EFFECTS OF THE PROBIOTIC, *SACCHAROMYCES CEREVISIAE* FEED SUPPLEMENTATION ON OOCYST SHEDDING, HAEMATOLOGY AND SERUM PROTEINS OF BROILERS EXPERIMENTALLY INFECTED WITH MIXED *EIMERIA* OOCYSTS

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ABSTRACT

This study determines the effects of probiotics - Saccharomyces cerevisiae on oocysts shedding, haematology and serum proteins of broilers infected with mixed Eimeria oocysts. 120-day-old broiler chicks were randomly assigned to four groups (Groups A – D) of 30 birds each. Group A - was fed a plain diet and not infected, Group B - was fed a supplemented diet and infected, Group C - was fed a plain diet and infected, and Group D - was fed a supplemented diet and not infected. S. cerevisiae was supplemented at 0.1 %/kg of feed. At week 3, Groups B and C were infected with sporulated mixed Eimeria oocysts orally, followed by a daily faecal examination of all groups. The rate of oocyst shedding, packed cell volume (PCV), haemoglobin concentration (Hb), red blood cell (RBC) count, total white blood cell (WBC) count, differential WBC count and serum levels of total protein, albumin and globulin were determined at five days' intervals. The data collected were analyzed using a one-way analysis of variance at a 95% confidence interval (p<0.05). Group C had the significantly higher (p<0.05) number of oocysts in faeces, total WBC count and globulin levels, with the lowest PCV, Hb, RBC count, total protein and albumin levels. Group D had significantly higher (p<0.05) heterophil, eosinophil and monocyte counts. In conclusion, dietary supplementation with S. cerevisiae (1 g/kg) ameliorated the effect of Eimeria infection in broilers, by reducing the rate of oocyst shedding, anaemia and hypoproteinaemia due to the activity of the parasite.

Keywords: Avian, Coccidiosis, Saccharomyces *cerevisiae*, Oocysts, Haematology, Serum proteins

INTRODUCTION

Avian coccidiosis is one of poultry's most important parasitic diseases worldwide (Ola-Fadunsin and Ademola, 2013; 2014). It is an important enteric parasitic disease associated with significant economic losses in poultry (Lawal *et al*., 2016). Infection with this pathogen normally occurs through ingestion of feed or water contaminated with sporulated oocysts. The parasites multiply in the intestine and mature to produce a zygote that matures into an oocyst,

ruptures the intestinal cell, and is passed with the faeces (Blake *et al*., 2021; Mesa-Pineda *et al*., 2021). This results in tissue damage, lowered feed intake, poor absorption of nutrients from the feed, dehydration, blood loss and death (Awais *et al*., 2012; Allen and Fetterer, 2002). About 1,800 *Eimeria* species have been reported to colonise and infect the intestinal tract of different animals (Haug *et al*., 2008; Lawal *et al*., 2016). Morgan *et al*. (2009) identified seven species of *Eimeria* in domesticated birds affecting birds at all stages of life. *Eimeria tenella* and *E. necatrix* are the most pathogenic species; *Eimeria acervulina, E. maxima, E. mitis* and *E. mivati* are common and moderately pathogenic; *E. brunetti* are uncommon but pathogenic when they occur. While *E. mitis, E. praecox* and *E. hagani* are relatively non-pathogenic species (Jadhav *et al*., 2011; Pal *et al*., 2024). Coccidiosis is characterized by clinical signs such as enteritis, diarrhoea (which may be bloody with certain *Eimeria* species), emaciation, lower feed conversion rate, delayed sexual maturity, drooping wings, poor growth, low production, severe morbidity and mortality (Rehman *et al.,* 2011; Awais *et al.,* 2012).

The prevention and control of coccidiosis is based on chemotherapy (use of anticoccidial drugs and vaccines), improved farm management and biosecurity (Quiroz-Castañeda and Dantán-González, 2015; Pal *et al*., 2024). The use of anti-microbial agents such as anti-protozoan drugs (monensin, metronidazole) and anti-bacterial drugs (oxytetracycline, sulphonamides) as feed additives in the management of coccidiosis and other gut diseases has great deleterious effect on the health of the animal, humans and environment due to anti-microbial resistance which is a global issue (Ayukekbong *et al*., 2017; Wang *et al*., 2023). Probiotics are live cultures of non-pathogenic microbes that promote gut health and benefit the host when administered in adequate quantity (Latif *et al*., 2023). These beneficial microbes compete and secure the attachment sites in the gut wall by competitive exclusion of pathogenic harmful microbes and improve the intestinal microbial balance. Examples of probiotic microorganisms are *Lactobacillus acidophilus, Lactobacillus rhamnosus, Saccharomyces boulardii, Streptococcus faecium,* B*ifidobacterium bifidum,* and *Bacillus coagulans* (McFarland, 2007; Fijan, 2014). Live yeast culture with *Lactobacillus* administered to broilers (1 kg/ton feed) showed improved weight gain and FCR, reduced mortality and morbidity (Fesseha *et al.,* 2021). Probiotics can be a potential alternative to antimicrobial feed additives to manage enteric pathogen load in poultry by reducing intestinal colonization and the spread of enteric pathogens (Ogbuewu *et al.*, 2022). Probiotics having *Pediococcus acidilactici* and *Saccharomyces boulardii* have been used as prophylactic against coccidiosis in birds (Lee *et al*., 2007a, b).

The yeast *Saccharomyces cerevisiae* (MG865964), among all these natural alternative growth promoters used in animal and poultry production, is one of the most prominent probiotics. *S. cerevisiae* maintains gut health by reducing the population of gut pathogens by competing and securing the attachment sites in the gut wall by competitive exclusion of harmful pathogenic bacteria and improving the intestinal microbial balance (Elghandour *et al.,* 2020). Also, yeast aids digestion via enzymatic action and produces lactic acid that makes the gastrointestinal tract acidic hence reducing the population of pathogenic microbes. *S. cerevisiae* has been found to enhance immune modulation and maintain gut health thereby improving the health of the animal and boosting productivity (Xu *et al*., 2021). *S. cerevisiae* is a good feed additive in poultry feed. There is a need to evaluate the effect of *S. cerevisiae* on the management of avian coccidiosis. This study is therefore aimed at evaluating the effect of *S. cerevisiae* on oocyst shedding, haematology and serum proteins of broilers experimentally infected with mixed *Eimeria* oocysts.

MATERIALS AND METHODS

Experimental Design: 120-day-old broiler chicks (Ross 308), procured from Agrited Nigeria Limited, Ibadan, Oyo State, Nigeria were used for the study. The study lasted for a period of eight weeks from October 3rd, 2023 to November 28th, 2023. The poultry housing had temperature ranges between 28.06 – 30.1°C, the humidity range was 74.36 – 87.9% and the day length was

12:01:31 – 11:43:56 throughout the study period. The animals were kept on a deep litter housing system in a well-aerated poultry house. They were fed an experimental diet and fresh drinking water was provided *ad libitum.* The house, feeders and drinkers were thoroughly cleaned and disinfected before stocking the chickens. The birds were handled following the guidelines of the Institutional Animal Care and Use Committee of the Faculty of Veterinary Medicine, University of Nigeria Nsukka, from which approval was obtained for the use of the birds for the study (Approval Reference Number: FVM-UNN-IACUC-2021- 0467).

The birds were randomly assigned to four groups (n = 30) – A, B, C and D and each group was further subdivided into three replicates of ten birds each. Group A - fed a plain diet and was not infected with *Eimeria* oocysts (unsupplemented and unchallenged), Group B - fed probiotics supplemented diet and infected with *Eimeria* oocyst (supplemented and challenged), Group C - fed a plain diet and infected with *Eimeria* oocysts (unsupplemented and challenged), and Group D - fed probiotic supplemented diet and not infected with *Eimeria* oocysts (supplemented and unchallenged). The birds were brooded for three weeks. The brooding temperature was provided by a gas stove and maintained at 29 – 31^{o}C for the first week and was reduced by 1 – 3^{o}C weekly up to the 3rd week of life. The birds were vaccinated against Infectious Bursal Disease (IBD) and Newcastle Disease infections. The birds were fed a broiler starter diet for the first four weeks and switched to a finisher diet for the remaining period. The yeast, *S. cerevisiae* (MG 865964 strain) was used as a feed supplement in the starter and finisher diets for Groups B and D birds at an inclusion rate of 1 g per kg of feed.

Faecal examinations were carried out routinely to establish the *Eimeria* infection status of the birds before the experimental challenge. Later, the birds in groups B and C were challenged with sporulated *Eimeria* oocysts in week three.

The Inoculum: *Eimeria* oocysts were obtained from naturally infected chickens using the methods described by Collett *et al.* (2020). Five broiler chickens infected with *Eimeria* species were obtained from a reported case of coccidiosis. The birds were placed in a large plastic bath and a lid made of wire mesh was placed on the top of the bath to allow for ventilation. Faecal samples excreted by the birds were collected and placed in a polythene bag packed with ice and taken to the Parasitology Laboratory for processing. The organism was harvested from the faecal sample according to Bowman (2009), sporulated (Conway and Mckenzie, 2007) and the number of sporulated oocysts was determined using the McMaster method (Holdsworth *et al.*, 2004). 1.5 ml of the sediment containing 10×10^4 (100,000) sporulated *Eimeria* oocysts were used for the challenge per bird, as described by Djemai *et al.* (2023). An equal volume of sterile water was given orally using a 5 ml syringe to each of the birds in the unchallenged groups A and D.

After the experimental challenge with the sporulated oocysts, faecal examination was carried out for each of the birds in all the groups daily until the first appearance of oocysts in the faeces of any of the birds in any of the groups. On the appearance of oocyst in any bird in any of the groups, a faecal examination was carried out at five days intervals post-challenge (PC). The birds were maintained in good rearing condition with feed and water given *ad libitum*.

Experimental Diet: The starter and finisher experimental diets were compounded based on the crude protein and carbohydrate compositions of the various dietary ingredients using the Pearson square method (Wagner and Stanton, 2012). All dietary ingredients as well as the experimental diets were assayed for their proximate composition using AOAC (2000) (Table 1).

Sample Collection: On a proper restraint, 4 ml of blood was collected from the right jugular vein of each bird using a 5 ml hypodermic needle and syringe, and 1 ml was quickly and gently dispensed into sample bottles containing Na-EDTA. The sample bottles were gently rocked to mix the blood with Na-EDTA to prevent coagulation, for haematology analyses.

Table 1: Nutrient composition of the experimental diet

Ingredients	Broiler Starter Diet		Broiler Finisher Diet	
	Unsupplemented Diet	Supplemented Diet	Unsupplemented Diet	Supplemented Diet
Maize	60	60	69.9	69.9
Soybean meal	29.5	29.4	22.5	22.4
Lysine	1.7	1.7	0.8	0.8
Methionine	1.3	1.3	0.8	0.8
Vitamin/Mineral Premix*	3.5	3.5	2.5	2.5
Oil	2	2	1.5	1.5
Salt	2	2	2	2
Probiotic	0.00	0.10	0.00	0.10
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
Crude protein (%)	22.00	22.00	18.00	18.00
Metabolizable Energy (Kcal/kg)	2950.00	2950.00	3150.00	3150.00
Calcium (%)	0.95	0.95	0.85	0.85
Phosphorus (%)	0.4	0.4	0.42	0.42
Lysine (%)	0.4	0.4	1.05	1.05
Methionine (%)	0.55	0.55	0.46	0.46

**Each 1 kg of the vitamins and mineral premix contains 800,000 IU of Vitamin A, 1600,000 IU of Vitamin D3; 5,000 IU of Vitamin E; 2000 mg of Vitamin K; 1500 mg of B1; 4000 mg of B2; 80g of manganese, 50 g of Zinc; 20 g of Iron; 5 g of Copper, 15000 mg of Niacin; 10 mg of B12; 5000 mg of Pantothenic acid, 5000 mg of Folic acid, 20 mg of Biotin, 125 mg of Antioxidant; 200 g of Selenium; 200 mg of Cobalt and 200 mg of Choline*

While the remaining 3 ml was dispensed into plain sample bottles for serum harvest, for serum biochemistry analyses.

Fresh faecal samples were collected from all the groups on days 0, 1, 2, 3, 4, 5, 10, 15, 20, 25, 30 and 35 PC and examined for the presence and rate of oocysts shedding per gram of faeces using the floatation method (Conway and Mckenzie, 2007).

Determination of Rate of Oocysts Shedding: 1 g of the faecal sample from each bird was placed into different labelled test tubes. 14 ml of saturated salt solution was added into the 1 g of faeces in each of the test tubes. The test tubes were agitated and allowed to stand for 5 minutes. The solution in the test tubes was agitated and the liquid filtered into a fresh test tube. 1ml of the solution (mixture) described above, after rocking was aspirated and dispensed into another test tube containing 9 ml of saturated salt solution. This (solution) was rocked and a pipette was used to draw from it to fill the McMaster chamber. The filled McMaster chamber was placed under a light microscope and viewed using a ×10 objective lens. The numbers of oocysts were counted in each chamber and were multiplied by 1000 because of the 1:9 dilutions, i.e. 10 ml dilution used. The values of oocysts counted per chamber were quantified as oocysts count/gram of faeces (OPG) (Holdsworth *et al.*, 2004).

Haematological Examinations: The packed cell volume (PCV) was determined by the microhaematocrit method (Thrall and Weiser, 2002). The haemoglobin (Hb) concentration of the blood samples was determined by the cyanomethaemoglobin method (Higgins *et al.*, 2008). The red blood cell (RBC) and white blood cell (WBC) counts were done following the haemocytometer method (Campbell, 1994). The Leishman technique was dues to determine the differential WBC count, while the WBC counts were calculated using the standard formula (Campbell, 1994; Thrall and Weiser, 2002).

Determination of Serum Proteins: The direct Biuret method (Lubran, 1978; Johnson, 2008) was used to determine the serum protein level. The serum albumin level was determined by the bromocresol green method (Doumas and Peters, 1997; Johnson, 2008). The globulin fraction was calculated as a difference between serum protein and serum albumin levels i.e. Serum globulin

level (g/dl) = Serum protein – Serum albumin (Doumas and Peters, 1997; Johnson, 2008).

Data Analysis: Data generated were analyzed using one-way analysis of variance (ANOVA). Variant means were separated using a post hoc - the least significant difference (LSD) method. The level of statistical significance was accepted at 95% probability ($p<0.05$).

RESULTS

Oocysts Shedding: The presence of *Eimeria* oocysts in the faeces of the birds was detected on day 5 post-challenge (PC) in birds in Groups B and C - supplemented challenged and unsupplemented challenged, respectively (Figure 1). From day 10 to day 35 PC, the presence of *Eimeria* oocysts was detected in the faeces of the birds in all the groups. Birds in Group C had a significantly higher ($p<0.05$) number of *Eimeria oocysts* in their faeces, followed by Group B, while birds in Group D had a significantly lower ($p<0.05$) number of *Eimeria* oocysts in their faeces, followed by Group A. The number of *Eimeria oocysts* reduces across the experimental period PC (Figure 1).

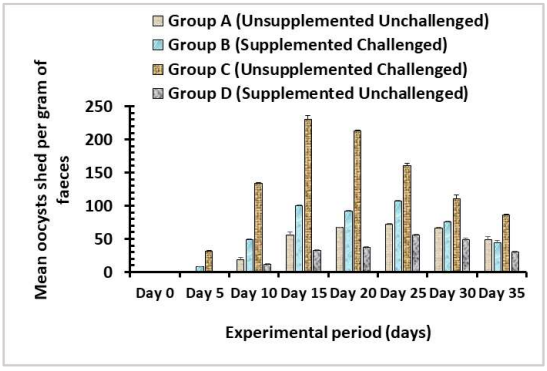

Figure 1: Number of oocysts in faeces from birds in the four experimental groups

Packed Cell Volume: There was no significant difference ($p>0.05$) in the PCV of the birds in all the groups on day 5 PC. However, on days 10 and 15 PC, the mean PCV of birds in Groups D and B, respectively, were significantly higher ($p<0.05$) when compared with birds in other groups. While on day 35 PC, the mean PCV of birds in Group C was significantly lower ($p<0.05$) when compared with other groups (Figure 2).

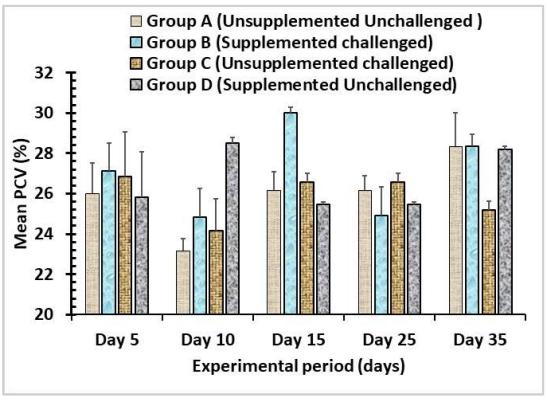

Figure 2: Mean packed cell volume of birds in the four experimental groups

Haemoglobin Concentration: On days 10 and 15 PC, the mean haemoglobin concentration of birds in Groups D and B, respectively, were significantly higher ($p<0.05$) when compared with birds in other groups. While on day 35 PC, the mean haemoglobin concentration of birds in Groups A and C was significantly lower ($p<0.05$) when compared with other groups (Figure 3).

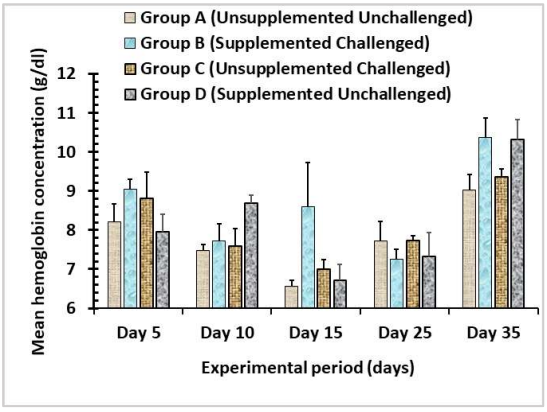

Figure 3: Mean haemoglobin concentration of birds in the four experimental groups

Red Blood Cell Count: On days 10 and 15 PC, the mean RBC count of birds in Groups D and B respectively, were significantly higher ($p<0.05$) when compared with birds in other groups. On day 35 PC, the mean RBC count of birds in Group C was significantly lower ($p<0.05$) when compared with other groups (Figure 4).

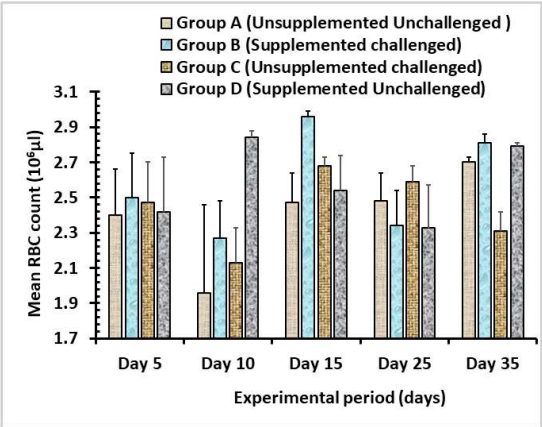

Figure 4: Mean red blood cell counts of birds in the four experimental groups

Leukocyte Counts: On day 10 PC, the mean leukocyte count of birds in Group A was significantly lower ($p<0.05$) than other groups, while that of Group B was significantly higher ($p<0.05$) than other groups. Also, on day 25 PC, the mean leukocyte count of birds in Group A was significantly lower ($p<0.05$), while that of Group B was significantly higher ($p<0.05$) than other groups. However, on day 35 PC, Groups B and C birds had a significantly higher ($p<0.05$) leukocyte count when compared to other groups (Figure 5).

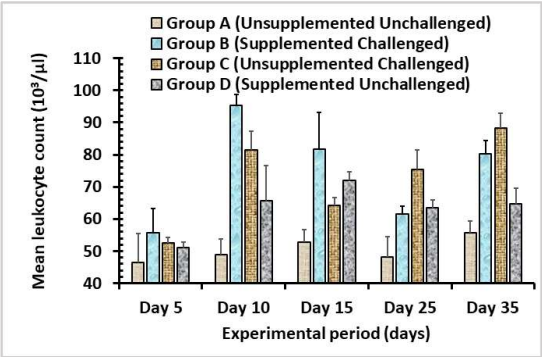

Figure 5: Mean total leukocyte counts of birds of birds in the four experimental groups

Lymphocyte Count: On day 10 PC, the mean lymphocyte count of birds in Group A was significantly lower ($p<0.05$) than other groups. Also, on day 25 PC, the mean lymphocyte count of birds in Group C was significantly higher ($p<0.05$) than other groups (Figure 6).

Heterophil Count: On day 10 PC, the mean heterophil count of birds in Group B was significantly higher ($p<0.05$) than other groups. While, on days 15, 25 and 35 PC, the mean heterophil count of birds in Group D was significantly higher ($p<0.05$) than in other groups (Figure 7).

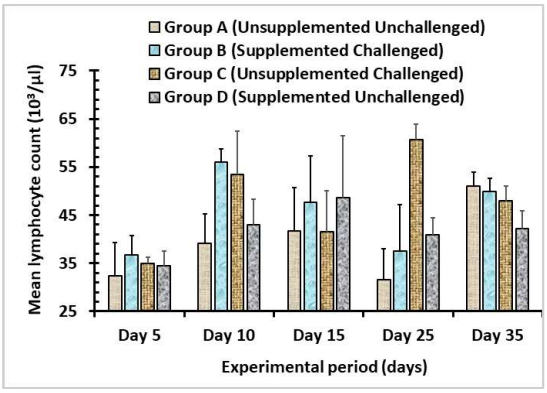

Figure 6: Mean lymphocyte counts of birds in the four experimental groups

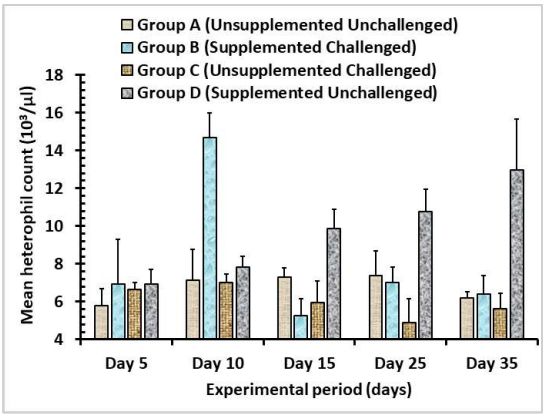

Figure 7: Mean heterophil counts of birds in the four experimental groups

Eosinophil Count: The mean eosinophil count of birds in Group B was significantly higher ($p<0.05$) than other groups on day 10 PC. However, on day 35 PC, the mean eosinophil count of birds in Groups A and D was significantly higher ($p<0.05$) than birds in Groups B and C (Figure 8).

Monocyte Count: The mean monocyte count of birds in Group C was significantly higher ($p<0.05$) than other groups on day 10 PC. While, on day 35 PC, the mean monocyte count of birds in Groups A and D was significantly higher ($p<0.05$) than birds in Groups B and C (Figure 9).

Serum Protein Level: On days 25 and 35 PC, birds in Group C had significantly lower ($p<0.05$) levels of serum protein. However, birds in Group

D birds had significantly higher ($p<0.05$) levels of serum protein (Figure 10).

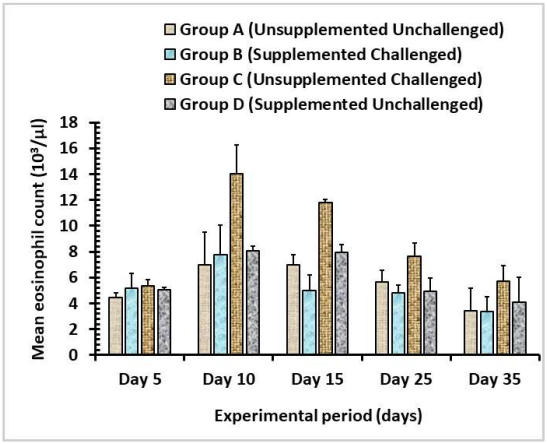

Figure 8: Mean eosinophil counts of birds in the four experimental groups

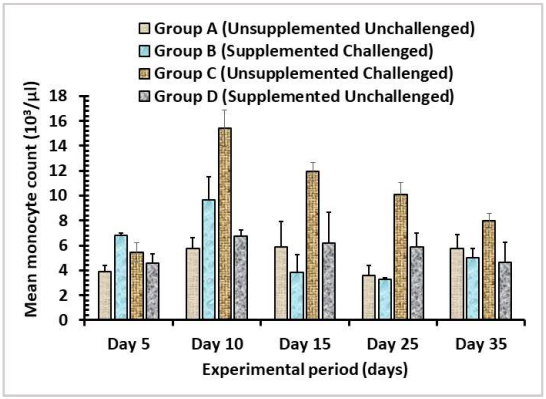

Figure 9: Mean monocyte counts of birds in the four experimental groups

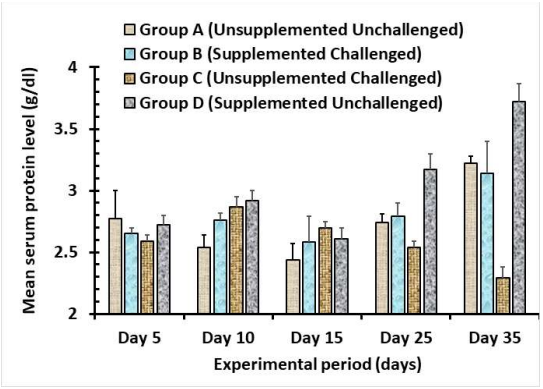

Figure 10: Mean serum protein level of birds in the four experimental groups

Serum Albumin Level: The serum level of albumin of birds in Group C was significantly lower ($p<0.05$) on days 25 and 35 PC, while, Group D birds had significantly higher ($p<0.05$) levels of serum albumin (Figure 11).

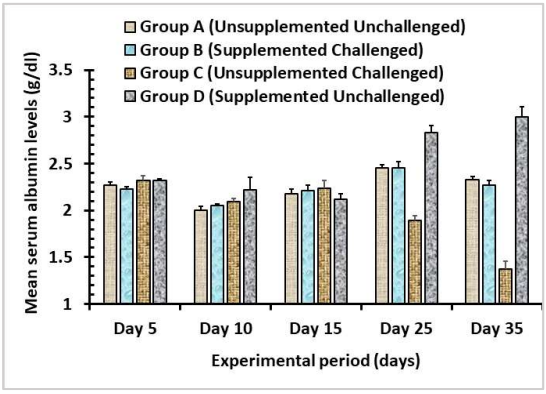

Figure 11: Mean serum albumin level of birds in the four experimental groups

Serum Globulin Level: On days 25 PC, the serum globulin level of birds in Group C was significantly higher ($p<0.05$) when compared to other groups (Figure 12).

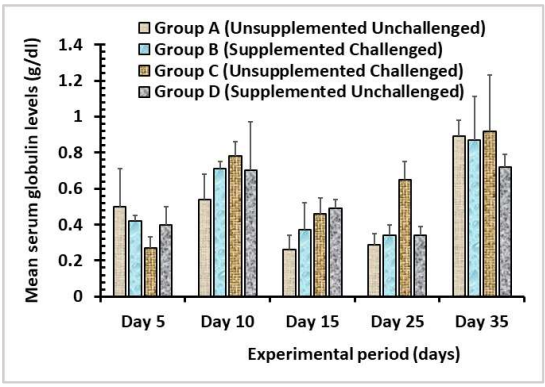

Figure 12: Mean serum globulin level of birds in the four experimental groups

DISCUSSION

This study investigated the ameliorative effect of *S. cerevisiae* on *Eimeria* infection in broilers. The findings of the study revealed that *S. cerevisiae* reduced the severity of coccidiosis in the supplemented Groups B and D. This was evident by the significantly high number of oocysts shedding in faeces from birds in the unsupplemented challenged Group C. The birds in Group A, though not supplemented and not challenged had a higher number of oocysts in faeces when compared to birds in Group D that were supplemented and not challenged. The

number of oocysts in the faeces of Group B birds (supplemented challenged) though higher than Group A (unsupplemented unchallenged), it was significantly lower than Group C (unsupplemented challenged). The lower number of oocysts shedding in the supplemented groups may be attributed to the activity of *S. cerevisiae* in the gastrointestinal tract by adhesion capacity to intestinal cells, direct antagonistic effect on enterobacteria and other yeast cells, inhibition of the formation of pathogenic bacteria development in feed, digestibility and enhancement of beneficial micro-organisms in the gut, improving gut morphological structure, enhanced secretion of digestive enzyme activity, tolerance to high gastrointestinal acidity, resistance to bile salts, immune modulatory effect (Pourabedin *et al.,* 2014; Ogbuewu *et al.,* 2018).

Anaemia diagnosed by reduced PCV and RBC levels was evident in Group C (unsupplemented and challenged) on day 35 PC. This may be due to the attachment, invasion and destruction of the epithelial cells of the gastrointestinal tract. This leads to bloody diarrhoea in birds due to haemorrhagic enteritis caused by the action of the parasite. Studies by Ogbe *et al*. (2010) and Wakenell (2010) reported a slight drop in PCV, HBC and RBC count in chickens infected with *E. tenella* and *E. acervulina*. Also, Melkamu *et al*. (2018) reported a significant decrease in the mean erythrocyte counts in chickens infected with *E. necatrix*. On days 10 and 15 PC, birds in Groups D (supplemented and unchallenged) and B (supplemented and challenged) had a significantly higher level of PCV, RBC count and haemoglobin concentration than other groups. This may be due to the effect of *S. cerevisiae* on erythropoietic function which enhances erythropoiesis leading to the formation and maturation of RBC. *S. cerevisiae* may be digested by intestinal microflora when they clinically die after about 24 hours and degraded to amino acids which can be used for synthesis and maturation of RBC or other erythropoietic cells amongst other functions in the body (Ezema and Eze, 2010). The anaemia seen in avian coccidiosis is haemorrhagic (blood loss) anaemia and depends on the Eimeria species' pathogenicity and the lesion's severity (Debbou-Iouknane *et al*., 2018). This suggests that the administration of *S. cerevisiae* to broilers can prevent anaemia caused by *Eimeria* infection due to the nutritive and gut-protective effect of the yeast.

The leucocytosis observed in Groups B, C and D on day 10 PC indicates immune stimulation due to *Eimeria* infection and/or probiotic supplementation. Which was absent in birds in Group A that were unsupplemented and unchallenged. On day 15 PC only, birds fed probiotic-supplemented diets (B and D) maintained the leucocytosis. This explains the immuno-protective effect of *S. cerevisiae*, as it has primed the system and stimulated the release of immune cells that will fight infection and keep the body healthy (Meriggi *et al*., 2019). However, from day 25 PC the leucocytosis in Groups B and C was due to the body's reaction to *Eimeria* infection leading to the release of WBCs. Hidayat *et al*. (2020) reported that the presence of leukocytes in blood is normal but increased during infection. The increased WBC counts observed in birds fed probiotics were in line with the finding of Aguihe *et al.* (2018) who reported that when a poultry diet was supplemented with probiotics, haematological profiles showed an increase in leucocyte count and a marked increase in the percentage of heterophils.

One of the striking pathological lesions of coccidiosis is the massive release and infiltration of lymphocytes, monocytes, heterophils and eosinophils into the digestive tract (Stockdale and Fernando, 1975; Rose *et al*., 1979). At day 10 PC, there were increased lymphocytes and heterophils count in the supplemented challenged Group B than in other groups. This may probably be because the probiotic stimulated the immune system of birds by increasing the leucocyte proliferation (Hidayat *et al.,* 2020). Thereby, making the birds to be immune-competent. However, the unsupplemented challenged Group C birds, from day 10 PC had a significantly higher eosinophils and monocyte count, than other groups. High eosinophil count is a common pathological lesion seen in parasitic infection due to its cellular activity against the parasite (Britannica, 2022). Monocytes are large phagocytes that clear tissue debris and large

microbes (Britannica, 2022). Therefore, the higher number of eosinophils and monocytes seen in the unsupplemented challenged Group C birds indicates the severity of the disease and tissue damage, respectively. This correlates positively with the level of oocysts shedding, as birds in Group C shed more oocysts than other groups. This finding corresponds with the report of Gao *et al*. (2008; 2009) that the *S. cerevisiae* fermentation product showed an increase in the immune function of the broiler when fed for 42 days. Other studies have shown similar results on the broiler immune system when fed *S. cerevisiae* fermentation product (Al-Homidan and Fahmy, 2007; EL-Husseiny *et al*., 2008). Ezema and Ugwu (2014) hypothesised that a fermentation product derived from *S. cerevisiae* could modulate the immune system of birds to better handle stress and intestinal pathogenic infection.

The significant decrease in serum protein and albumin levels observed in the unsupplemented challenged Group C birds on days 25 and 35 PC was consistent with the findings of Fagner (2014) who reported a significant reduction in serum protein in chickens infected with *Eimeria* species, on different days' PC. This may result from nutrient malabsorption due to damaged intestinal epithelium, loss of blood proteins through haemorrhage and acute stress leading to cortisol secretion and rapid catabolism of protein (Sanchez, 2018). This corresponds with the high level of oocyst shedding reported in Group C birds. However, the supplemented unchallenged Group D birds had a significant increase in serum protein and albumin levels on days 25 and 35 PC. Probiotics increased the apparent ileal digestibility of essential amino acids with a significant increase in digestibility of crude protein and crude fat (Apata, 2008), with a 5% improvement in body weight gain (Zhang and Kim, 2014) and improved the bioavailability of calcium in chicken (Chawla *et al*., 2013). Also, probiotics cause increased enzyme activity in the GIT of animals either by production of enzymes by the probiotic itself or induced change in the microbial population and hence enzyme production. Probiotics increased the height of intestinal villi and villus height: crypt ratio in poultry (Afsharmanesh and Sadaghi, 2014), thus increasing the surface area for nutrient absorption.

The significant high serum globulin level reported in Group C birds on day 25 PC may be due to antibody production from severe challenge by *Eimeria* infection. It was also observed that Group C birds had a significantly high monocyte count. This confirms the presence of both humoral and cell-mediated immune responses during coccidiosis. Although the serum globulin levels of the supplemented groups B and D were high on days 10 and 15 PC, it was not significant. However, this corresponds to the increased lymphocyte proliferation observed in the supplemented groups due to immune stimulation (Gao *et al*., 2009). The study by Landy and Kavyani (2013) reported that antibody titre against the common poultry diseases Newcastle Disease, Infectious Bronchitis and Infectious Bursal Disease was increased by the use of the commercial probiotic product Primalac.

Conclusion: the supplementation of diet with S. cerevisiae at the dose of 1 mg/kg ameliorated the effect of *Eimeria* infection in broilers, by reducing the rate of oocysts shedding, and increasing PCV thereby minimizing anaemia and decreasing hypoproteinaemia due to the activity of the parasite.

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