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Effects of dietary inclusion of Fermented Brewer's Dried Grains (FBDG) on the growth performance, nutrient digestibility and Caecal microbial profile of broiler chickens

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ABSTRACT

This study evaluated the effects of dietary inclusion of Fermented Brewer's Dried Grains (FBDG) on the growth performance, nutrient digestibility and caecal microbial profile of broiler chickens over a 42 days period. Proximate analysis of fermented brewers dry grain showed that it contained dry matter (92.28 %), crude protein (26.18 %), crude fibre (10.21 %), ether extract (4.87 %), ash (6.67 %) and energy (2850 Kcal/kg). A total of 300 one- day-old unsexed broiler chicks (Hubbard) were randomly allocated to 5 dietary treatments in a Completely Randomized Design (CRD), with 6 replicates of 10 birds each. Experimental diet was formulated according to the nutritional requirements for broilers according to NRC (1994). Fermented brewers dry grain was used to replace maize at 0 % (T1, control), 5 % (T2), 10 % (T3), 15 % (T4), and 20 % (T5). Results obtained demonstrated that birds fed T2 to T5 achieved higher body weight gain (BWG) and feed intake alongside lower Feed Conversion Ratios (FCR) compared to control (T1) groups. Similarly, there was an increase in dressed weight, carcass weight, dressing percentage and weights of organs in T2 to T5 compared to T1. Apparent total tract digestibility of dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash content was highest in T3 - T5, intermediate in T2 and lower in T1. Furthermore, the population of *Escherichia coli*, *Salmonella spp* and *Streptococcus spp* profile in the caecum high in T2 to T5 compared to the other group except *Lactobacillus spp* which increased among birds which received FBDG. In conclusion, solid-state fermentation successfully degraded all fibre fractions and reduced the anti-nutrients in brewer's dry grain. Replacing maize with FBDG up to 20 % can improve growth performance, feed intake, optimize gut digestive function and carcass characteristics of broiler chickens.

Keywords: Brewers Dry Grain, Fermentation, *Trichoderma reesei*, Growth, Performance, Digestibility

1. INTRODUCTION

The swift growth of the worldwide poultry sector has increased the need for

traditional feed components, especially maize and soybean meal (Zubairu et al., 2025; Shittu et al., 2020). This demand has increased production expenses, forcing nutritionists to assess agro-industrial byproducts as alternative feed sources. Brewer's Dried Grains (BDG), a significant byproduct of barley malt fermentation, provides a high crude protein content ranging from 20–28% (Alagbe, 2018; Adejumo et al., 2013). Nevertheless, its application in broiler feeds is significantly limited by elevated crude fiber levels (15–20%), substantial non-starch polysaccharide (NSP) content (mainly insoluble arabinoxylans and cellulose), low metabolizable energy, and high bulk density (Alagbe, 2026; Alagbe et al., 2026; Alagbe, 2025). In its unfermented state, high levels of BDG in the diet restrict feed consumption and hinder nutrient uptake, leading to suboptimal growth rates and ineffective feed conversion in birds (Alagbe and Anorue, 2026; Okon et al., 2007).

Earlier research by Onifade and Babatunde (1998); Denstadli et al. (2010) indicated that including unfermented BDG over 10% in broiler feeds substantially decreased final body weight, diminished apparent nitrogen retention, and raised the feed conversion ratio due to elevated non-starch polysaccharides, resulting in mucosal irritation. Inoculating fibrous residues with *Aspergillus niger*, *Trichoderma reesei*, or *Bacillus subtilis* has been demonstrated to decrease crude fiber by 30–40% and increase crude protein by 15–25% via single-cell protein synthesis (Sugiharto and Ranjitkar, 2019; Onu and Madubuike, 2012). Research by Niba et al. (2009) and Gao et al. (2008) on fermented fiber sources, such as fermented rice bran or palm kernel meal, showed considerable enhancements in dry matter, crude protein, and amino acid digestibility when compared to unfermented controls, resulting in 8–12% greater weight gains in finishing broilers. Sun et al., (2015) state that incorporating fermented feeds high in organic acids into broiler diets enhances the ratios of duodenal villus height to crypt depth, thereby increasing the functional absorption area and inhibiting pathogenic enterobacteria (*E. coli*, *Salmonella* spp.) due to reduced intestinal pH.

Though the theoretical advantages of solid-state fermentation are noted, significant knowledge gaps persist concerning the exact dosage thresholds and nutrient use of high levels of FBDG inclusion in contemporary broiler breeds. Information regarding the impact of substituting maize with fermented brewer's dry grain on broiler performance is limited. An prompt assessment will assist in tackling feed price challenges and promoting sustainable circular-economy farming methods.

2. RESEARCH METHODOLOGY

Experimental Site Location

The study was conducted at the Poultry Research Unit, Department of Animal Production and Management, Gandhi College of Agriculture, Rajasthan, India. The experimental period lasted for 42 days and the site lies between latitude 23° 03'N and 30° 01'N and longitude 69° 03'E and 78° 01'E. The annual rainfall and temperature range from 575 - 600 mm and 26.8 to 47.1°C respectively. Relative humidity is about 55 % during the raining season and 30% during the dry season.

Pre-Experimental Hygiene and ethical approval

Two weeks prior to the commencement of the trial, battery cages, pens was thoroughly washed, and disinfected using a Morigad solution containing Glutaraldehyde (15% w/v) + Aquaclean applied at a 0.5% v/v concentration (5 mL/L of water). Feeders and drinkers were washed with detergent and clean water. All handling and experimental procedures were approved by the Institutional Animal Ethics Committee of Gandhi College of Agriculture, Rajasthan (Approval No. GAC/2720C/2025) according to the guidelines for the care and use of laboratory animals in research.

Collection and Fermentation of Brewers Dry Grain

Fresh Brewers Dried Grain (BDG) was collected from a brewery in Rajasthan, India. After collection, it was pressed to drain excess liquor, and sun-dried for 12 days until a stable weight was achieved then rehydrated with sterile distilled water to achieve an optimal moisture content of 65 % (w/w). The rehydrated substrate is steam-sterilized at 121°C for 20 minutes to eliminate indigenous microbes, cooled to room temperature (28°C), and inoculated with an active culture of *Trichoderma reesei* at a rate of 5 % (w/w, providing approximately 1×10^7 CFU/g of dry substrate). After inoculation the sample was mixed thoroughly for 3 minutes, spread into micro-aerophilic fermentation vessels and incubated at a temperature of 28°C for 72 hours. Finally, the fermented brewer's dry grain was oven-dried at low heat 55°C before being mixed into experimental diets.

Management of Experimental Birds, Rations and Design

A total of 300 unsexed day old Hubbard broiler chicks were used for the experiment. Chicks were purchased from a reputable hatchery in Rajasthan India. Upon arrival, average initial body weight of birds was recorded using a digital weighing scale before it was randomly divided into 5 groups each with 60 chicks. Each group was further sub-divided into six replicates each with 10 chicks of comparable group weight. Each group was housed in cages with dimension of 3.5 × 2.2 m, which was designed to accommodate 10 birds along galvanized feeders and plastic drinkers. Starter (Days 1–21) and Finisher (Days 22–42) diets were formulated isonitrogenous and isocaloric according to NRC (1994) requirements. Treatment 1 served as the control (0% FBDG), while Treatments 2, 3, 4, and 5 replaced maize with Fermented Brewers Dried Grain (FBDG) at 5 %, 10 %, 15 %, and 20 %, respectively as presented in Table 2 and 3. Feed and fresh drinking water were offered *ad libitum*. Routine vaccines (Newcastle Disease Lasota strain on Days 5 and 28; Infectious Bursal Disease intermediate strain on Days 12 and 19) were administered per regional guidelines. Other health precautions and sanitary measures were also taken throughout the 42 days experimental period.

Data Collection

Growth Performance

The amount of feed consumed in each replicate was determined as the difference between the feed offered and refused. Body weight was calculated as the difference between final and initial weight (Final body weight – Initial body weight). Average daily feed intake was estimated by dividing the total feed consumption by the experimental period in days. Feed Conversion Ratio (FCR) = Total feed consumed ÷ Body weight gain

Determination of Carcass Characteristics

At the end of the 42 days of the feeding trial, 2 birds were randomly selected per replicate for carcass and organ weight evaluation. The selected birds were starved for 12 hours prior to slaughter while water was provided. The birds were weighed to compare live weights before it was slaughtered by cervical dislocation. After evisceration, the carcass and organ weights were recorded. The eviscerated carcass was chilled at 4 °C for 24 hours. Dressing percentage was calculated as percentage of eviscerated weight divided by live weight multiplied by 100. The weight of the cut-up parts and organs was weighed.

$$\text{Dressing \%} = \frac{\text{Eviscerated weight}}{\text{Live weight}} \times 100$$

Nutrient Digestibility Trial

On Day 35, 6 birds per treatment (1 bird randomly selected from each of the 6 replicates per treatment; 30 bird's total) were transferred to individual metabolic cages equipped with galvanized feeding troughs, nipple drinkers, and individual collection trays. Following a 2 days adaptation period, a 5-day total excreta collection period was carried out. Feed consumed was measured daily per bird. Total daily excreta output was collected quantitatively, weighed, oven dried at 65°C for 24 hours and stored at -20°C. Pooled excreta and feed samples were analyzed for their proximate analysis. Components analyzed includes: dry matter, crude protein, crude fiber, ether extract, and ash following AOAC (2019) procedure. Energy in experimental diet was determined using an Isoperibol Bomb Calorimeter (Model 6200, Parr Instrument Co., Moline, IL, USA).

Caecal Microbiological Quantification

Immediately following slaughter, caecal digesta was collected under sterile conditions. 1.0 g of digesta was homogenized in 9.0 mL of sterile peptone water and diluted serially (10^{-1} to 10^{-8}) in sterile peptone water and plated on selective media (HiMedia Laboratories Pvt. Ltd., Mumbai (10^{-1} to 10^{-8}) in sterile peptone water and plated on selective media (HiMedia Laboratories Pvt. Ltd., Mumbai. Serial dilutions were plated on selective media: *Lactobacillus spp*: De Man, Rogosa and Sharpe (MRS) Agar (HiMedia Laboratories Pvt. Ltd., Mumbai, India), incubated anaerobically at 37°C for 48 hours. *Escherichia coli* on MacConkey Agar (HiMedia Laboratories Pvt. Ltd.), incubated aerobically at 37°C for 24 hours. *Salmonella spp*: Xylose Lysine Deoxycholate (XLD) Agar (HiMedia Laboratories Pvt. Ltd.), incubated aerobically at 37°C for 24 hours. *Streptococcus spp*: KF Streptococcus Agar (HiMedia Laboratories Pvt. Ltd.), incubated aerobically at 37°C for 48 hours. Colonies were counted and log-transformed ($\log_{10}$ CFU/g).

Data analysis and model adopted

Data obtained were subjected to One-Way Analysis of Variance (ANOVA) under a Completely Randomized Design model using SAS (version 9.4, SAS Institute Inc., Cary, NC, USA). Differences between treatment means were separated using Tukey’s test at a significance threshold of $P<0.05$.

The statistical model is shown below:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

Where Y_{ij} is the dependent response parameter, μ is the overall population mean, T_i is the fixed effect of dietary inclusion level ($i=1,2,3,4,5$), and ε_{ij} is the random error term

3. RESULTS

Proximate composition of test ingredients is presented in Table 1. Fermented brewers dry grain had higher concentration of dry matter (92.18 %), crude protein (26.18 %), ash (6.67 %) and energy (2950.1 Kcal/kg) compared to unfermented brewers dry grain with dry matter (89.16 %), crude protein (17.46 %), ash (4.51 %) and energy (1986.2 Kcal/kg). Conversely, crude fibre (18.33 %) and ether extract (6.12 %) were more in unfermented brewers dry grain than 10.21 % (crude fibre) and 4.87 % (ether extract) in fermented brewers dry grain.

As presented in Table 4, growth performance of broiler chickens fed fermented brewers dry grain showed that average daily weight gain, average daily feed intake and feed conversion ratio were influenced ($p<0.05$) by the treatment. Average daily weight gain and feed intake values varied from 44.28 – 53.97 g and 112.2 – 119.5 g ($p<0.05$). Feed conversion ratio (2.21 – 2.53) was highest in T1 compared to the other groups ($p<0.05$).

Carcass characteristics of broiler chickens fed fermented brewers dry grain is presented in Table 5. Dressed weight, eviscerated weight and dressing percentage were influenced ($p<0.05$) by the treatment and their values varied from 1800.1 – 2308.3 g, 1402.2 – 2009.1 g and 73.09 – 83.39 % respectively. Weights of head, neck, wing, back, breast, drumstick, thigh and shank were highest in T2 –T5 than T1 ($p<0.05$).

Table 1. Proximate composition of test ingredients

Parameters	Unfermented BDG (UBDG)	Fermented BDG (FBDG)
Dry Matter	89.16	92.28
Crude Protein	17.46	26.18
Crude Fibre	18.33	10.21
Ether Extract	6.12	4.87
Ash	4.51	6.67
ME (kcal/kg)	1986.2	2,850

Table 2. The composition (%) of the experimental diets for broiler starter (0–28 days)

Ingredients	T1	T2	T3	T4	T5
Maize	51.33	48.76	46.2	43.63	41.06
Fermented Brewers Dry Grain (FBDG)	0.00	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

Vitamin and Mineral premix Each 2.5 kg consists of: Vit A 12000, 000 IU; Vit D3, 2000, 000 IU; Vit. E. 10g; Vit k3 2 g; Vit B1, 1000 mg ; Vit B2, 49g ; Vit B6, 105 g; Vit B12, 10 mg; Pantothenic acid, 10 g; Niacin, 20 g , Folic acid , 1000 mg ; Biotin, 50 g; Choline Chloride, 500 mg, Fe, 30 g; Mn, 40 g; Cu, 3 g; Co, 200 mg; Si, 100 mg and Zn , 45g.

Table 3. The composition (%) of the experimental diets for broiler finisher (29–42 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
Fish meal	35.1	35.1	35.1	35.1	35.1
Soybean 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	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	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

Vitamin and Mineral premix Each 2.5 kg consists of: Vit A 12000, 000 IU; Vit D3, 2000, 000 IU; Vit. E. 10g; Vit k3 2 g; Vit B1, 1000 mg ; Vit B2, 49g ; Vit B6, 105 g; Vit B12, 10 mg; Pantothenic acid, 10 g; Niacin, 20 g , Folic acid , 1000 mg ; Biotin, 50 g; Choline Chloride, 500 mg, Fe, 30 g; Mn, 40 g; Cu, 3 g; Co, 200 mg; Si, 100 mg and Zn , 45g.

Table 4. Growth performance of broiler chickens fed fermented brewers dry grain

Parameters	T1	T2	T3	T4	T5	SEM
Duration of the experiment	42.00	42.00	42.00	42.00	42.00	0.01

Number of birds	60.00	60.00	60.00	60.00	60.00	0.03
Initial body weight (g)	42.31	42.28	43.01	42.55	42.56	0.02
Final body weight (g)	1902.3 ^b	2228.1 ^a	2221.3 ^a	2223.9 ^a	2309.7 ^a	121.4
Body weight gain (g)	1859.99 ^b	2185.82 ^a	2178.29 ^a	2181.35 ^a	2267.14 ^a	130.8
Average daily weight gain (g)	44.28 ^b	51.04 ^a	51.86 ^a	51.93 ^a	53.97 ^a	0.02
Cumulative feed intake (g)	4711.2 ^b	5006.2 ^a	5009.7 ^a	5011.1 ^a	5012.4 ^a	191.7
Average daily feed intake (g)	112.2 ^b	119.2 ^a	119.3 ^a	119.4 ^a	119.5 ^a	0.07
Feed conversion ratio	2.53 ^a	2.29 ^b	2.29 ^b	2.29 ^b	2.21 ^b	0.01

^{abc} Means on the same row having different superscripts are significantly different ($P < 0.05$)

T1 (Control) 0 % FBDG

T2 5% FBDG replacing Maize

T3 10% FBDG replacing Maize

T4 15% FBDG replacing Maize

T5 20% FBDG replacing Maize

Table 5. Carcass characteristics of broiler chickens fed fermented brewers dry grain

Items	T1	T2	T3	T4	T5	SEM
Live weight	1918.2 ^b	2388.1 ^a	2391.8 ^a	2409.1 ^a	2410.2 ^a	128.2
Dressed weight	1800.1 ^b	2220.6 ^a	2221.8 ^a	2308.3 ^a	2301.7 ^a	120.7
Eviscerated weight	1402.2 ^b	1902.4 ^a	1906.3 ^a	2009.1 ^a	2005.4 ^a	112.9
Dressing percentage (%)	73.09 ^b	80.66 ^a	80.70 ^a	83.39 ^a	83.29 ^a	0.07
Head (g)	41.18 ^b	47.12 ^a	47.55 ^a	47.63 ^a	48.23 ^a	0.03
Neck (g)	70.09 ^b	86.55 ^a	86.57 ^a	86.83 ^a	87.66 ^a	0.06
Wing (g)	120.2 ^b	153.7 ^a	153.7 ^a	153.8 ^a	154.2 ^a	0.03
Back (g)	231.4 ^b	267.1 ^a	267.6 ^a	269.8 ^a	271.1 ^a	0.08
Breast (g)	365.4 ^b	431.5 ^a	435.4 ^a	441.5 ^a	445.2 ^a	1.45
Drumstick (g)	191.4 ^b	216.6 ^a	217.4 ^a	218.1 ^a	220.3 ^a	0.06
Thigh (g)	146.4 ^b	200.5 ^a	200.8 ^a	201.4 ^a	208.6 ^a	0.07
Shank (g)	73.91 ^b	84.61 ^a	85.15 ^a	85.34 ^a	87.45 ^a	0.92

^{abc} Means on the same row having different superscripts are significantly different ($P < 0.05$)

T1 (Control) 0 % FBDG

T2 5% FBDG replacing Maize

T3 10% FBDG replacing Maize

T4 15% FBDG replacing Maize

T5 20% FBDG replacing Maize

Table 6. Nutrient digestibility of broiler chickens fed fermented brewers dry grain

Items (%)	T1	T2	T3	T4	T5	SEM
Dry matter	70.18 ^b	79.17 ^b	83.16 ^a	85.85 ^a	86.09 ^a	0.03
Crude protein	68.72 ^b	70.96 ^b	78.11 ^a	78.07 ^a	78.13 ^a	0.02
Ether extract	56.81 ^b	60.72 ^b	67.86 ^a	68.04 ^a	68.55 ^a	0.02

Crude fibre	45.74 ^b	50.91 ^b	54.36 ^a	55.17 ^a	56.09 ^a	0.03
Ash	38.77 ^b	40.88 ^b	44.87 ^a	45.92 ^a	45.98 ^a	0.02

^{abc} Means on the same row having different superscripts are significantly different (P < 0.05)

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

Table 7. Caecal microbial population of broiler chickens fed fermented brewers dry grain

Parameters (Cfu/g)	T1	T2	T3	T4	T5	SEM
<i>Lactobacillus spp</i>	2.95 ^c	5.37 ^b	5.52 ^b	5.75 ^b	6.01 ^a	0.01
<i>Escherichia coli</i>	4.11 ^a	2.93 ^b	2.64 ^b	2.31 ^b	2.25 ^b	0.02
<i>Streptococcus spp</i>	2.07 ^a	1.95 ^b	1.11 ^c	1.05 ^c	1.01 ^c	0.01
<i>Salmonella spp</i>	4.93 ^a	2.72 ^b	2.44 ^b	2.21 ^b	2.16 ^b	0.02

^{abc} Means on the same row having different superscripts are significantly different (P < 0.05)

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

Nutrient digestibility of broiler chickens fed fermented brewers dry grain is presented in Table 6. Dry matter (70.18 – 86.09 %), crude protein (68.72 – 78.13 %), ether extract (56.81 – 68.55 %), crude fibre (45.74 – 56.09 %) and ash digestibility (38.77 – 45.98 %) was higher in T3 – T5, intermediate in T2 and lower in T1 (p<0.05).

As presented in Table 7, caecal microbial population of broiler chickens fed fermented brewers dry grain showed that *Escherichia coli*, *Streptococcus spp* and *Salmonella spp* population were highest (p<0.05) in T1 compared to T2 – T5. These pathogens showed this rank order: T1 > T2 > T3 > T4 > T5 (all p<0.05). *Lactobacillus spp* count were similar (p>0.05) among T2 – T5 but significantly more (p<0.05) than T1.

4. DISCUSSION

Solid-state fermentation (SSF) of brewer’s dry grain allows exogenous fungi (*Trichoderma reesei*) to break down complex plant cell walls into simple sugars and shorter peptides (Mourão *et al.*, 2008). Furthermore, SSF improves dietary protein, enriches the brewers dry grain with B-complex vitamins, lowers pH via organic acid synthesis, and reduces anti-nutritional factors and improves overall nutrient digestibility. Microbes secrete extracellular enzymes (cellulases, xylanases, and glucanases) that cleave complex structural lignocellulosic cell walls (non-starch polysaccharides), solubilizing insoluble fibers into bioavailable oligosaccharides thereby reducing the crude fibre and protein concentration from 18.33 to 10.21 % and 18.0 to 27.1 % respectively (Bist *et al.*, 2024; Van, 2022). The energy increase from 1980.1 (unfermented brewers dry grain) to 2980 kcal/kg (fermented brewers dry grain) suggests that there was efficient breakdown of fibre fractions thereby exposing previously trapped intracellular nutrients while generating short-chain organic acids (Velázquez-De Lucio *et al.*, 2021).

The significant (P<0.05) increase in body weight gain (BWG) and feed intake (FI) alongside lower (improved) Feed Conversion Ratio (FCR) in T2–T5 compared to the control (T1) demonstrates the effectiveness of solid-state fermentation in overcoming the nutritional limitations of raw brewers grain. Raw brewer’s dry grain is fibrous, which typically restricts feed intake in monogastric animals.

However, fermentation by *Trichoderma reesei* positively influences the aroma of experimental diets leading to improved palatability and higher voluntary consumption across all FBDG inclusion levels (5 % – 20 %). The high feed conversion ratio in T1 indicates a lower feed utilization. In contrast, birds fed FBDG converted feed into body weight more efficiently due to reduced gut digesta viscosity and enhanced nutrient bio-accessibility. The result obtained in this experiment is in agreement with the findings of Udedibe et al. (2004) when fermented and unfermented cassava tuber meals were fed to broiler chickens. Similar outcome was also recorded by Emmanuel et al. (2025) who fed broilers fermented citrus pulp as replacement for maize. The feed conversion ratio range recorded in this study was within 2.06 – 2.61 reported by Uchegbu et al. (2010).

The enhanced apparent digestibility of dry matter, crude protein, crude fibre, ether extract and ash content in T2–T5 compared to T1 indicates that the microbial fermentation of brewer's dry grain breaks down lignocellulosic fractions into soluble oligosaccharides, directly improving fiber and total dry matter digestibility. In unfermented feedstuffs, nutrients are trapped within thick cell wall structures. Fermentation disrupts these cell walls, exposing intracellular proteins and lipids to endogenous pepsin, trypsin, and lipase. Furthermore, *Trichoderma reesei* synthesizes high-quality microbial single-cell protein, improving bioavailable amino acid in the gut of birds. This result is in consonance with the reports of Uchegbu et al. (2010) when treated cocoyam tubers were fed to broiler chickens. Dry matter and crude protein range obtained in this study was within 70.00 – 89.00 % and 67.00 – 83.00 % recorded by Panda (2009); Shoremi et al. (1998) when treated palm kernel and cassava peel were fed to birds.

The improved carcass and eviscerated weight, dressing percentage as well as cut part yields (breast, thighs, drumsticks) in birds fed T2 to T5 directly reflect superior nutrient retention. The elevated dressing percentage in FBDG groups shows that a greater proportion of body weight was converted into edible tissue rather than visceral waste. Deposition of skeletal muscle particularly the *Pectoralis major* (breast muscle) depends on balanced essential amino acid absorption (lysine, methionine, and threonine). This report agrees with the earlier findings of Mufwa et al. (2014) when broiler finisher were fed graded levels of *Detarium microcarpum* seed meal fortified with brewers' dried grain. Olajide (2014) also recorded a dressing percentage range of 78.00 – 89.00 % when broilers were fed graded levels of fermented cocoyam peel.

Fermentation of brewer's dry grain promotes organic acid (lactic, acetic, and butyric acids) production in the intestinal flora causing a lower pH to discourage the proliferation of pathogenic organisms (Hernandez and Alagbe, 2025a & 2025b). Acidic environments favors multiplication of *Lactobacillus* spp whereas pathogenic, *Escherichia coli*, *Salmonella* spp., and *Streptococcus* spp are activities are suppressed or eliminated. FBDG in the diet of birds facilitates the production of short-chain fatty acids (SCFAs) primarily butyrate, propionate, and acetate within the caeca to prevent dysbiosis. These short-chain fatty acids creates a balanced intestinal flora, increasing nutrient absorption villus height, and tightening intercellular junction proteins (Hernandez and Alagbe, 2025a & 2025b; Shittu et al., 2021). Elevated SCFA concentrations in T2 – T5 also destroys cell membrane and their virulent parts of pathogenic organisms. The outcome of this study is in conformity with the reports of Velázquez-De Lucio et al. (2021); Etop et al. (2024) who recorded a decrease in *Escherichia coli* and increase in *Lactobacillus* spp in the guts of birds fed different levels of probiotics and organic acid respectively.

5. CONCLUSION AND RECOMMENDATIONS

Replacing maize with *Saccharomyces cerevisiae*-fermented brewers dried grain (FBDG) up to 20% in Hubbard broiler diets improves growth performance, feed conversion efficiency, nutrient digestibility, dressing percentage, and commercial carcass yields. FBDG represents an effective, sustainable maize substitute that enhances nutrient availability and meat yield in broiler chickens without adverse physiological effects. Consequently, FBDG can safely replace conventional feedstuffs up to a 20 % inclusion level, reducing feed costs while supporting optimal digestive and growth performance in broiler chickens.

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Author Contributions

Alagbe Olujimi John, designed the work, laboratory analysis and correction of manuscripts, Friday Ubong, Ige Odunayo, Xing Liu and Daniel Anorue did the statistical analysis, data collection and correction of manuscript.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval & declaration

The Animal ethical guidelines are followed in the study for species observation & identification. (Ethical approval code: UD/2-2035Y).

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Data and materials availability

All data associated with this study will be available based on the reasonable request to corresponding author.

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