https://www.mediresonline.org/

ISSN: 2836-2276 Open Access

Journal of Food and Nutrition

Research Article

Hematological and Serum Biochemical Profiles of Hubbard Broiler Chickens Fed Fermented Brewers Dried Grain as Replacement for Maize

Alagbe, John Olujimi*

[1]Adjunct Lecturer, Department of Animal Nutrition and Biochemistry, Gandhi College of Agriculture, Rajasthan, India
[2]Department of Animal Science, Center for Distance Learning and Continuing Education, University of Abuja, Gwagwalada, Nigeria

***Corresponding Author:** Alagbe, John Olujimi, Adjunct Lecturer, Department of Animal Nutrition and Biochemistry, Gandhi Col -lege of Agriculture, Department of Animal Science, Center for Distance Learning and Continuing Edu -cation, University of Abuja, Gwagwalada, Nigeria.

Received Date: 10 October 2026; **Accepted Date:** 21 October 2026; **Published Date:** 02 November 2026

Copyright: © 2026 Alagbe, John Olujimi, this is an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

A 42-days trial evaluated the effects of replacing maize with fermented brewers dried grain (FBDG) on hematology, serum biochemistry, and electrolyte profiles of broiler chickens. 300 one-day-old Hubbard broiler chicks were assigned to five treatments (6 replicates of 10 birds each) under a Completely Randomized Design (CRD). Diets were formulated isonitrogenous and isocaloric according to NRC requirements. Treatment 1 (control) contained no FBDG, while T2, T3, T4, and T5 replaced maize with FBDG at 5 %, 10 %, 15 %, and 20 %, respectively. Solid-state fermentation significantly upgraded raw BDG: Crude Protein (18.0 to 27.1%), Ash (5.08 to 6.89%), and Metabolizable Energy (1980 to 2980 kcal/kg) increased, whereas Crude Fiber (16.0 to 10.01%) and Ether Extract (4.98 to 3.91%) decreased. Hematological indices (PCV, Hb, RBC, MCV, MCH, MCHC, WBC) were significantly higher ($P<0.05$) in FBDG groups (T2–T5) than T1. Similarly, serum total protein, albumin, globulin, calcium, phosphorus, potassium, and bicarbonate were elevated in T2–T5 relative to T1. Conversely, serum AST, ALT, ALP, urea, creatinine were not significantly affected. In conclusion, solid-state fermentation enhances the bio-nutritional value of BDG, and replacing maize up to 20% with FBDG improves oxygen-carrying capacity, protein metabolism, mineral balance, and hypocholesterolemic status without inducing hepato-renal stress.

Keywords: Brewers dry grain, Broilers, Blood, Fermentation, Yeast, Anti-nutrients

Introduction

Maize (Zea mays) is traditionally the primary energy constituent in poultry rations, often making up 50 % to 70 % of the total diet [1]. However, intense competition for maize between human nutrition, livestock feeds, and industrial applications such as biofuel production has inflated its market price [2, 3]. To ensure the financial viability and long-term sustainability of broiler enterprise, researchers and animal nutritionists are actively evaluating low-cost, non-conventional Agro-Industrial By-Products (AIBPs) capable of partially or fully replacing maize without compromising physiological health or growth performance [4].

The main constraint to using agro-industrial by-products like Brewers Dried Grain (BDG) as maize substitutes in monogastric diets is their high fibre composition and the presence of anti-nutrients [5]. BDG is the solid residue remaining after the extraction of wort from barley malt and secondary grains during brewing [6]. It is rich in crude protein (20 % – 28 %) and minerals, but it also contains high levels of Crude Fiber

(CF) and insoluble Non-Starch Polysaccharides (NSPs) such as cellulose, hemicellulose, and lignin [7]. Monogastric animals, including broiler chickens, lack endogenous enzymes (such as cellulases and xylanases) necessary to hydrolyze these complex plant cell wall structures. Consequently, high inclusion levels of raw BDG can impair the access of endogenous digestive enzymes (pepsin, trypsin, amylase, lipase) to ingested nutrients [8, 9], dilutes dietary metabolizable energy and accelerates gut transit time, limiting overall nutrient absorption [10].

Blood parameters serve as internal indicators of physiological health, metabolic status, and tissue safety [11]. Ingesting unprocessed or high-fiber agro-industrial residues can induce metabolic stress, subclinical anemia, organ toxicity, or impaired protein synthesis, which manifest as alterations in blood profiles [12]. Therefore, understanding the physiological boundary of maize replacement with BDG requires thorough evaluation of systemic blood homeostasis.

Previous investigations have shown that substituting maize with cassava by-products reported that high cyanogenic glycoside content and elevated fiber led to reduced Packed Cell Volume (PCV), lower Hemoglobin (Hb) concentrations, and elevated serum transaminases (AST and ALT), signaling subclinical anemia and hepatocyte stress when fed raw or unfermented [13]. Research evaluating raw palm kernel cake as a replacement for maize observed a significant drop in Red Blood Cell (RBC) counts and serum total protein at inclusion levels exceeding 10 % – 15 %. This was attributed to the high β-mannan fiber content, which restricted protein digestibility and mineral absorption required for erythropoiesis [13].

Investigations utilizing rice bran and wheat offal demonstrated that moderate inclusion levels maintained stable hematological profiles, whereas higher levels elevated serum urea and creatinine, indicating increased amino acid oxidation and elevated renal clearance burdens [14]. Conversely, trials utilizing biologically processed or solid-state fermented agro-wastes (such as fungal- or yeast-fermented cassava peels, cocoa pod husks, and rice bran) showed improved hematological values (elevated PCV, Hb, and RBC) and balanced serum proteins [15]. Fermentation reduced anti-nutritional factors, degraded complex NSPs, and released bioavailable minerals (Fe2+, Cu2+) necessary for hematopoiesis [15].

Although Brewers Dried Grain is widely available and cost-effective, its direct application in broiler diets is limited by fiber constraints and variable energy density. Processing strategies such as solid-state microbial fermentation can upgrade its nutritional value and reduce their level of anti-nutrients. Therefore, evaluating the effects of replacing maize with Brewers Dried Grain on the hematological and serum biochemical profiles of broiler chickens is necessary to confirm that this feed ingredient supports optimal growth without inducing physiological stress, organ damage, or metabolic impairment

Materials and Methods

Experimental Site and Environmental Conditions

The feeding trial was conducted from March to May 2025 at the Poultry Unit, Section of Animal Husbandry and Animal Nutrition, Gandhi College of Agriculture, Rajasthan, India. The farm is geographically positioned at latitude 26°55' N and longitude 75°49' E. The area experiences a semi-arid climate; during the experimental period (March to May), the average daily ambient temperature ranged between 28.5^0 and 41.2^0, with a mean relative humidity ranging from 32 % to 58 %. The region receives an average annual rainfall of approximately 500 mm (Encyclopedia Britannica, 2026). Brooding and rearing temperatures were maintained using automated thermostatic controllers within the environmentally controlled house.

Institutional Ethical Approval

All animal handling protocols, surgical procedures, and blood sampling techniques were reviewed and approved by the Institutional Animal Ethics Committee (IAEC) of Gandhi College of Agriculture (Approval Protocol No.: GCA/IAEC/2025/POUL-04). Birds were humanely cared for in strict accordance with national guidelines for laboratory animal welfare.

Pre-Experimental Operations and Sanitation

Two weeks prior to bird arrival, the environmentally controlled battery cage and poultry house was thoroughly swept, washed with high-pressure hot water, and disinfected using a broad-spectrum disinfectant solution containing 2% glutaraldehyde and benzalkonium chloride (Kohrsolin TH, Bode Chemie GmbH, Hamburg, Germany). Feed troughs, nipple drinkers, tray liners, and brooding equipment were scrubbed, disinfected, and sun-dried. The pen was kept sealed for 10 days before chick placement.

Collection, Processing, and Saccharomyces cerevisiae Fermentation of BDG

To process Brewers Dried Grain (BDG) via fungal solid-state fermentation, fresh wet spent grain is first collected from a brewery, pressed or spun to drain excess liquor, and oven-dried or sun-dried to a stable moisture level (~10–12%) for storage before being rehydrated with sterile distilled water to achieve an optimal moisture content of 65%. The rehydrated substrate is pasteurized or steam-sterilized at 121°C for 15–20 minutes to eliminate indigenous microbes, cooled to room temperature (~28–30°C), and inoculated with an active culture of Saccharomyces cerevisiae (live baker's or brewer's yeast) at a rate of 1–5% (w/w, providing approximately 1×107 CFU/g of dry substrate). The inoculated mass is mixed thoroughly, spread into shallow anaerobic or micro-aerophilic fermentation vessels fitted with

one-way airlocks or gas-permeable covers, and incubated at a controlled temperature of 28–32°C for 48 to 72 hours. During this incubation, S. cerevisiae actively metabolizes simple sugars, secretes exogenous enzymes, synthesizes B-complex vitamins, and converts non-protein nitrogen into single-cell microbial protein while producing organic acids that lower substrate pH. Finally, the fermented biomass is oven-dried at low heat (50–55°C) to arrest yeast metabolic activity while preserving heat-sensitive enzymes, vitamins, and probiotic cell wall components (such as β-glucans and mannan-oligosaccharides), before being ground into a fine, nutrient-enriched meal for feed incorporation.

Experimental Animals, Design, and Housing

300 one-day-old unsexed Hubbard broiler chicks were purchased from a reputable hatchery in Rajasthan, India within the month of September, 2025. On arrival, average initial body weight of chicks were recorded using a digital electronic balance (Model A&D FX-300i, A&D Company Ltd., Tokyo, Japan; accuracy: 0.001 g). Birds were randomly allocated to 6 dietary treatments in a Completely Randomized Design (CRD). Each treatment consisted of 6 replicates with 10 birds per replicate. Birds were housed in three-tier galvanized battery cages (100 cm×60 cm×45 cm per pen) equipped with nipple drinkers and trough feeders, providing an floor space allowance of approximately 600 cm2/bird. Starter (Days 1–21) and Finisher (Days 22–42) diets were formulated to be isonitrogenous and isocaloric, fulfilling NRC [16] nutritional requirements for broiler chickens. Feed and clean drinking water were offered at all times. Routine vaccinations were administered according to the prevalent disease profile in the region: At day 5: Newcastle Disease (ND) vaccine (Lasota strain, Hester Biosciences Ltd., Gujarat, India) via eye-drop. Day 12: Infectious Bursal Disease (IBD) vaccine (Intermediate strain, Venkateshwara Hatcheries Pvt. Ltd., Pune, India) via drinking water. Day 19: IBD Booster vaccine via drinking water. Day 28: Newcastle Disease (Lasota strain) booster via drinking water.

The replacement level of maize with FBDG (percentage) includes:

T1 (Control)	0 % FBDG (100% Maize control)
T2	5 % FBDG replacing Maize
T3	10 % FBDG replacing Maize
T4	15 % FBDG replacing Maize
T5	20 % FBDG replacing Maize

Ingredients	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	51.33	48.76	46.2	43.63	41.06
Fermented Brewers Dry Grain (FBDG)	0	2.57	5.13	7.7	10.27
Wheat bran	4.11	4.11	4.11	4.11	4.11
Fish meal	4.00	4.00	4.00	4.00	4.00
Soybean meal	35.01	35.01	35.01	35.01	35.01
Limestone	1.50	1.50	1.50	1.50	1.50
Mono Calcium Phosphate	3.00	3.00	3.00	3.00	3.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Growers Mineral-Vitamin Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30
Total	100.0	100.0	100.0	100.0	100.0
Determined analysis					
Crude protein	23.44	23.21	23.13	23.08	23.02
Crude fibre	3.96	3.87	3.85	3.83	3.82
Ether extract	4.13	4.08	4.05	4.03	4.01
Ash	5.06	6.02	6.02	6.02	6.02
Energy (Kcal/kg)	2998.7	2996.3	2995.1	2993.6	2991.4

Each 2.5 kg contain: 6000000 IU Vit. A; 900000 IU Vit. D3; 40000 mg Vit. E; 2000 mg Vit. K3; 2000 mg Vit. B1; 4000 mg Vit. B2; 2000 mg Vit. B6; 10 mg Vit. B12; 50 mg Biotin; 10000 mg Pantothenic acid; 50000 Niacin; 3000 mg Folic acid; 250000 mg Choline; 8500 mg

Mn; 50000 mg Zn; 50000 mg Fe; 200 mg I; 100 mg Se, 5000 mg Cu

Table 1: Composition of the experimental diets (Starter) from 0 – 28 days

Ingredients	T1	T2	T3	T4	T5
Maize	53.8	51.11	48.52	45.73	43.04
Fermented Brewers Dry Grain (FBDG)	0.00	2.69	5.38	8.07	10.76
Wheat bran	4.00	4.00	4.00	4.00	4.00
Soya meal	35.1	35.1	35.1	35.1	35.1
Fish meal	2.00	2.00	2.00	2.00	2.00
Limestone	4.00	4.00	4.00	4.00	4.00
Mono Calcium Phosphate	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Mineral-Vitamin Premix	0.35	0.35	0.35	0.35	0.35
Salt	100.0	100.0	100.0	100.0	100.0
Total					
Determined analysis					
Crude protein	21.11	21.02	20.92	20.88	20.83
Crude fibre	4.34	3.94	3.89	3.87	3.86
Ether extract	3.93	3.78	3.75	3.73	3.71
Ash	5.87	6.83	6.83	6.83	6.83
Energy (Kcal/kg)	3110.2	3108.9	3106.7	3102.6	3100.2

Each 2.5 kg contain 6000000 IU Vit. A; 900000 IU Vit. D3; 40000 mg Vit. E; 2000 mg Vit. K3; 2000 mg Vit. B1; 4000 mg Vit. B2; 2000 mg Vit. B6; 10 mg Vit. B12; 50 mg Biotin; 10000 mg Pantothenic acid; 50000 Niacin; 3000 mg Folic acid; 250000 mg Choline; 8500 mg Mn; 50000 mg Zn; 50000 mg Fe; 200 mg I; 100 mg Se, 5000 mg Cu

Table 2: Composition of the experimental diets (Finisher) from 28 – 42 days

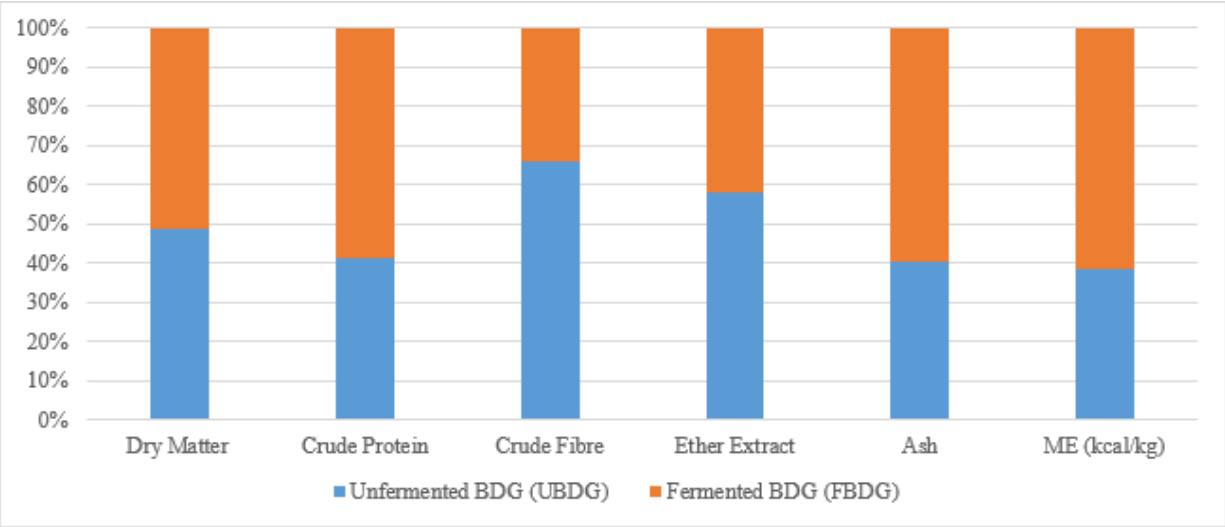


Table 3: Proximate composition of Unfermented (UBDG) and Fermented Brewers Dry Grain (FBDG)

Parameters	T1	T2	T3	T4	T5	SEM
RBC (× 1012/L)	2.37b	3.12a	3.21a	3.35a	3.46a	0.02
Hb (g/dL)	8.97b	10.98a	11.12a	11.35a	11.47a	0.03
Haematocrit (%)	27.18b	32.22a	32.80a	32.91a	32.98a	1.66
WBC (×109/L)	15.06b	19.97a	20.03a	20.09a	20.15a	0.98
MCV (fl)	100.2b	121.6a	123.8a	124.5a	124.8a	7.91
MCH (pg)	39.88b	46.73a	47.11a	47.18a	47.39a	1.87
MCHC (g/dL)	30.09b	37.18a	37.37a	37.81a	37.89a	1.25
Lymphocytes (%)	59.81b	69.87a	70.07a	70.12a	70.15a	2.31
Monocytes (%)	0.93b	1.97a	1.99a	2.02a	2.04a	0.02
Neutrophils (%)	20.87	20.33	20.14	20.09	20.03	0.85

Note on Superscripts: [a, b] Means along the same row with different superscripts are significantly different ($p<0.05$). Rows without superscripts show no significant difference ($p>0.05$); SEM: Standard error of mean

T1 (Control)	0 % FBDG (100% Maize control)
T2	5 % FBDG replacing Maize
T3	10 % FBDG replacing Maize
T4	15 % FBDG replacing Maize
T5	20 % FBDG replacing Maize

Table 4: Haematological indices of broiler chickens fed fermented brewers dry grain

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**
Total protein (g/dL)	5.05b	6.12a	6.19a	6.25a	6.29a	0.03
Albumin (g/dL)	2.61b	3.07a	3.11a	3.15a	3.18a	0.02
Globulin (g/dL)	2.44b	3.05a	3.08a	3.10a	3.11a	0.02
Creatinine (mg/dL)	0.71	0.71	0.73	0.75	0.76	0.01
Urea (mg/dL)	4.72	4.65	4.88	4.92	4.95	0.02
HDL (mg/dL)	32.11b	40.82a	44.15a	44.20a	44.31a	2.11
Triglycerides (mg/dL)	48.92b	61.12a	63.08a	63.21a	63.25a	4.05

Note on Superscripts: [a, b] Means along the same row with different superscripts are significantly different ($p<0.05$). Rows without superscripts show no significant difference ($p>0.05$); SEM: Standard error of mean, HDL: High-density lipoprotein

T1 (Control)	0 % FBDG (100% Maize control)
T2	5 % FBDG replacing Maize
T3	10 % FBDG replacing Maize
T4	15 % FBDG replacing Maize
T5	20 % FBDG replacing Maize

Table 5: Serum biochemical indices of broiler chickens fed fermented brewers dry grain

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**
Calcium (mg/dL)	8.21b	12.34a	12.56a	12.84a	12.92a	0.96
Phosphorus (mg/dL)	4.32b	6.09a	6.17a	6.21a	6.23a	0.02

Potassium (mmol/L)	2.33b	4.46a	4.52a	4.58a	4.61a	0.02
Magnesium (mg/dL)	2.12b	3.54a	3.72a	3.78a	3.91a	0.02
Sodium (mmol/L)	120.4	125.6	128.1	128.7	128.9	8.54
Chloride (mmol/L)	100.8	102.3	105.8	106.2	106.7	11.08
Bicarbonate (mmol/L)	12.33b	18.71a	19.02a	19.55a	19.56a	0.86
Alanine Amino transferase (IU/L)	48.71	50.03	51.12	51.27	51.41	0.73
Aspartate Amino transferase (IU/L)	86.11	87.09	87.22	87.45	87.51	0.61
Alanine phosphatase (IU/L)	61.13	65.08	67.18	68.09	68.11	0.54

Note on Superscripts: [a, b] Means along the same row with different superscripts are significantly different ($p<0.05$). Rows without superscripts show no significant difference ($p>0.05$); SEM: Standard error of mean

T1 (Control)	0 % FBDG (100% Maize control)
T2	5 % FBDG replacing Maize
T3	10 % FBDG replacing Maize
T4	15 % FBDG replacing Maize
T5	20 % FBDG replacing Maize

Table 6: Serum electrolytes and enzymes of broiler chickens fed fermented brewers dry grain

Data Collection

Hematological Determination

Blood (2.5 mL) was drawn from the bronchial vein into K2-EDTA vacuum tubes (BD Vacutainer, Becton, Dickinson and Company, Franklin Lakes, NJ, USA). Samples were analyzed within 2 hours using an Abacus 380 Automated Veterinary Hematology Analyzer (Diatron MI PLC, Budapest, Hungary): Technical Specifications: 3-part WBC differential; 22 parameters; impedance method for cell counting (RBC, WBC, Platelets); light absorption photometry at 540 nm for Hemoglobin (Hb); throughput of 80 tests/hour. Packed Cell Volume (PCV) and erythrocyte indices (MCV, MCH, and MCHC) were computed automatically.

Serum Biochemistry, Mineral Electrolytes, and Enzymes

Blood (2.5 mL) was collected into plain serum separation tubes, clotted at 25^{0}C for 30 minutes, and centrifuged at 3,000×g for 10 minutes at 4^{0}C (Eppendorf Centrifuge 5810 R, Eppendorf AG, Hamburg, Germany). Serum was analyzed on an Erba XL 200 Fully Automated Clinical Chemistry Analyzer (Erba Lachema Brno, Czech Republic) using pre-packaged colorimetric diagnostic kits (Erba Diagnostics Mannheim GmbH, Mannheim, Germany): Technical Specifications: Photometric throughput of 200 tests/hour; diffraction grating spectrophotometer (340–800 nm wavelength range); Peltier-controlled cuvette temperature (37^{0}C±0.1^{0}C).

Specific Assay Methods: Total Protein (Biuret method), Albumin (Bromocresol Green method), AST, ALP and ALT (UV kinetic IFCC method without pyridoxal phosphate), Urea (Urease-GLDH kinetic method), Creatinine (Modified Jaffe kinetic method), Cholesterol (CHOD-PAP enzymatic colorimetric method), Calcium (Arsenazo III method), and Phosphorus (Molybdate UV method).

Electrolytes (K+ and HCO3−): Measured using an InLyte Automated Ion-Selective Electrode (ISE) Electrolyte Analyzer (Fisher Scientific Inc., Waltham, MA, USA) with solid-state crown-ether membrane electrodes.

Proximate analysis of experimental diet and test material was carried out according to the procedure of AOAC [17].

Statistical Analysis

One-Way Analysis of Variance (ANOVA) analyzed data for a Completely Randomized Design using SPSS software (Version 26.0, IBM Corp., Armonk, NY, USA). Means were separated using Duncan's Multiple Range Test with statistical significance established at $P<0.05$.

Results and Discussion

Solid-state fermentation (SSF) of brewer's dried grains (BDG) using (Saccharomyces cerevisiae) serves as a highly

effective processing method to improve low-quality agro-industrial byproducts into high-value feedstuffs [18]. The increase in crude protein from 16.86 % to 24.11 % is primarily driven by the rapid proliferation of yeast biomass and the concentrating effect resulting from fungal and yeast enzymes metabolizing soluble carbohydrates. Simultaneously, the reduction in crude fiber from 19.42 % down to 9.97 % highlights the enzymatic breakdown of lignocellulosic structures, turning indigestible fractions into nutrients that can be easily utilized by the birds [19]. Furthermore, the increase in dry matter (86.22 % to 90.56 %) and ash content (4.86 % to 7.12 %) reflects moisture removal during processing and the relative concentration of essential minerals as organic matter is oxidized [20, 48]. Similarly, the fibrolytic activity directly accounts for the significant boost in metabolizable energy from 1873.1 kcal/kg in the unfermented brewer's dry grain to 2997.0 kcal/kg post-fermentation as complex polysaccharides were hydrolyzed into fermentable sugars and easily digestible organic acids [21, 46].

As revealed in Table 4, haematological indices of broiler chickens fed fermented brewers dry grain. Red blood cell, haemoglobin, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, white blood cell, lymphocytes and monocytes were influenced ($p<0.05$) by the treatment except neutrophil count ($p>0.05$). However, all values recorded were within the standard reference range for healthy birds reported by Campbell (2015). Red blood cell, haematocrit and haemoglobin values were within the normal range [(2.00 – 4.50 (× 1012/L)], 22.00 – 36.00 % and 7.80 – 15.00 g/dL reported by [22, 23]. Red blood cells are responsible for carrying oxygen from lungs to tissues and return carbon dioxide to lungs [24]. This outcome indicates efficient oxygen circulation to drive absorbed nutrients in the tissue of birds. Abnormal mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration suggests iron, folate, vitamin B12 deficiency and other blood disorders [25]. Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration recorded in this study aligns with the range 98.22 – 200 fl, 35.00 – 85.00 pg and 25.00 – 70.00 g/dL cited by [26, 27]. Fermentation lowers anti-nutrients and fibre fractions that typically chelate ions, thereby enhancing the bioavailability of iron, copper, and amino acids essential for hemoglobin synthesis [28. 41]. Low white blood cells and its differentials suggests weak immunity. Elevated white blood cell counts in fermented brewers dry grain groups suggest an active, strengthened cellular immune system without systemic inflammation, supported by prebiotics present in the fermented substrate [29]. White blood cell, lymphocytes, monocytes and neutrophil count were within normal range: 14.50 – 26.00 (×109/L), 40.00 – 75.00 %, 0.01 – 4.00 % and 10.20 – 25.00 % recorded by [30, 31].

Serum biochemical indices of broiler chickens fed fermented brewers dry grain is presented in Table 5. Total protein (5.05 – 6.29 g/dL), albumin (2.61 – 3.18 g/dL), globulin (2.44 – 3.11 g/dL), high-density lipoprotein (32.11 – 44.31 mg/dL) and triglyceride concentrations (48.92 – 63.25 mg/dL) were affected ($p<0.05$) by the treatment except creatinine (0.71 – 0.76 mg/dL) and urea (4.72 – 4.95 mg/dL) ($p>0.05$). Serum total protein, albumin and globulin concentrations were within standard range: 3.80 – 7.00 g/dL, 2.00 – 4.00 g/dL and 1.80 – 4.50 g/dL reported by [28, 49]. Elevated total protein concentrations indicate enhanced intestinal absorption of amino acids from fermented brewer's dry grain [24, 40]. The increase in globulin reflects enhanced humoral immune response and immunoglobulin synthesis [32, 35]. Lower serum urea and creatinine indicate efficient protein utilization and minimal amino acid degradation, resulting in a reduced renal filtration workload [23]. Urea and creatinine values were within 3.70 – 5.00 mg/dL and 0.03 – 1.00 mg/dL recorded by [19]. High-density lipoproteins carries cholesterol from the arteries back to the liver while triglycerides are needed for energy in the body of birds [16, 33]. Though High-density lipoprotein and triglycerides concentrations were higher in groups fed fermented brewers dry grain (T2 – T5) compared to T1, however, values were within the standard reference range reported by [18]. This suggests that the outcome promotes better heart health [12, 34].

Serum electrolytes and enzymes of broiler chickens fed fermented brewers dry grain is presented in Table 6. Calcium, phosphorus, potassium, magnesium, bicarbonate concentrations were higher in T2 – T5 than T1 ($p<0.05$). However, sodium, chloride, alanine amino transferase [ALT], aspartate amino transferase [AST] and alanine phosphatase [ALP] concentrations were not affected ($p>0.05$). Fermentation lowers phytic acid concentration, freeing bound minerals (calcium, phosphorus, potassium and magnesium ion) for systemic intestinal absorption [23]. Higher serum bicarbonate indicates effective acid-base buffering and metabolic stability in fermented brewer's dry grain (FBDG) fed birds [29, 44]. Calcium, phosphorus and potassium concentration recorded in this experiment are within the normal range 7.00 – 15.00 mg/dL, 4.00 – 16.00 mg/dL and 2.00 – 8.50 mmol/L cited by Viñuela et al. (1991). Magnesium, sodium, chloride and bicarbonate values were within 2.10 – 6.00 mg/dL, 100.2 – 200.4 mmol/L, 87.11 – 150.6 mmol/L and 10.00 – 30.00 mmol/L reported by [33, 34. 43]. Alanine aminotransferase (ALT), Alanine phosphatase (ALP) and aspartate aminotransferase (AST) leak into circulation during hepatocyte membrane damage. The non-significant difference in these parameters confirm that FBDG contains no hepatotoxins, preserving liver tissue integrity.

Conclusion

This study confirms that Fermentation can reduce the anti-nutrients and boost the nutritional profile brewer's dry

grain. Replacing maize with fermented brewer's dry grain up to 20 % enhanced physiological and immunological state of birds. It also enhanced nutrient absorption and metabolic balance. Haematological and serum biochemical parameters in all the treatments were within the standard reference range for healthy birds.

References

1. Alagbe, J.O and Oluwafemi, R.A. (2019). Growth performance of weaner rabbits fed Noni (Morinda citrifolia) and Moringa olifera leaf mixture as partial replacement of soya bean meal. International Journal of Advanced Biological and Biomedical Research. 7(2): 185-195
2. Alagbe, J.O and Omokore, E.A. (2019). Effect of replacing soya bean meal with Indigofera zollingeriana leaf meal on the performance and carcass characteristics of growing rabbits. International Journal of Multidisciplinary Research and Development. 6(5): 74-77.
3. Abbasi, Hossein, Alireza Seidavi, Wuyi Liu, and Leila Asadpour. "Investigation on the effect of different levels of dried sweet orange (Citrus sinensis) pulp on performance, carcass characteristics and physiological and biochemical parameters in broiler chicken." Saudi journal of biological sciences 22, no. 2 (2015): 139-146.
4. Olusiyi, J.A. (2014) Performance and carcass charac teristics of broiler finisher fed graded levels of Detarium microcarpium seed meal fortified with brewers' dried grain. Taraba J. Agric. Res., 2: 90-101.
5. Uchegbu, M.C., Omedec, A.A., Chiedozie, I.C., Nwaodu, C.H. and Ezeokeke, C.T. (2010) Performance of finisher broilers fed varying level of raw (sun-dried) cocoyam (Xanthosoma sagittifolium) corm meals. Rep. Opin., 2: 22-25.
6. OKEREKE, Charles O. "Utilization of cassava, sweet potato, and cocoyam meals as dietary sources for poultry." World Journal of Engineering and Pure & Applied Sciences 2, no. 2 (2012): 63.
7. Alagbe, J.O. (2017). Nutrient evaluation of sweet orange (Citrus sinensis) fruit peel as a replacement for maize in the diets of weaner grass cutters. Scholarly Journal of Agricultural Science. 6(8):277-282.
8. Alagbe, J.O and Anuore, D.N. (2024). Growth performance and egg quality of laying hens fed diet supplemented with date palm seed powder. Journal of Trends in Life Sciences, 2(2): 31-38.
9. John, Alagbe Olujimi, and Daniel Nnadozie Anorue. "Effect of Doun Palm Mesocarp Meal (Hyphaene ebaica) As Partial Replacement for Maize on Growth Performance and Haematological Indices of Weaned Pigs." Journal of Biotechnology & Bioinformatics Research. SRC/JBBR-167. DOI: doi. org/10.47363/JBBR/2023 (5) 161 (2023): 2-6.
10. Shittu, M. D., O. J. Alagbe, O. Alaba, E. O. Okanlawon, F. A. Adelakun, P. O. Emmanuel, and D. O. Adejumo. "Effect of ginger, garlic and negro pepper on gut microbes, gut histomorphometry and pathological assessment of selected organs of broiler chickens." Adan Journal of Agriculture 5, no. 1 (2024).
11. Sharma, Singh, Alagbe Olujimi John, Liu Xing, Sharma Ram, and Kumar Amita. "Comparative analysis of ethanolic Juniperus thurifera leaf, stem bark and root extract using gas chromatography and mass spectroemetry." International Journal of Agriculture and Animal Production 2, no. 6 (2022): 18-27.
12. Adewale, A. O., J. O. Alagbe, and Adekemi O. Adeoye. "Dietary supplementation of Rauvolfia vomitoria root extract as a phytogenic feed additive in growing rabbit diets: Haematology and serum biochemical indices." International Journal of Orange Technologies 3, no. 3 (2021): 1-12.
13. Singh, A. S., J. O. Alagbe, S. Sharma, R. A. Oluwafemi, and O. C. P. Agubosi. "Effect of dietary supplementation of melon (Citrallus lanatus) seed oil on the growth performance and antioxidant status of growing rabbits." Indonesian Journal of Innovation and Applied Sciences (IJIAS) 1, no. 2 (2021): 134-143.
14. Ojediran, Taiwo Kayode, I. A. Emiola, V. Durojave, and John Olujimi Alagbe. "Proximate, vitamin and GC-MS profiling of Kigelia africana fruit powder." Cerrado: Agricultural and Biological Research 1, no. 1 (2024): 13-20.
15. Ojediran, Taiwo Kayode, Olujimi John Alagbe, Durojaye Victor, and Emiola Adewale. "Analysis of Kigelia africana (Lam.) Benth. fruit powder's antioxidant and phytochemical properties." Brazilian Journal of Science 3, no. 7 (2024): 38-49.
16. National Research Council, and Subcommittee on Poultry Nutrition. Nutrient requirements of poultry: 1994. National Academies Press, 1994.
17. National Research Council, and Subcommittee on Poultry Nutrition. Nutrient requirements of poultry: 1994. National Academies Press, 1994.
18. Nnadozie Anorue, Daniel, Friday Ubong, and Alagbe Olujimi John. "INVESTIGATING THE EFFECT OF PAWPAW (Carica papaya) ESSENTIAL OIL DIETARY SUPPLEMENTATION ON THE GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF BROILERS." Research in: Agricultural & Veterinary Sciences 7, no. 3 (2023): 164.
19. Shittu, M. T., John Olujimi Alagbe, Olusegun Ojeniyi Ojebiyi, Taiwo Kayode Ojediran, and Trimisiyu Adewale Rafiu. "Growth performance and haematological and serum biochemical parameters of broiler chickens given varied concentrations of Polyalthia longifolia leaf extract in place of conventional antibiotics." Animal Science and Genetics 18, no. 2 (2022).
20. MD, Shittu, J. O. Alagbe, D. O. Adejumo, S. G. Ademola, A. O. Abiola, and B. O. Samson. "Productive performance, caeca microbial population and immune-modulatory activity of broiler chicks fed different levels Sida acuta leaf extract in replacement of antibiotics." Bioinform Proteomics Open Access J 5 (2021): 000143.

21. Olafadehan, O. A., R. A. Oluwafemi, and J. O. Alagbe. "Performance, haemato-biochemical parameters of broiler chicks administered Rolfe (Daniellia oliveri) leaf extract as an antibiotic alternative." Drug Discovery 14, no. 33 (2020): 135-145.
22. Bashir, Musa, John O. Alagbe, Adegbite Motunrade Betty, and E. A. Omokore. "Growth Performance, caeca microbial population and immune response of starter broiler chicks fed aqueous extract of Balanites aegyptiaca and Alchornea cordifolia stem bark mixture." United Journal for Research and Technology 2, no. 2 (2020): 13-21.
23. Polo, Francisco J., Victor I. Peinado, Gines Viscor, and Jesus Palomeque. "Hematologic and plasma chemistry values in captive psittacine birds." Avian diseases (1998): 523-535.
24. Campbell, Terry W., and Christine K. Ellis. Avian and exotic animal hematology and cytology. John Wiley & Sons, 2013.
25. Ammersbach, Mélanie, Hugues Beaufrère, Annick Gionet Rollick, and Thomas Tully. "Laboratory blood analysis in Strigiformes—part I: hematologic reference intervals and agreement between manual blood cell counting techniques." Veterinary clinical pathology 44, no. 1 (2015): 94-108.
26. Gaspar, Helena, Ferran Bargallo, Jordi Grifols, Elisete Correia, and Maria de Lurdes Pinto. "Age and sex-related differences in the haematological parameters of captive African grey parrots (Psittacus erithacus)." (2021): 330-341.
27. Nwaigwe, Chioma U., John I. Ihedioha, Shodeinde V. Shoyinka, and Chukwuemeka O. Nwaigwe. "Evaluation of the hematological and clinical biochemical markers of stress in broiler chickens." Veterinary World 13, no. 10 (2020): 2294.
28. Townsend, Andrea K., Sarah S. Wheeler, David Freund, Ravinder NM Sehgal, and Walter M. Boyce. "Links between blood parasites, blood chemistry, and the survival of nestling American crows." Ecology and Evolution 8, no. 17 (2018): 8779-8790.
29. van Balveren, Jasmijn A., Mirelle JAJ Huijskens, Eugenie FA Gemen, Nathalie CV Péquériaux, and Ron Kusters. "Effects of time and temperature on 48 routine chemistry, haematology and coagulation analytes in whole blood samples." Annals of clinical biochemistry 54, no. 4 (2017): 448-462.
30. Chin, Yi Ling, Kong Fei Chai, and Wei Ning Chen. "Upcycling of brewers' spent grains via solid-state fermentation for the production of protein hydrolysates with antioxidant and techno-functional properties." Food Chemistry: X 13 (2022): 100184.
31. Tan, Yong Xing, Wai Kit Mok, Jaslyn Lee, Jaejung Kim, and Wei Ning Chen. "Solid state fermentation of Brewers' spent grains for improved nutritional profile using Bacillus subtilis WX-17." Fermentation 5, no. 3 (2019): 52.
32. Terefe, Geberemariyam, Mulugeta Walelgne, Dereje Fekadu, Getu Kitaw, Mesfin Dejene, Aeimro Kehaliu, Bethlehem Mekonnen, and Yohannse Habteyesus. "Effect of sun dry brewer spent yeast on chemical composition, in vitro digestibility, and ruminal degradation kinetics of wheat straw." CABI Agriculture and Bioscience 4, no. 1 (2023): 20.
33. Yitayew, Tadlo, Demewez Moges, and Neela Satheesh. "Effect of brewery spent grain level and fermentation time on the quality of bread." International Journal of Food Science 2022, no. 1 (2022): 8704684.
34. Vin, Javier, Miguel Ferrer, and Fernando Recio. "Age-related variations in plasma levels of alkaline phosphatase, calcium and inorganic phosphorus in chicks of two species of raptors." Comparative Biochemistry and Physiology Part A: Physiology 99, no. 1-2 (1991): 49-54.
35. Mitchell, Elizabeth B., and Jennifer Johns. "Avian hematology and related disorders." Veterinary Clinics of North America: Exotic Animal Practice 11, no. 3 (2008): 501-522.
36. Oladele, S. B. "The significance of haematology in the diagnosis and therapy of avian diseases: a review." (2009): 24-39.
37. Kilgas, Priit, Raivo Mänd, Marko Mägi, and Vallo Tilgar. "Hematological parameters in brood-rearing great tits in relation to habitat, multiple breeding and sex." Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 144, no. 2 (2006): 224-231.
38. Latimer, Kenneth S., ed. Duncan and Prasse's veterinary laboratory medicine: clinical pathology. John Wiley & Sons, 2011.
39. Lloyd, S., and J. S. Gibson. "Haematology and biochemistry in healthy young pheasants and red-legged partridges and effects of spironucleosis on these parameters." Avian pathology 35, no. 4 (2006): 335-340.
40. Szabo, A., M. Mezes, P. Horn, Z. Sütő, G. Y. Bázár, and R. Romvari. "Developmental dynamics of some blood biochemical parameters in the growing turkey (Meleagris gallopavo)." Acta Veterinaria Hungarica 53, no. 4 (2005): 397-409.
41. Agubosi, O. C. P., Soliu Muminat Bisola, and J. O. Alagbe. "Effect OF Dietary Inclusion Levels OF Moringaolerifera Oil on the Growth Performance AND Nutrient Retention OF Broiler Starter Chicks." Repository Antis Publisher (2022): 698981.
42. American Metabolic Testing Laboratories, Inc. Chemistry Profile. (2001). www.caprofile.net/t3.html.
43. Café, Marcos Barcellos, Fabrício Pereira Rinaldi, Hugo Ribeiro Morais, M. R. B. M. Nascimento, Antônio Vicente Mundim, and Cristiane Ferreira Prazeres Marchini. "Biochemical blood parameters of broilers at different ages under thermoneutral environment." Worlds Poultry Science Journal 5, no. 9 (2012): 143-146.
44. Liu, Xing, Alagbe John Olujimi, Anorue Daniel Nnadozie, Friday Ubong, and Ige Odunayo Felicia. "Effects of dietary inclusion of Fermented Brewer's Dried Grains (FBDG) on the growth performance, nutrient digestibility and Caecal microbial profile of broiler chickens." (2026).
45. Alagbe, John Olujimi. "Nutritional Evaluation of Fermented Delonix Regia Seed Meal as a Substitute for Soybean Meal in Matured Rabbit Diets: Impact on Growth Performance and Feed Efficiency." International Journal of Modern Medicine and Natural Sciences 1, no. 1 (2026): 15-23.

46. Alagbe, J.O (2026). Haemato-biochemical indices of growing rabbits fed diets containing Hunteria umbellata seed meal as replacement for Soybean meal. Hematology and Disorders, 5(1): 018.
47. Olujimi, Alagbe John. "Effect of partial replacement of Soya meal with Albizia lebbeck seed meal on the growth performance, egg quality and haemato-biochemical constituents of Nera black hens." Discovery Agriculture 11, no. 24 (2025): e18da3161.
48. Olujimi, Alagbe J. "Evaluating the Dietary Supplementation of Canna indica essential oil on the growth performance and Carcass measurement of broiler chickens." Clinical Research and Studies 4, no. 6 (2025): 2835-2882.
49. Olatunji, A.K., Alagbe, J.O and Hammed, M.A. (2016). Effects of varying levels of Moringa olifera leaf meal on performance and blood profile of weaner rabbits. International Journal of Science and Research. 5(6):803-806.
50. Alagbe, J. O. "Effects of feeding varying levels of tigernut (Cyperus esculentus) seed meal on the performance and blood profile of weaner grass cutters." Scholarly Journal of Agricultural Science 7, no. 1 (2017): 15-19.
51. Alagbe, J.O. (2017). Studies on growth performance, nutrient utilization and haematological characteristics of broiler chickens fed different levels of Azolla-Moringa olifera mixture. Greener Journal of Agricultural Sciences. 7(6):145-156.

Citation: Alagbe, John Olujimi, Hematological and Serum Biochemical Profiles of Hubbard Broiler Chickens Fed Fermented Brewers Dried Grain as Replacement for Maize, *J. Food Nutr.* Vol 5, Iss 2. (2026). DOI: 10.58489/2836-2276/053