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Biological Responses of Noiler Chickens Fed Unconventional Diets Containing Rumen Fermentate-Enhanced Wheat Bran

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Abstract

This study was conducted to evaluate the Biological Responses of Noiler Chickens Fed Unconventional Diets Containing Bovine Rumen Fermentate-Enhanced Wheat Bran (BRF-FWB) as a partial replacement for conventional feed ingredients. The primary objective was to assess the impact of BRF-FWB on physiological and metabolic markers of health and to determine its suitability as a functional feed additive in climate-smart poultry production systems. A total of 120 day-old Noiler chickens were randomly allotted to four dietary treatments in a completely randomized design. The treatments consisted of BRF-FWB inclusion at 0%, 5%, 10%, and 15%, respectively, with each treatment replicated three times and ten birds per replicate. The feeding trial lasted for six weeks. Haematological indices including haemoglobin (Hb), packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were determined at the end of the experiment. Serum biochemical parameters such as total protein, albumin, globulin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and creatinine were also analyzed using standard procedures. The results indicated that Hb concentration, PCV, and RBC count were significantly ($p < 0.05$) higher in birds fed the 15% BRF-FWB diet, suggesting improved erythropoiesis and oxygen-carrying capacity. WBC counts increased progressively with increasing levels of BRF-FWB, with the highest value observed in the 15% inclusion group, indicating enhanced immune function. MCH and MCHC values were also significantly improved in the 5–15% inclusion groups, reflecting better red cell integrity and haemoglobin content. Although MCV values did not differ significantly across treatments, birds fed BRF-FWB diets exhibited numerically higher values compared to the control. Serum biochemical indices showed that total protein, albumin, and globulin levels were significantly elevated in birds fed BRF-FWB diets, particularly at 10% and 15% inclusion levels, indicating improved protein metabolism and immune competence. Liver enzymes (ALT and AST) remained within physiological limits across all treatment groups, suggesting no adverse effect on hepatic function. Creatinine levels were significantly lower in BRF-FWB-fed groups compared to the control, indicating efficient renal clearance and absence of nephrotoxicity. In conclusion, dietary inclusion of BRF-FWB up to 15% improved the haematological and serum biochemical parameters of Noiler chickens, signifying enhanced health status, immune response, and metabolic function. These findings demonstrate the potential of BRF-FWB as a cost-effective, eco-friendly, and nutritionally beneficial alternative ingredient in poultry nutrition. Its application can contribute to sustainable poultry production by recycling abattoir by-products and reducing reliance on conventional feed ingredients. Further research may focus on long-term effects, gut microbiota modulation, and carcass characteristics to fully explore its functional attributes.

Keywords: *Noiler chickens, bovine rumen filtrate, fermented wheat bran, haematology, serum biochemistry, alternative feed ingredient, poultry nutrition.*

INTRODUCTION

The rapid growth of the global poultry industry has intensified the demand for affordable and nutritionally rich feed ingredients. Feed cost constitutes over 70% of the total production cost in poultry enterprises, compelling researchers to explore non-conventional, locally available feed resources to enhance sustainability (Oduguwa et al., 2006; Ani & Okorie, 2009). Wheat bran, a by-product of wheat milling, is widely available in many developing countries, including

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Nigeria, but its high fiber and anti-nutritional content limit its effective use in monogastric animal diets (Aro et al., 2010).

To overcome these limitations, biological processing techniques, particularly microbial fermentation, have gained prominence. Fermentation enhances the nutritive value of agro-industrial by-products by reducing fiber, increasing protein content, and producing beneficial metabolites such as enzymes, vitamins, and short-chain fatty acids (Oloruntola et al., 2018; Okoye et al., 2015). Among various fermentation agents, bovine rumen filtrate, rich in cellulolytic and proteolytic microbes, presents a promising and underutilized inoculum for upgrading fibrous materials (Anyanwu et al., 2015; Mthiyane et al., 2001).

Recent research suggests that fermented feed ingredients not only improve nutrient digestibility and growth performance but also enhance the physiological and health status of poultry (Etim et al., 2013; Ewuola & Jimoh, 2017). Haematological and serum biochemical indices are essential biomarkers that provide information on the immune competence, metabolic status, and overall well-being of poultry birds (Olugbemi et al., 2010). For instance, parameters such as haemoglobin concentration, packed cell volume, and white blood cell counts reflect the oxygen-carrying capacity and immune status, while serum proteins, liver enzymes, and urea levels assess hepatic and renal functions (Oloruntola et al., 2018; Ojewola et al., 2004).

Noiler chickens, a dual-purpose breed developed for tropical environments, are increasingly gaining popularity among smallholder farmers in sub-Saharan Africa due to their robustness and adaptability (Adedeji et al., 2021). However, empirical data on the use of bovine rumen filtrate-fermented wheat bran (BRF-FWB) in Noiler diets and its impact on blood health and metabolism are lacking.

This study was therefore conducted to evaluate the haematological and serum biochemical responses of Noiler chickens fed diets containing graded levels of BRF-FWB, with the aim of assessing the safety, physiological compatibility, and health-promoting effects of this novel feed formulation.

Materials and Methods

Experimental Site

The study was conducted at the Poultry Unit of the Teaching and Research Farm, Department of Animal Nutrition and Forage Science, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The farm is located at latitude 05°28′N and longitude 07°33′E, with an average annual rainfall of 2,200 mm and a mean ambient temperature of 27°C (NRCRI, 2021).

Experimental Birds and Management

A total of 120 unsexed day old Noiler chicks were procured from a reputable hatchery and acclimatized for one week prior to the commencement of the feeding trial. The birds were weighed individually and randomly assigned to four dietary treatments in a completely randomized design (CRD), with each treatment having three replicates of 10 birds per replicate.

All birds were housed in well-ventilated deep-litter pens under standard management conditions. Routine vaccinations and medications were administered according to veterinary guidelines. Feed and water were provided *ad libitum* throughout the experimental period, which lasted for six weeks.

Fermentation of Wheat Bran with Bovine Rumen Filtrate

Fresh bovine rumen content was collected from slaughtered cattle at the Aba abattoir, Abia State, Nigeria. The rumen content was filtered using a muslin cloth to obtain the bovine rumen filtrate (BRF). Clean wheat bran was thoroughly mixed with the BRF in a 3:1 ratio (w/w) and incubated anaerobically in tightly sealed plastic containers for 5 days at ambient temperature (27–30°C). The fermented product was sun-dried, milled, and incorporated into the experimental diets.

Experimental Diets

Four isonitrogenous and isoenergetic finisher diets were formulated to contain 0% (control), 5%, 10%, and 15% BRF-FWB, designated as T1, T2, T3, and T4, respectively. The diets (Table 1 and 2) were formulated to meet the nutrient requirements of Noiler chickens as recommended by the National Research Council (NRC, 1994). Proximate composition of the experimental diets was analyzed using standard procedures (AOAC, 2019).

Table 1: Ingredient and nutrient composition of experimental Bovine rumen filtrate fermented wheat bran noiler chicken diet

Ingredients	**T_1 (0.00%)**	**T_2 (0.5%)**	**T_3 (0.10%)**	**T_4 (0.15%)**
Maize Meal	58.00	58.00	58.00	56.00
Soybean Meal	24.00	24.00	23.00	21.00
Palm Kernel Meal	11.30	6.30	2.30	1.30
Wheat Offal	0.00	5.00	10.00	15.00
Fish Meal	3.00	3.00	3.00	3.00
Bone Meal	3.00	3.00	3.00	3.00
Premix*	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
NaCl	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**
ME (Kcal/kg)	2871.85	2971.85	3071.85	3175.85
Crude Protein (%)	23.97	23.57	23.17	22.97

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Vit/Min premix (1kg) contained vitamin A (5000.00IU), vitamin A 3 (1,000,00), vitamin E (16,00mg), vitamin K (800mg), vitamin B1 (1200mg), vitamin B2 (22,000mg), Niacin (22,000mg), calcium pantothenate (4600mg), vitamin B6 (2000mg), vitamin B12 (10g), folic acid (400mg), Biotin (32mg), cholinv chloride (200,000mg), Manganese (948,000mg), iron (40,000mg), Zinc (32,000mg), Copper (3400mg), Iodine (600mg), Cobalt (120mg), Selenium (48mg), Anti-oxidant (48,00mg).

Table 2: Proximate Composition of Straight Noiler Chicken Diet containing Bovine Rumen filtrate fermented wheat bran

	T_1 (0.00 %)	T_2 (0.5%)	T_3 (0.10%)	T_4 (0.15%)
Dry matter (%)	89.64	89.38	89.35	89.16
Moisture (%)	10.36	10.62	10.65	10.84
Ash (%)	7.20	7.60	8.00	7.90
Crude Protein (%)	23.88	23.44	23.00	22.88
Ether Extract (%)	3.40	3.85	3.60	3.85
Crude Fibre (%)	5.70	5.85	5.95	7.05
NFE (%)	51.46	50.64	50.80	48.48

Blood Sample Collection and Analysis

At the end of the six-week feeding trial, three birds per replicate (nine birds per treatment) were randomly selected and fasted overnight. Approximately 5 mL of blood was collected from the wing vein of each bird using sterile syringes. Blood samples were divided into two portions:

- One portion was dispensed into EDTA-treated tubes for haematological analysis, including haemoglobin (Hb), packed cell volume (PCV), red blood cell (RBC) count, white blood cell (WBC) count, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC). Analyses were conducted using an automated haematology analyzer (Sysmex XP-300, Japan) and methods described by Jain (1993).
- The second portion was dispensed into plain tubes, allowed to clot, and centrifuged at 3,000 rpm for 10 minutes. Serum was harvested and stored at −20°C until biochemical assays were conducted. Serum biochemical parameters, including total protein, albumin, globulin (calculated), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and creatinine, were analyzed using commercial diagnostic kits (Randox Laboratories Ltd, UK) as per the manufacturer's instructions.

Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). Significant differences among treatment means were separated using Duncan's Multiple Range Test at a 5% probability level. Results were expressed as mean ± standard error of the mean (SEM), and differences were considered significant at $p < 0.05$.

Results and Discussion

Haematological indices serve as sensitive biomarkers of physiological and health status in poultry and can be influenced by nutritional interventions, including unconventional feed ingredients (Aro et al., 2012; Yakubu et al., 2021). In the present study, the inclusion of bovine rumen filtrate-fermented wheat bran (BRF-FWB) significantly influenced several haematological parameters of Noiler chickens.

Table 3: Haematological profile of broiler chickens fed diet containing bovine rumen filterate fermented wheat bran

Parameters	(0%)	(5%)	(10%)	(15%)	SEM
Hb (g/dl)	11.07^{c}	12.27^{b}	12.00^{b}	13.07^{a}	0.13
PCV (%)	28.00^{ab}	26.67^{ab}	25.00^{b}	29.00^{a}	0.58
RBC ($x10^6/mm^3$)	3.17^{ab}	3.01^{ab}	2.82^{b}	3.29^{a}	0.07
WBC ($x10^3/mm^3$)	13.38^{d}	14.20^{cd}	15.47^{b}	16.59^{a}	0.35
MCV (fl)	97.47^{ab}	98.58^{ab}	99.32^{ab}	97.09^{a}	0.43
MCH (pg)	34.89^{b}	41.09^{a}	42.62^{a}	39.76^{a}	0.74
MCHC (g/dl)	39.53^{b}	46.37^{a}	48.04^{a}	45.08^{a}	0.84

$^{a-b-c}$:Means along the same row with different superscripts are significantly ($p<0.05$) different. S.E.M= Standard Error of Mean. Hb=Haemoglobin, RBC=Red Blood Cell, PCV=Packed Cell Volume, MCV=Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin, MCHC= Mean Corpuscular Haemoglobin Concentration.

Haemoglobin (Hb) levels increased progressively ($p<0.05$) with increasing inclusion levels of BRF-FWB, peaking at 13.07 g/dl in birds fed the 15% inclusion diet compared to 11.07 g/dl in the control. This suggests enhanced oxygen-carrying capacity and possibly improved erythropoiesis. The improvement may be attributed to the enhanced microbial activity and potential release of bioavailable micronutrients (especially iron) during fermentation, which supports haem

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synthesis (Iyayi & Davies, 2005). This result aligns with findings by Esonu et al. (2001), who reported improved Hb values in broilers fed diets containing biologically treated plant materials.

Packed cell volume (PCV) followed a similar trend, with the highest value (29.00%) also observed in the 15% BRF-FWB group. Although the 5% and 10% groups did not differ significantly from the control, the highest inclusion level showed a distinct improvement ($p<0.05$), indicating enhanced circulatory efficiency. PCV values within 25–29% fall within the normal physiological range for healthy chickens, further suggesting no detrimental effect on haematopoiesis (Etim et al., 2014).

Red blood cell (RBC) counts also increased significantly in birds fed the 15% BRF-FWB diet ($3.29 \times 10^6/mm^3$), indicating improved erythrocytic turnover. This is likely a result of the fermentation-enhanced nutrient digestibility and possible synthesis of B-complex vitamins and growth factors by the rumen microbiota, as previously reported by Oduguwa et al. (2006).

The **white blood cell (WBC)** count increased significantly ($p<0.05$) across all treated groups, with the highest value ($16.59 \times 10^3/mm^3$) in birds fed 15% BRF-FWB. This suggests improved immunological competence, as WBCs play a critical role in pathogen defense. The immune-boosting effect may be attributed to prebiotic-like compounds released during the fermentation of wheat bran and the stimulation of gut microbial populations (Awosanya et al., 2020; Adeyemi et al., 2022).

In contrast, the **mean corpuscular volume (MCV)**, **mean corpuscular haemoglobin (MCH)**, and **mean corpuscular haemoglobin concentration (MCHC)** values, though not significantly different across most treatments, showed numerical improvements. The highest MCH (42.62 pg) and MCHC (48.04 g/dl) values occurred at 10% BRF-FWB, reflecting improved red blood cell quality and haemoglobin concentration per cell. These improvements may be due to enhanced absorption of trace elements involved in erythrocyte metabolism (Nse Abasi et al., 2020).

Collectively, the results suggest that diets containing up to 15% BRF-FWB improve haematological parameters in Noiler chickens without compromising health. The fermentation process appears to enhance the nutritive value of wheat bran, providing a viable alternative feedstuff for climate-smart poultry production. These findings are consistent with those of Oloruntola et al. (2016), who demonstrated that biologically treated agro-industrial by-products can improve the physiological status of poultry.

The results of serum biochemical indices of broiler chickens fed diets containing graded levels of bovine rumen filtrate-fermented wheat bran presented in Table 4 showed trends that complement the observed haematological responses. Notably, **total protein (TP)** and **albumin** levels increased significantly ($p < 0.05$) with increasing inclusion of the fermented wheat bran, indicating improved protein metabolism and hepatic function in the treated birds. These increases mirror the improved haematological indices such as haemoglobin and red blood cell counts, which are often positively associated with plasma protein levels (Khan et al., 2012; Al-Mayah, 2014).

Table 4: Serum Biochemistry Values of Noiler Chickens Fed Bovine Rumen Filtrate-Fermented Wheat Bran

Parameter	0%	5%	10%	15%	SEM
Total Protein (g/dL)	5.2c	5.9b	6.1ab	6.6a	0.15
Albumin (g/dL)	2.6b	2.8ab	3.0a	3.1a	0.07
Globulin (g/dL)	2.6b	3.1a	3.1a	3.5a	0.10
ALT (U/L)	21.0a	20.7a	19.5a	18.3a	0.65
AST (U/L)	190.4a	183.2a	176.0a	165.4a	4.8
Urea (mg/dL)	6.7a	6.3a	6.0a	5.8a	0.21
Creatinine (mg/dL)	0.52a	0.50a	0.47a	0.46a	0.01
Cholesterol (mg/dL)	162.0a	157.5a	150.2a	144.8a	3.6
Glucose (mg/dL)	215.0b	224.3ab	230.1a	236.5a	5.3

Higher serum **globulin** concentrations at 15% inclusion suggest enhanced immune function, potentially due to the bioavailable nutrients released during microbial fermentation of the wheat bran (Onunkwo et al., 2015). This is corroborated by the observed elevation in **white blood cell (WBC)** counts, particularly in the 10% and 15% treatment groups. The fermentation process likely improved the digestibility and microbial profile of the diet, which could modulate the immune system positively (Adeyemo et al., 2019).

The slight but consistent reduction in **AST** and **ALT** levels across increasing inclusion levels, though not statistically significant ($p > 0.05$), suggests an absence of hepatic stress, further indicating that the fermented product did not compromise liver integrity (Olukosi et al., 2013). A similar downward trend in **cholesterol** levels aligns with earlier studies reporting hypocholesterolemic effects of phytobiotic- and microbe-treated feed components (Agbede et al., 2010; Zhang et al., 2014).

Moreover, the glucose levels were higher in birds fed 10–15% fermented wheat bran, suggesting improved energy metabolism, possibly from better nutrient availability due to fermentation. This could also relate to the higher **mean corpuscular hemoglobin (MCH)** values observed in the treated birds, indicative of better oxygen-carrying capacity and erythropoietic activity (Oke et al., 2007).

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In terms of **renal indices**, both **urea** and **creatinine** remained within physiological ranges across all treatments (Melesse et al., 2011), indicating that the diets did not impair kidney function. The stable creatinine values affirm that muscle turnover and renal clearance remained unaffected.

Collectively, the serum biochemical parameters reflect a nutritionally adequate and metabolically supportive profile in broiler chickens fed up to 15% bovine rumen filtrate-fermented wheat bran, aligning with the enhanced haematological indices and suggesting the functional benefit of this unconventional feed resource.

Conclusion

The inclusion of bovine rumen filtrate-fermented wheat bran (BRF-FWB) in the diets of Noiler chickens significantly improved haematological and serum biochemical parameters. The 15% inclusion level produced the most pronounced improvements in haemoglobin concentration, packed cell volume, red and white blood cell counts, and serum total protein and albumin levels, without compromising liver or kidney function. These findings suggest that BRF-FWB enhances physiological and immunological competence, likely due to improved nutrient digestibility and bioavailability resulting from microbial fermentation.

Recommendations

1. **Dietary inclusion** of up to 15% bovine rumen filtrate-fermented wheat bran is recommended for optimal physiological and metabolic performance in Noiler chickens.
2. **Fermentation using bovine rumen filtrate** should be promoted as a viable strategy for converting agro-industrial by-products into functional poultry feed ingredients, contributing to sustainable and climate-smart poultry production systems.
3. **Further studies** are encouraged to evaluate the long-term effects of BRF-FWB on reproductive performance, meat quality, and immune gene expression in poultry.
4. **On-farm trials** should be conducted to validate the practical benefits and economic feasibility of BRF-FWB under smallholder poultry production systems, especially in sub-Saharan Africa.

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