Performance Characteristics and Nutrient Utilization by Meat Type Chicken Fed *Fusarium oxysporum* Degraded Brewer Dried Grain

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to determine the effect of *Fusarium oxysporum* degraded Brewer dried grain (BDG) on the performance and nutrient utilization of broiler chicken at starter and finisher phases. Undegraded and degraded (BDG) were used to compound rations for broiler birds for 8 weeks. The undegraded BDG was used at 7% inclusion level and the degraded BDG was used at 3, 5, and 7%. A total of 150 day old chicks were randomly selected and allocated for 5 treatments. Thirty 30 birds were allocated to each treatment with three replicates each. *Fusarium oxysporum* was inoculated into BDG through Solid State Fermentation for a period of 7 days. This was used as degraded sample. There was improvement in the crude protein, ash, and gross energy after biodegradation. Biodegradation led to reduction in crude fibre, cellulose, hemicellulose, and detergent fibre content. At starter phase, there were significant ($P < 0.05$) ($P = 0.05$) differences in feed consumption and body weight gain and the highest feed consumption (FC) and body weight

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gain (BWG) were found in treatment 5, which contained 7% degraded BDG (DBDG) and the FC and BWG they were 88.93 and 41.07g/bird/day, respectively. At the finisher phase, there were significant ($P=0.05$) differences in both the average feed intake and the average body weight gain by the birds. The highest feed intake was found in treatment 5 (140 g/b/d) and the highest body weight gain was also observed in treatment 5 (78.21g/b/d). Significant differences ($P=0.05$) were also observed for the feed conversion ratio at the finisher phase. The best value (1.64) was recorded at the control treatment and this was followed by the value recorded for treatment 5 (1.79). The relative cost benefits revealed that it is profitable to feed broilers with *F. oxysporum* degraded BDG. The results showed that *F. oxysporum* was able to enhance the feeding value of BDG and this impacted positively on the feed consumption and body weight gain by the birds.

Keywords: Biodegradation; brewer dried grains; broilers; *Fusarium oxysporum*.

1. INTRODUCTION

Low poultry production cost can be achieved if the use of unconventional agro-industrial by-products (AIBs) agro-industrial by-products is put into consideration. The ever widening competition between humans and livestock is the cause of unabated increase in the cost of conventional feed ingredients. This, undoubtedly, affects the cost of feeding and many farmers may not be able to afford it. Researchers are therefore challenged to find alternatives to these conventional ingredients. So far, the considered alternatives are the agro-industrial by-products.

(AIBs)(AIBs) are obtained from agricultural products after the main products have been obtained. They [1,2]. AIBs are the most abundant renewable resources on earth and they are considered because they are available and inexpensive. Furthermore, it is pertinent to consider the use of AIBs because they are beginning to constitute environmental nuisance in some cases. Hence, recently there has been a great campaign for the exploitation of these wastes as low cost materials for the production of microbial enzymes through the instrumentality of solid state fermentation or submerged fermentation techniques.

AIBs cannot be added in high levels because of their low energy content, high fibre content and poor availability of nutrients owing to non-starch polysaccharides content which can account for about 70-90% of the cell wall [3,4,5]. The primary challenge about the use of these unconventional ingredients is the high level of fibre present in them. The presence of the fibre does not make the content to be readily digested by the monogastric animals. Although the animals' innate enzyme production is enough to handle normal digestive activities, the presence of high fibre content and lack of sufficient

microorganisms in the gastrointestinal tract make the digestion difficult. The external processing of these non-conventional ingredients consists of enhancing and breaking complex contents like lignin, cellulose, and hemicellulose present in their respective plant cell walls.

It has been shown that after processing (chemical, physical or biological); there tend to be an improvement in the nutritional quality of such materials which invariably leads to increase in productivity of the animals. Brewers' grains are the solid residue remaining after the processing of dried cereal grains for the production of beer and other malt products. Though barley is the major cereal that is being used for brewing, beers can also be made from other cereals such as: wheat, maize, rice, and sorghum. Brewers' grains are obtained at the end of the brewing process [6].

The objectives of this study include: Assessment of the effect of *Fusarium oxysporum* in degrading brewer dried grain; assessment of the effect of feeding degraded brewer dried grain on the performance of broilers; and assessment of the effect of degraded brewer dried grain on the nutrient utilization by broilers.

2. MATERIALS AND METHODS

The used BDG were obtained from a brewery located in Ibadan, Nigeria. It was dried to constant weight at 60°C. A total of 25kg of the dried BDG were autoclaved at 121°C for 15 minutes. The autoclaved BDG was then inoculated with *F. oxysporum* under aseptic condition after adjusting its moisture level to 25%. After 7 days, the biodegradation reaction was stopped and the material was dried [7]. Samples were then withdrawn for proximate analysis using the method of [8]. The *F. oxysporum* used was obtained from Microbiology

Unit of Department of Biological Sciences of Bowen University, Iwo, Nigeria. The characterization of the obtained *F. oxysporum* was known by the use of manual of [9]. A total of 150 day old broiler chicks (Anak strain) were used for the experiment. There were five dietary treatments of 30 birds each and three replicate of 10 birds each. Diet 1 (control) contained neither degraded nor undegraded BDG. Diet 2 contained 7% undegraded BDG, whereas diets 3, 4, and 5 contained 3, 5, and 7% levels of *F. oxysporum* degraded BDG, respectively. The experimental design used was Completely Randomized Design. Data were analyzed statistically using the Analysis of Variance (ANOVA) technique of [10]. Where statistical significant differences were observed, the treatment means were compared according to [11].

3. RESULTS AND DISCUSSION

Results of improvements in the levels of crude fibre, gross energy, crude protein, detergent fibres, and ash in BDG after biodegradation with *F. oxysporum* are shown in Table 1. It was

observed, after fungal biodegradation that there were positive changes in crude protein value from 26.11 to 32.11g/100gDM (22.98%). The ash content increased from 9.94 to 12.51g/100gDM which were 25.86%. It was noted that the detergent fibre and the crude fibre content of the BDG reduced after biodegradation. The cellulose, acid detergent lignin, and crude fibre had 15.25, 14.71%, and 38.87% reduction, respectively, after biodegradation.

At the starter phase, body weight gain and feed intake were significantly ($P=0.05$) affected. The relative cost benefit revealed that the birds fed DBDG gave better profit margin than the ones fed UBDG. At the finisher phase, the performance of the birds showed that there were significant ($P=0.05$) differences in body weight gain, feed intake, and feed conversion ratio. Besides, the profitability of placing the birds on DBDG was shown by the relative cost benefit as the birds placed on DBDG showed better profit margins. Fungal biodegradation of fibrous agro-industrial by-products has been earlier reported by [12,13,14,15]. The previous work of [16]

Table 1. Proximate and detergent fibre analysis of undegraded and degraded brewer dried grain (g/100 gDM)

Parameter	Undegraded BDG	Degraded BDG
Dry matter	90.95	88.78
Crude protein	26.11	32.11
Ether extract	6.83	4.39
Ash	9.94	12.51
Crude Fibre	16.13	9.86
Gross Energy (Kcal/kg)	4.81	5.91
Cellulose	7.21	6.11
Hemicellulose	5.80	4.41
Neutral detergent fibre	2.43	1.30
Acid detergent fibre	2.24	1.96
Acid detergent lignin	6.12	5.22

Table 2. Performance of broiler starter fed diets containing undegraded and degraded brewer dried grain

Parameter	Control	7%UBDG	3%DBDG	5%DBDG	7%DBDG	SEM
Body weight gain (g/b/d)	37.5 ^c	38.92 ^b	39.64 ^b	40.56 ^a	41.07 ^a	1.10
Feed intake (g/b/d)	81.79 ^b	78.57 ^c	87.5 ^a	88.21 ^a	88.93 ^a	2.21
Feed conversion ratio	2.18	2.01	2.20	2.19	2.16	0.051
Mortality (%)	0	0	1	1	0	-
Relative cost benefit (%)	0.00	3.85	3.90	4.22	4.42	-

a, b, c, Means in the same row with different superscripts differ significantly ($P<0.05$); UBDG= Undegraded brewer dried grains; DBDG=degraded brewer dried grains.

SEM = Standard Error of Mean

showed improvement in the nutritional value of plantain wastes via the activities of fungi using solid state fermentation technique. These authors reported that ripe plantain peels and unripe plantain peels were subjected to biodegradation using *A. niger*, *A. flavus*, and *Penicillium spp.* After 7 days of fermentation, *A. niger*, *A. flavus*, and *Penicillium spp.* increased the crude protein content of the unripe plantain peel by 34.00, 30.30, and 2.30 and ripe plantain by 9.50, 4.50, and 4.00%, respectively. *A. niger* and *A. flavus* grown on pineapple wastes produced similar results and there was reduction in cellulose and crude fibre contents [17]. In the earlier works of [7], the authors reported that over 35% of the original cellulose content of the substrate was lost during solid-state fermentation. Dhanasekaran and Paneerselvam (2011) also opined that fungi have the ability to produce a variety of enzymes and that cellulase, hemicellulase, pectinase, and xylanases among others were produced by fungi, which could degrade the non-starch polysaccharides (NSPs) in the substrate. The cell contents of AIBs are digestible but for the cell walls which consist primarily of cellulose and hemicellulose. In addition, the AIBs are poorly digested also because they are highly lignified. The improvement in crude protein value of the DBDG may be due to the ability of *F. oxysporum* (like other fungi earlier mentioned) to release multiple enzymes during biodegradation which will break the plant cell wall and hence the release of the hidden proteins in the cells. The improvements may also be due to the addition of single cell protein by the biodegradation agent *F. oxysporum* [18]. Improvement in the energy availability in DBDG may be due to ability of the *F. oxysporum* to dismantle the starch and the non-starch polymers into monomer sugars [13,19]. The gross energy in DBDG increased after biodegradation possibly because of the

oxidation of the ether extract. Lipids when oxidized have the ability to yield tremendous quantity of energy. Performance characteristics revealed better weight gain by the birds placed on DBDG than those placed on UBDG at both starter and finisher phases. The breaking down of NSPs contained in the BDG may be responsible for this. NSPs have been reported to increase viscosity of digestive content and this will negatively affect digestion of the feed and bioavailability of the nutrient content. The NSPs can make nutrients complex, thereby obstructing their absorption and the complete utilization of the diets. The performance of the birds was better at the finisher phase, possibly due to a better utilization of nutrients as the birds increased in age. In the works of [20], it was reported that inclusion level of agro-industrial by products in animal's diet is determined by some factors which are: the quality and digestibility of the materials, the species of the animals, and the age of the animals. It can also be seen from Tables 2 and 3 that the feed intake of the birds increased with their age. The older the birds, the more quantity of feed they consumed. In Tables 6 and 7, it was observed that there were significant ($P=0.05$) differences in the digestibility of ether extract, crude protein, crude fibre, ash, and dry matter at both starter and finisher phases. The use of fungi to improve the digestibility of high fibrous materials has been documented by [21]. The author observed that with increment of cellulose level in diet, there was a great reduction in the digestibility and hence reduction in metabolizable energy values.

It was also reported by the author that the efficiency of utilization of metabolizable energy by broilers decreased with increasing cellulose in the diets. Besides, it was also submitted that feed utilization decreased as fiber level increased and as a result of these, energy utilization also

Table 3. Performance of broiler finishers fed diets containing undegraded and degraded brewer dried grain

Parameter	Control	7%UBDG	3%DBDG	5%DBDG	7%DBDG	SEM
Body weight gain (g/b/d)	72.14 ^d	72.50 ^d	74.64 ^c	76.78 ^b	78.21 ^a	2.24
Feed intake (g/b/d)	118.57 ^d	119.29 ^d	126.79 ^c	133.93 ^b	140.00 ^a	4.24
Feed conversion ratio	1.64 ^c	1.65 ^c	1.70 ^b	1.74 ^a	1.79 ^a	0.014
Mortality (%)	0	1	1	1	0	-
Relative cost benefit (%)	0.00	3.14	3.56	4.22	4.55	-

a, b, c, Means in the same row with different superscripts differ significantly ($P<0.05$); UBDG=undegraded brewer dried grains; DBDG=degraded brewer dried grains

SEM = Standard Error of Mean

Table 4. Composition of experimental diet at starter phase

Ingredients	Control	7% UBDG	3% DBDG	5% DBDG	7% DBDG
Maize	54	56	53	54	54
UBDG	-	7.0	-	-	-
DBDG	-	-	3.0	5.0	7.0
Wheat offal	5.2	0.3	2.3	2.3	2.3
Groundnut cake	11.1	15	15	12	11
Soya bean meal	20	12	17	17	16
Fish meal	6	6	6	6	6
Bone meal	2	2	2	2	2
Oyster shell	1	1	1	1	1
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Metabolizable energy	2912.34	2958.71	2874.47	2906.52	2890.03
Crude protein	23.20	23.43	22.68	22.70	22.36

UBDG=undegraded brewer dried grains; DBDG=degraded brewer dried grains. *Vitamin mineral premix supplied the following vitamins and trace elements per kg diet: Vit. A 12500IU, Vit. D₃ 2500IU, Vit. E 40 mg, Vit. K₃ 3 mg, Vit. B₁ 3 mg, Vit. B₂ 5.5 mg, Niacin 5.5 mg, Calcium Pantothenate 11.5 mg, Vit B₆ 5mg, Vit B₁₂ 0.025 mg, Folic Acid 1mg, Biotin 0.08 mg, Mn 120 mg, Choline Chloride 500 mg, Fe 100 mg, Zn 80 mg, Cu 8.5 mg, I 1.5 mg, Co 0.3 mg, Se 0.48 mg and Antioxidant 120 mg

Table 5. Composition of experimental diet at finisher phase

Ingredients	Control	7%UBDG	3%DBDG	5%DBDG	7%DBDG
Maize	54	57	56	57	57
UBDG	-	7.0	-	-	-
DBDG	-	-	3.0	5.0	7.0
Wheat offal	12.4	6.5	11.0	9.1	6.5
Groundnut cake	10.2	10.2	10.2	10.2	10.2
Soya bean meal	16.7	12.6	13.1	12	12.6
Fish meal	3	3	3	3	3
Bone meal	2	2	2	2	2
Oyster shell	1	1	1	1	1
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Metabolizable energy	2904.44	2998.20	2911.72	2928.09	2947.24
Crude protein	20.57	20.36	20.55	20.29	20.51

UBDG=undegraded brewer dried grains; DBDG=degraded brewer dried grains. *Vitamin mineral premix supplied the following vitamins and trace elements per kg diet: Vit. A 12500IU, Vit. D₃ 2500IU, Vit. E 40 mg, Vit. K₃ 3 mg, Vit. B₁ 3 mg, Vit. B₂ 5.5 mg, Niacin 5.5 mg, Calcium Pantothenate 11.5 mg, Vit B₆ 5 mg, Vit B₁₂ 0.025 mg, Folic Acid 1 mg, Biotin 0.08 mg, Mn 120 mg, Choline Chloride 500 mg, Fe 100 mg, Zn 80 mg, Cu 8.5mg, I 1.5 mg, Co 0.3 mg, Se 0.48 mg and Antioxidant 120 mg

Table 6. Nutrient digestibility of experimental broilers at starter phase

Composition (%)	Control	7%UBDG	3%DBDG	5%DBDG	7%DBDG	SEM
Ether extract	61.11 ^a	51.63 ^c	55.35 ^c	54.55 ^c	57.09 ^b	2.02
Crude protein	72.35 ^c	72.70 ^c	75.77 ^b	78.39 ^a	79.00 ^a	1.93
Crude fibre	58.43 ^d	60.31 ^c	62.22 ^b	64.11 ^b	66.12 ^a	1.54
Ash	35.56 ^c	34.44 ^c	38.21 ^b	38.01 ^b	44.91 ^a	1.23
Dry matter	70.84 ^b	71.29 ^b	71.15 ^b	71.46 ^b	72.33 ^a	2.45

a, b, c, Means in the same row with different superscripts differ significantly ($P < 0.05$); UBDG=undegraded brewer dried grains; DBDG=degraded brewer dried grains

Table 7. Nutrient digestibility of experimental broilers (finisher phase)

Composition (%)	Control	7%UBDG	3%DBDG	5%DBDG	7%DBDG	SEM
Ether extract	62.49 ^b	60.07 ^c	63.53 ^c	65.41 ^b	69.92 ^a	2.12
Crude protein	63.95 ^b	63.35 ^c	64.29 ^b	65.15 ^b	67.07 ^a	1.45
Crude fibre	62.45 ^d	65.56 ^c	66.61 ^c	68.33 ^b	71.31 ^a	1.31
Ash	46.08 ^b	44.01 ^c	45.45 ^b	49.97 ^b	48.79 ^a	1.12
Dry matter	69.52 ^c	66.81 ^d	70.25 ^b	70.21 ^b	72.75 ^a	2.34

a, b, c, Means in the same row with different superscripts differ significantly ($P < 0.05$); UBDG=undegraded brewer dried grains; DBDG=degraded brewer dried grains
SEM= Standard Error of the Mean

decreased. Furthermore, it was shown to improve nutrient digestibility, destroy anti-nutritional factors, and manipulate gut flora population. In the work of another author [12], it was reported that the better utilization of nutrients could also be attributed to increase in bioavailability of nutrients present within the cells and possibly elimination of the anti-nutritional factors and reduction in intestinal viscosity after fungal biodegradation. The improvement in the various nutrient digestibilities shows that biodegradation of BDG provided the birds free access to the nutrients trapped within the cells and allows maximum utilization for the birds.

4. CONCLUSION

The improvement in the birds' performance may possibly be attributed to the effect of biodegradation process on the fibrous BDG. In addition, the synergistic activities of the cocktail of enzymes produced by *F. oxysporum* during the biodegradation process led to positive modification of the BDG, which subsequently affected the performance of the birds. There were improvements in the body weight gain, feed intake, feed conversion ratio, and relative cost benefits. These would make broiler production a profitable business for farmers. This generally shows that solid state fermentation or inclusion of brewer dried grains degraded with *F. oxysporum* can positively affect the performance of broiler birds and that fungal biodegradation is beneficial to the poultry industry.

ETHICAL APPROVAL

Animal Ethic committee approval has been taken to carry out this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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