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The blood profile and immune response of Noiler chickens fed diets containing different supplemental levels of Saccharomyces cerevisiae.

By

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Abstract

This study evaluated the blood profile and immune response of Noiler chickens fed diets containing graded levels of Saccharomyces cerevisiae. A total of 300 day-old Noiler chickens were assigned to five dietary treatments comprising a basal diet supplemented with 0% (control), 0.5%, 1.0%, 1.5% and 2.0% S. cerevisiae in a completely randomised design, with three replicates per treatment over a 16-week feeding trial. Haematological indices, serum biochemical parameters and immune responses (including differential leukocyte counts and antibody titres to Newcastle disease virus) were determined using standard laboratory procedures. Data were analysed using one-way ANOVA. Results showed significant ($P < 0.05$) effects of dietary S. cerevisiae on most haematological and serum biochemical parameters. Birds fed yeast-supplemented diets exhibited higher haemoglobin concentration, packed cell volume, red blood cell counts and total white blood cell counts compared with the control, with the highest values generally recorded in birds fed 1.5–2.0% inclusion levels. Serum total protein and globulin concentrations were significantly improved in yeast-fed groups, indicating enhanced protein metabolism and immune stimulation. Lipid profile indices were also significantly influenced, with birds fed 1.0% S. cerevisiae showing improved high-density lipoprotein cholesterol and reduced low-density lipoprotein cholesterol and triglyceride levels. Differential leukocyte counts revealed enhanced immune responsiveness, particularly in birds fed 1.5% and 2.0% supplementation levels. All measured blood and biochemical parameters remained within physiological reference ranges, suggesting no adverse metabolic effects. In conclusion, dietary supplementation of Saccharomyces cerevisiae improved haematological status, serum biochemical balance and immune responsiveness of Noiler chickens, with optimal responses generally observed between 1.0% and 1.5% inclusion levels. The study demonstrates that S. cerevisiae is a safe and effective functional feed additive for enhancing physiological health and immunity in Noiler chickens under tropical production conditions.

Keywords: *Blood profile, Immune response, Noiler chickens, Saccharomyces cerevisiae.*

INTRODUCTION

Poultry production in Nigeria continues to face significant constraints, including high feed costs, inconsistent growth performance, and recurrent disease outbreaks that compromise profitability and food security. While Noiler chickens offer genetic advantages in adaptability and dual-purpose productivity, their performance and immune competence are still influenced by nutritional strategies. The global shift away from antibiotic growth promoters further underscores the necessity for safe, natural feed additives capable of enhancing physiological stability and immune responsiveness.

The poultry industry plays a pivotal role in bridging the animal protein gap in developing countries, particularly in sub-Saharan Africa. However, escalating feed costs—largely driven by competition between humans and livestock for cereals and oilseeds—continue to threaten the sustainability and profitability of poultry production systems. Feed accounts for up to 70–75% of total production costs, thereby necessitating the exploration of alternative nutritional strategies that are less competitive with human food resources, economically viable, and supportive of bird health and productivity (Iji et al., 2017; Tanimo et al., 2020). With Nigeria's population exceeding 200 million and growing rapidly, the demand for affordable, high-quality animal protein continues to rise, intensifying the need for efficient poultry genotypes and cost-effective feeding strategies capable of shortening production cycles while maintaining optimal health status.

In response to these challenges, dual-purpose and resilient poultry breeds have gained increasing attention. Noiler chickens, developed in Nigeria by Amo Farm Sieberer Hatchery, are a hybrid strain derived from crossing Nigerian indigenous chickens with exotic broiler-type lines, including the White Plymouth Rock. This strategic crossbreeding programme produced a bird that combines the rapid growth characteristics of broilers with the hardiness, disease tolerance, and scavenging ability of indigenous chickens. Noilers are well adapted to tropical environments, demonstrate relatively high survivability under semi-intensive and backyard systems, and possess dual-purpose attributes for both meat and egg production. Typically, males attain market weights of approximately 2.5–2.8 kg by 12–14 weeks, while females begin laying at about 20–22 weeks, producing 150–200 eggs annually under appropriate management. Their adaptability and moderate input requirements make them particularly suitable for small-holder and resource-constrained farmers, thereby contributing to rural livelihoods and food security.

Despite their genetic advantages, optimal productivity in Noilers depends largely on nutritional adequacy and immune competence. Modern poultry production has progressively shifted from antibiotic growth promoters towards natural alternatives due to concerns over antimicrobial resistance and food safety. Probiotics, prebiotics, phytogenics, and yeast-based products are increasingly employed as functional feed additives to enhance gut health, nutrient utilisation, and immune modulation. Among these, Saccharomyces cerevisiae has received considerable scientific attention.

Saccharomyces cerevisiae is a non-pathogenic yeast widely used in animal nutrition as a probiotic or yeast culture. Its cell wall components—particularly β-glucans and mannan-oligosaccharides—are known to modulate immune function, improve intestinal integrity, and inhibit colonisation by enteric pathogens. Recent studies have demonstrated that dietary supplementation with S. cerevisiae can enhance feed efficiency, nutrient digestibility, and antioxidant status, while positively influencing haematological indices and humoral immune responses in broiler chickens and other poultry species (Elghandour et al., 2020; Abdel-Rahman et al., 2022; Alagawany et al., 2023). Yeast supplementation has also been associated with improved red blood cell counts, haemoglobin concentration, packed cell volume, and antibody titres against common poultry vaccines, indicating enhanced physiological and immunological resilience.

Haematological and serum biochemical parameters are reliable indicators of the physiological, nutritional, and health status of poultry. Alterations in blood profile may reflect metabolic adaptation, immune stimulation, stress response, or pathological conditions. Therefore, evaluating blood indices alongside immune response provides a comprehensive understanding of how dietary interventions influence systemic health. Although numerous studies have evaluated the effects of S. cerevisiae in conventional broilers, there remains a paucity of data regarding its influence on the blood profile and immune response of Noiler chickens under tropical production conditions.

Although Saccharomyces cerevisiae has demonstrated promising immunomodulatory and haematopoietic effects in broilers, limited empirical data exist on its optimal supplemental levels and physiological impacts in Noiler chickens. Consequently, there is a need for systematic evaluation of graded levels of S. cerevisiae on haematological parameters and immune indices in this genotype. Generating such data will provide evidence-based recommendations for improving health status, productivity, and profitability in Noiler production systems.

Materials and Methods

Experimental location

The study was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Umudike is located at a latitude of 5°27′N and a longitude of 7°32′E, at an altitude of approximately 123 m above sea level. The area lies within the humid rainforest zone of south-eastern Nigeria, characterised by a mean annual rainfall of approximately 2,177 mm, ambient temperature ranging from 22–36 °C, and relative humidity of 50–90% (National Root Crops Research Institute [NRCRI], 2017).

Experimental birds and management

A total of 300 day-old Noiler chickens (mixed sex) were used for the 16-week feeding trial. The chicks were obtained from a reputable commercial distributor in Owerri, Imo State, Nigeria. Upon arrival, birds were brooded for seven days to allow acclimatisation. During brooding, commercial starter feed was provided, and supplemental heat was supplied using electric bulbs (200 W), kerosene lanterns and stoves. Tarpaulin sheets were used to minimise cold stress.

At the end of brooding, birds were individually weighed and randomly allocated to five dietary treatments in a completely randomised design (CRD). Each treatment comprised 60 birds with three replicates of 20 birds each. Birds were reared on deep litter pens bedded with clean wood shavings. Feed and fresh drinking water were provided *ad libitum* throughout the experiment.

Routine vaccination and health management followed standard poultry practice. Birds were vaccinated against Newcastle disease (intra-ocular route) on day 1, infectious bursal disease (Gumboro) on day 11, and Newcastle disease (Lasota) on day 28. Deworming was carried out at week 6. Prophylactic measures against common bacterial and parasitic infections were administered as required. Glucose and vitamin–mineral supplements were provided in drinking water during periods of stress.

All management procedures complied with institutional guidelines for the care and use of experimental animals.

Experimental diets

Five iso-nitrogenous and iso-caloric diets were formulated to meet or exceed the nutrient requirements of growing indigenous chickens as recommended by the National Research Council (1994).

The dietary treatments were as follows:

1. **T1**: Basal diet (0% *Saccharomyces cerevisiae*)
2. **T2**: Basal diet + 0.5% *Saccharomyces cerevisiae*
3. **T3**: Basal diet + 1.0% *Saccharomyces cerevisiae*
4. **T4**: Basal diet + 1.5% *Saccharomyces cerevisiae*
5. **T5**: Basal diet + 2.0% *Saccharomyces cerevisiae*

The yeast (*Saccharomyces cerevisiae*) product used was a commercial live yeast preparation containing $\geq 10^9$ CFU/g. Diets were thoroughly mixed to ensure uniform distribution of the supplement. All diets (Tables 1 and 2) were formulated to meet or exceed the nutrient requirements for Noiler chickens as recommended by NRC (1994).

TABLE 1: Percentage composition of Starter Noiler fed diets containing supplemental levels cf Saccharomyces Cerevisiae

INGREDIENTS (kg)	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	40	40	40	40	40
Wheat offal	14	14.5	15	15.5	16
SC	_	0.5	1.0	1.5	2.0
Brewers Dry Grain	12	12	12	12	12
Soybean meal	20	20	20	20	20
Fish meal	3	3	3	3	3
Palm Kernel Cake	8	8	8	8	8
Bone meal	2.2	2.2	2.2	2.2	2.2
Lysine	0.2	0.2	0.2	0.2	0.2
Methionine	0.1	0.1	0.1	0.1	0.1
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total (kg)	**100**	**100**	**100**	**100**	**100**
Calculated composition					
Crude protein (%)	21.90	21.72	21.61	21.42	21.23
Energy (Kcal/kg ME)	2895.97	2874.12	2862.27	2843.42	2821.57
Crude fibre (%)	4.87	5.12	5.23	5.44	5.54

TABLE 2: Percentage composition of Grower Noiler fed diets containing supplemental levels cf Saccharomyces Cerevisiae

INGREDIENTS (kg)	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	46	46	46	46	46
Wheat offal	14	14.5	15	15.5	16
SC	_	0.5	1.0	1.5	2.0
Brewers Dry Grain	13	13	13	13	13
Soybean meal	15	15	15	15	15
Fish meal	3	3	3	3	3
Palm Kernel Cake	6	6	6	6	6
Bone meal	2.2	2.2	2.2	2.2	2.2
Lysine	0.2	0.2	0.2	0.2	0.2
Methionine	0.1	0.1	0.1	0.1	0.1
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total (kg)	**100**	**100**	**100**	**100**	**100**
Calculated composition					
Crude protein (%)	19.70	19.62	19.41	19.22	19.13
Energy (Kcal/kg ME)	3015.97	3009.12	3002.27	2998.42	2970.57
Crude fibre (%)	5.21	5.41	5.53	5.64	5.74

Blood sampling and immune response evaluation

Sample collection

At weeks 4, 8 and 16 of the feeding trial, one bird per replicate (three birds per treatment) was randomly selected for blood sampling. Approximately 5 mL of blood was collected from the brachial vein using sterile syringes.

1. Blood for haematological analysis was collected into EDTA-treated tubes.
2. Blood for serum biochemical and immunological assays was collected into plain tubes, allowed to clot, and centrifuged at 3,000 rpm for 10 minutes to obtain serum.

Serum samples were stored at −20 °C pending analysis.

Haematological indices

Haematological parameters, including packed cell volume (PCV), haemoglobin concentration (Hb), red blood cell count

(RBC), and white blood cell count (WBC), were determined using standard laboratory procedures as described by Schalm's Veterinary Haematology and Veterinary Clinical Pathology.

i. **PCV** was determined using the micro-haematocrit centrifugation method.
ii. **Hb** was determined using the cyanomethaemoglobin method.
iii. **RBC and WBC counts** were determined using an improved Neubauer haemocytometer.

Erythrocyte indices were calculated as follows:

$$\text{MCV(fL)} = \frac{\text{RBC}}{\text{PCV} \times 10}$$

$$\text{MCH(pg)} = \frac{\text{RBC}}{\text{Hb} \times 10}$$

$$\text{MCHC(g/dL)} = \frac{\text{Hb}}{\text{PCV}} \times 100$$

Serum biochemical indices

Serum biochemical parameters evaluated included total protein, albumin, globulin, urea, creatinine, and cholesterol.

I. **Total protein** was determined using the Biuret method.
II. **Albumin** was analysed using the bromocresol green method.
III. **Globulin** was calculated as the difference between total protein and albumin.
IV. **Urea** was determined using the urease–indophenol method.
V. **Creatinine** was determined using the Jaffe reaction method.
VI. **Cholesterol** was analysed using the enzymatic colourimetric method described by Allain CC et al. (1974).

All absorbance readings were obtained using a UV–visible spectrophotometer at appropriate wavelengths.

Immune response assessment

Antibody titre to Newcastle disease virus

Humoral immune response was assessed by determining antibody titres against Newcastle disease virus (NDV) using the haemagglutination inhibition (HI) test, following standard procedures outlined by the World Organisation for Animal Health (WOAH, 2022). Serum samples collected at weeks 4 and 8 post-vaccination were analysed, and titres were expressed as $\log_2$ values.

Differential leukocyte count

Blood smears were prepared, air-dried, fixed in methanol and stained using Wright–Giemsa stain. Differential leukocyte counts (heterophils, lymphocytes, monocytes, eosinophils and basophils) were determined under oil immersion microscopy. The heterophil-to-lymphocyte (H:L) ratio was calculated as an indicator of stress and immune modulation.

Statistical analysis

Data were subjected to one-way analysis of variance (ANOVA) using SPSS (Version 25.0). Differences among treatment means were separated using Duncan's multiple range test. Significance was declared at $P < 0.05$.

Results and Discussion

Haematological indices

The haematological profile of Noiler chickens fed graded levels of *S. cerevisiae* is presented in Table 3. Most parameters were significantly (P < 0.05) influenced by dietary treatments.

Haemoglobin (Hb), packed cell volume (PCV) and red blood cells (RBC)

Haemoglobin concentration, PCV, and RBC counts were significantly higher in yeast-supplemented groups compared with the control. Birds fed 2.0% yeast (T5) recorded the highest Hb (12.93 g/dl), PCV (35.33%) and RBC (4.01 $\times 10^6$/µl).

These improvements suggest enhanced erythropoiesis and oxygen-carrying capacity, likely linked to improved nutrient absorption and gut health. Yeast-derived β-glucans have been reported to stimulate haematopoiesis and immune function (Abdel-Hafeez et al. 2017 Asian-Australas J Anim Sci). All values were within normal physiological ranges, indicating the absence of anaemia or haemotoxic effects.

Total white blood cell count (TBC) and differential counts

Total white blood cell count increased significantly with higher yeast inclusion, with T5 recording the highest value (23.90 $\times 10^3$/µl). Elevated WBC counts within physiological limits indicate enhanced immune responsiveness rather than infection.

Neutrophils, monocytes, eosinophils and basophils were significantly influenced by treatment. Birds fed 1.5% and 2.0% yeast showed higher monocyte and eosinophil counts, suggesting immune stimulation. Increased monocytes may reflect improved innate immune activation, consistent with the immunomodulatory properties of yeast cell wall components (Elghandour et al. 2020 Animals).

Erythrocyte indices (MCV, MCH and MCHC)

MCV was not consistently influenced, whereas MCH and MCHC showed significant variation among treatments. Nevertheless, all values remained within established physiological ranges for chickens (Veterinary Haematology and Clinical Chemistry).

The improved haematological profile supports the hypothesis that *S. cerevisiae* supplementation enhances physiological stability, nutrient utilisation and immune competence in Noiler chickens.

Table 3: HAEMATOLOGY OF NOILER CHICKEN FED DIETS CONTAINING SUPPLEMENTAL LEVELS OF SACCAROMYCES CEREVISIAE

PARAMETER	T1	T2	T3	T4	T5	SEM
Hb	**11.13 ^{b}**	**12.40^{a}**	**12.40^{a}**	**12.53^{a}**	**12.93^{a}**	**0.19**

POV	**29.33^{b}**	**33.00^{a}**	**33.67^{a}**	**34.00^{a}**	**35.33^{a}**	**0.63**
RBC	**3.31^{b}**	**3.72^{b}**	**3.63^{b}**	**3.82^{b}**	**4.01^{a}**	**0.07**
TBC	**20.60^{d}**	**21.32^{c}**	**20.57^{d}**	**22.83^{b}**	**23.90^{a}**	**0.81**
MCV	**88.62^{a}**	**72.06^{b}**	**88.67^{a}**	**72.27^{b}**	**71.32^{b}**	**5.31**
MCH	**34.30^{a}**	**33.33^{b}**	**32.66^{c}**	**32.79^{c}**	**32.24^{c}**	**0.23**
MCHC	**37.97^{a}**	**37.57^{a}**	**36.83^{b}**	**36.86^{b}**	**36.66^{b}**	**0.195**
Neutrophils	**22.40^{d}**	**24.43^{b}**	**23.16^{c}**	**25.03^{a}**	**22.90^{d}**	**0.55**
Monocyte	**3.033^{c}**	**3.50^{c}**	**3.77^{c}**	**4.33^{b}**	**6.60^{a}**	**0.34**
Eosinophils	**2.13^{c}**	**2.00^{c}**	**2.23^{c}**	**3.03^{b}**	**5.13^{a}**	**0.32**
Basophils	**1.23^{b}**	**1.10^{b}**	**1.03^{b}**	**1.13^{b}**	**2.03^{a}**	**0.11**

Serum biochemical indices

The effects of graded dietary supplementation of *Saccharomyces cerevisiae* on the serum biochemical profile of Noiler chickens are presented in Table 4. Significant ($P < 0.05$) differences were observed for most parameters evaluated, indicating that yeast supplementation modulated metabolic responses in the birds.

Total protein

Total protein increased progressively with increasing inclusion level of *S. cerevisiae*, with birds fed 2.0% (T5) recording the highest value (3.99 g/dl). Birds on 1.0% (T3) and 1.5% (T4) diets showed intermediate values, while the control (T1) had the lowest. All values were within the physiological range reported for healthy chickens (Schalm's Veterinary Haematology).

The elevated total protein in yeast-supplemented groups may reflect enhanced protein synthesis and improved nutrient utilisation, possibly due to modulation of gut microbiota and improved intestinal integrity. Yeast cell wall components such as β-glucans and mannan-oligosaccharides are known to enhance nutrient absorption and immune function (Elghandour et al. 2020 Animals). This finding contrasts with that of Mohamed et al. (2022), who reported no significant effect of yeast inclusion up to 0.75% on serum total protein.

Albumin and globulin

Albumin values were not significantly influenced ($P > 0.05$) by dietary treatments, although numerically higher values were observed in T5. All values fell within normal physiological limits, indicating adequate hepatic synthetic function and absence of pathological conditions.

In contrast, globulin concentrations were significantly ($P < 0.05$) increased in T4 (1.5%) and T5 (2.0%) groups compared with lower inclusion levels. Elevated globulin suggests enhanced humoral immune activity, as globulins largely comprise immunoglobulins. Dietary yeast has been shown to stimulate antibody production and immune competence through β-glucan-mediated activation of macrophages and lymphocytes (Abdel-Hafeez et al. 2017 Asian-Australas J Anim Sci).

Urea, uric acid and creatinine

Serum urea showed a significant ($P < 0.05$) increase in T4 compared with other treatments, although values remained within the normal range. Uric acid did not differ significantly ($P > 0.05$) among treatments. Since uric acid is the principal nitrogenous waste in birds, the absence of marked elevation suggests that protein metabolism and renal function were not adversely affected.

Creatinine values were not significantly altered by yeast inclusion. This indicates stable muscle metabolism and renal clearance across treatments. The present findings differ from Gheisari and Kholeghipour (2006), who reported increased creatinine with yeast supplementation at certain inclusion levels.

Lipid profile (Triglycerides, HDL, LDL and VLDL)

Significant ($P < 0.05$) differences were observed in triglycerides, HDL-C, LDL-C and VLDL-C. Birds fed 1.0% yeast (T3) recorded the lowest triglyceride and LDL-C concentrations, suggesting improved lipid metabolism at moderate inclusion levels.

High-density lipoprotein cholesterol (HDL-C) was highest in T3, whereas LDL-C was lowest in the same group. This shift towards a more favourable lipid profile suggests that *S. cerevisiae* may influence lipid metabolism through improved gut microbial balance and bile acid metabolism. Yeast supplementation has been associated with reduced serum cholesterol and improved lipid fractions in poultry (Elghandour et al. 2020 Animals).

However, the present findings do not fully align with earlier observations by Onifade and Abu (1998), who reported increased HDL and LDL concentrations at lower yeast inclusion levels. Differences may be attributed to bird genotype, environmental conditions, inclusion rate and yeast strain.

Table 4: BIOCHEMICAL INDICES OF NOILER CHICKENS FED DIETS CONTAINING SUPPLEMNENTAL LEVELS OF SACCHAROMYCES CEREVISAE

PARAMETER	T1	T2	T3	T4	T5	SEM
Total Protein (g/dl)	**3.17^{c}**	**3.38^{d}**	**3.51^{ab}**	**3.67^{ab}**	**3.99^{a}**	**0.198**
Albumin	**1.67**	**1.65**	**1.73**	**1.64**	**2.13**	**0.1**

(g/dl)	^{a}	^{a}	**a**	^{a}	^{a}	**92**
Globulin (g/dl)	**1.63c**	**1.75**^{ab}	**1.79ab**	**1.88a**	**1.85a**	**0.014**
Urea (mg/dl)	**10.55b**	**10.99**^{b}	**10.12b**	**11.30a**	**10.02b**	**0.28**
Uric acid(mg/dl)	**4.25**^{a}	**4.51**^{a}	**4.17a**	**4.72**^{a}	**4.08**^{a}	**0.103**
Aspartate Transferase (lu/l)	**81.59**^{a}	**81.04**^{a}	**80.75a**	**81.62**^{a}	**81.02**^{a}	**0.298**
Creatine	**1.09**^{a}	**1.00**^{a}	**1.03a**	**1.09**^{a}	**1.23**^{a}	**1.09**
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**
Triglyceride (mg/dl)	**78.35 b**	**75.27b**	**68.51a**	**76.38b**	**76.34b**	**1.07**
HDLC (mg/dl)	**41.45 a**	**43.36a**	**48.45b**	**44.01 ab**	**44.40 ab**	**0.76**
LDLC (mg/dl)	**60.88a**	**54.93b**	**38.65c**	**57.81b**	**57.96b**	**2.26**
VLDLC (mg/dl)	**15.67a**	**15.05a**	**13.70b**	**15.28a**	**15.22a**	**0.21**

Conclusion

The observed increase in globulin concentration and total white blood cell counts suggests improved humoral and cellular immune responses. Yeast β-glucans are recognised for activating macrophages and enhancing antibody production, thereby strengthening host defence mechanisms (World Organisation for Animal Health, 2022).

Collectively, supplementation at 1.0–1.5% appeared to optimise lipid metabolism and immune indices without imposing metabolic stress, while 2.0% enhanced haematological parameters. These findings support the strategic use of *Saccharomyces cerevisiae* as a functional feed additive for improving blood health and immune status in dual-purpose indigenous chickens.

Overall, the biochemical indices indicate that dietary supplementation up to 2.0% *S. cerevisiae* did not exert deleterious effects on liver or kidney function and may enhance metabolic efficiency at optimal inclusion levels (1.0–1.5%).

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