the reports of Al Mansour *et al.* (2011), who reported no significant difference in hematocrit, haemoglobin and red blood cell values among treatment groups when broiler chicks were fed yeast culture-supplemented diets. On the contrary, Seyidoglu *et al.* (2014) reported a positive effect of live yeast culture on leucocyte, hematocrit and haemoglobin concentration of rabbits. They concluded that yeast culture has a positive effect on the immune system of the animals. The different species of animals used may be the reason for the difference in the observed research outcomes.

Table 3 Effect of dried yeast on hematological parameters of cockerels

Parameters	Treatment (Dried Yeast in g/ml)				SEM
	C	0.5	1	1.5	
Packed Cell Volume (%)	55	38.5	45.75	39.75	1.610
Red Blood Cellsx10^6(mm^{-1})	4.45	2.3	4.6	5	0.302
Haemoglobin (g/dl)	13	10.4	15.1	13.4	0.690
White Blood Cellsx10^3(mm^{-1})	5.05	6.25	5.9	5.85	0.273
Lymphocytes (%)	39.75	28.5	33.75	39	0.924
Neutrophils (%)	71	66.5	39.5	59.5	2.076
Eosinophils (%)	0.5	0.5	0.5	0.5	-
Neutrophil/Lymphocyte	1.78	2.47	1.53	1.13	0.051

C = control; SEM = standard error of means

CONCLUSION

The results of this study showed that including a low level (0.5mg/mL) of dried yeast in drinking water of cockerels may be beneficial in improving growth and testicular weight of the birds without comprising the hematological indices.

CONFLICT OF INTEREST

The authors declare no conflict of interest

REFERENCES

Allaoui, A., Safsaf, B., Laghrour, W.,Tlidjane, M. (2014). Factors affecting scrotal measurements and weight of OuledDjellal rams in Eastern and South-Eastern Algeria. APCBEE Proc. 8, 260 – 265.

Al-Mansour, S., Al- Khalf, A., Al- Homidan, I.,Fathi, M.M. (2011). Feed efficiency and blood hematology of broiler chicks given a diet supplemented with yeast culture. Int. J. Poult. Sci.10, 603-607.

Aluwong, T., Hassan, F.B., Dzenda, T., Kawu, M.U., Ayo, J.O. (2013a). Effect of different levels of supplemental yeast on body weight, thyroid hormone metabolism and lipid profile of broiler chickens.J. Vet. Med. Sci. 75, 291–298

Aluwong, T., Hassan, F.B., Raji, M.A., Kawu, M.U., Dzenda, T., Ayo, J.O. (2013b). Effect of different levels of supplemental yeast on performance indices, serum enzymes and electrolytes of broiler chickens. Afr. J. Biotechnol. 12, 5480-5485

Bolacali, M., Irak, K. (2017).Effect of dietary yeast autolysate on performance, slaughter, and carcass characteristics, as well as blood parameters, in quail of both genders. S. Afr. J. Anim. Sci. 47, 460-470.

Bortoluzzi, C., Barbosa, J.G.M., Pereira, R., Fagundes, N.S, Rafael, J.M., Menten, J.F.M. (2018). Autolyzed yeast (Saccharomyces cerevisiae) supplementation improves performance while modulating the intestinal immune-system and microbiology of broiler chickens. Front. Sustain. Food Syst. 2, 1 - 8.

Buba, W., Olugbemi, T.S., Omage, J.J., Duru, S., Iyiola-Tunji, A.O. (2016). Performance of broiler chickens fed varying levels of baker's Yeast (S*accharomyces cerevisiae*) during the hot season in the Northern guinea savannah of Nigeria. J. Anim. Prod. Res. 28, 215 – 226

Bushwereb, M., Kerban, A., Elraghig, M., Sola, H. (2019).Efficacy of baker yeast in ameliorating aflatoxicosis in broiler chicks fed aflatoxin-contaminated diet. Global J. Anim. Sci. Res. 7, 1 - 8

Dacie, J., Lewis, S. (1991). Practical hematology (7th ed.), Churchill Livingstone, pp. 37 - 48.

Dhama, K., Tiwari, R., Ullah, R., Sandip, K., Marappan, C., Gopi, K. K., Saminathan, M., Desingu, P. A., Sunkara, L.T. (2014). Growth promoters and novel feed additives improving poultry production and health, bioactive principles and beneficial applications: the trends and advances - a review. Int. J. Pharm. 10, 129-159.

El Iraqi, K.G., Fayed, R.H. (2012). Effect of Yeast as Feed Supplement on Behavioural and Productive Performance of Broiler Chickens. Life Sci. J. 9, 4026 – 4031

Hall, R., Malia, B. (1991). Medical Laboratory Haematology, Butterworth-Heinemann, Oxford.

Hatab, M.H., Elsayed, M.A., Ibrahim, N.S. (2016). Effect of some biological supplementation on productive performance, physiological and immunological response of layer chicks. J. Rad. Res. Appl. Sci. 9, 185 – 192

Heng, D., Zhang, T., Tian, Y., Yu, S., Liu, W., Xu, K., Liu, J., Ding, Y., Zhu, B., Yang, Y., Zhang, C. (2017). Effects of dietary soybean isoflavones (SI) on reproduction in the young breeder rooster. J. Dai. Sci. 177, 124–131

Mohamed, E., Ahmed, T.E.A., Mojahid, A.A. Dafaalla, E.M. (2015). Effect of dietary yeast (*Saccharomyces cerevisiae*) supplementation on performance, carcass characteristics and some metabolic responses of broilers.Ani. Vet. Sci. 3, 5-10

Moyle, J.R., Yoho, D.E., Whipple, S.M., Donoghue, A.M., Bramwell, R.K. (2012). Sperm production and testicular development of broiler breeder males reared on shortened growth cycles. J. Appl. Poult. Res. 21, 88 – 94

Mulatu K., Ameha N.,Girma, M. (2019).Effects of feeding different levels of baker's yeast on performance and hematological parameters in broiler chickens.J. World Poult. Res. 9: 38-49.

North, M.O. (1984). Commercial chicken production manual (3rd ed.), The AVI Publishing Co. Inc., West-port, Connecticut, U.S.A.

Olnood, C., Beski, S., Choct, M.,Iji, P. (2015). Novel probiotics: their effects on growth performance, gut development, microbial community and activity of broiler chickens. Anim. Nutr. 1, 184-191.

Onwurah, F.B., Okejim, J., Amaefula, K.U. (2013). Effect of yeast as water additive in the management of litter in the production starter broiler. Asian J. Nat. Appl. Sci. 2, 27 -30

Ozório, R. O., Portz, L., Borghesi, R., &Cyrino, J. E. (2012).Effects of dietary yeast (*Saccharomyces cerevisia*) supplementation in practical diets of Tilapia (*Oreochromisniloticus*). Animals: an open access journal from MDPI, 2(1), 16–24. doi:10.3390/ani2010016

Özsoy, B., Yalçin, S. (2011). The effects of dietary supplementation of yeast culture on performance, blood parameters and immune system in broiler turkeys.Ankara Üniv. Vet. Fak. Derg.58, 117-122

Özsoy, B., Karadağoğlu, O., Yakan, A., Önk, K., Çelik, E., Şahin, T. (2018).The role of yeast culture (Saccharomyces cerevisiae) on performance, egg yolk fatty acid composition, and fecalmicroflora of laying hens.R. Bras. Zootec. 47, 1-6

Powley, J. (2008). Testes Development and Fertility.Ross Tech Note, 1-4

Sarabia, F.J., Pizarro, D.M., Abad Moreno, J.C., Casanovas, I.P., Rodriguez-Bertos, A., Barger, K. (2013).Relationships between fertility and some parameters in male broiler breeders (body and testicular weight, histology and immunohistochemistry of testes, spermatogenesis and hormonal levels). Reprod. Domest. Anim. 48, 345 - 352

SAS Institute(2001). SAS User's Guide.Version 8.02 ed. SAS Institute Inc., Cary, NC.

Seyidoglu, N., Galip, N., Sonat F.A.K. (2013). Effect of Yeast culture on growth performance, haematological and biochemical indices of New Zealand white rabbits. Uludag Univ. J. Fac. Vet. Med. 32, 11 - 17

Shankar, P.A., Premavalli, K.A., Omprakash, V., Kirubakaran, J.J., Hudson, G.H. (2017). Effect of dietary yeast supplementation on the production performance of broilers. IJABR, 7, 222-228

Sharif, M., Shoaib, M., Aziz Ur Rahman, M., Ahmad F., Shahid Ur Rehman (2018). Effect of distillery yeast sludge on growth performance, nutrient digestibility and slaughter parameters in Japanese quails.Sci. Rep. 8, 1 - 6

Wati, T., Ghosh, T.K., Syed, B., Haldar, S. (2015). Comparative efficacy of a phytogenic feed additive and an antibiotic growth promoter on production performance, caecal microbial population and humoral immune response of broiler chickens inoculated with enteric pathogens. Anim. Nutr.1, 213–219

Wondifraw, Z., Tamir, B. (2014). The effect of feeding different levels of brewer's dried grain yeast mixture on the performance of white leghorn chicks. Int. J. Livest. Prod. 5, 10 – 14.

Xue, G, Wu, S., Choct, M., Swick, R.A. (2017). Effects of yeast cell wall on growth performance, immune responses and intestinal short chain fatty acid concentrations of broilers in an experimental necrotic enteritis model. Anim. Nutr. 3, 399-405.

Yasar, S.,Akıncı, M.A. (2014). Efficacy of a feed probiotic bacteria(Enterococcus faeciumNCIMB10415), spore (Bacillus subtilis ATCC PTA-6737) and yeast (*Saccharomyces cerevisiae*) in Japanese quails. Bull. UASVM 71, 63-70.

Yasar, S., Yegen, M.K. (2017). Yeast fermented additive enhances broiler growth. R. Bras. Zootec. 46, 814-820

Zhen, Y.G., Zhao, W., Chen, X., Li, L.J., Lee, H.G., Zhang, X.F., Wang, T. (2019). Effects of yeast culture on broiler growth performance, nutrient digestibility and caecal microbiota. S. Afr. J. Anim. Sci. 49, 99 – 108