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Growth Performance, Nutrient Utilization of Brewers Dried Grain and Sorghum Spent Grain (*Burukutu* Residue) by Broiler Chickens

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Abstract – **A study was conducted for 8 weeks to compare the utilization of Brewers Dried Grain and Sorghum Spent Grain (*Burukutu* residue) by broiler chickens. A total of 105, day-old broiler chicks (*Abor acre* strain) were used till 8 weeks. They were weight balanced and randomly divided into 3 treatment groups replicated 5 times with 7 birds in each, making a total 35 birds per treatment group. Three experimental diets, each diet per treatment group, were formulated with the control having neither Brewers' Dried Grain (BDG) nor Sorghum Spent Grain (SSG). The other two diets contained either 15% Brewers Dried Grain or 15% Sorghum Spent Grain. At the end of the starter phase, SSG was significantly (P<0.05) lower than the BDG and the control in terms of final weight, average weight and feed efficiency. BDG however, did not differ (P>0.05) from the control. The response criteria at the end of the finisher phase showed that, there were no differences (P>0.05) among the treatments in terms of final weight, average weight gain and feed efficiency. Control however had lower (P<0.05) feed intake compared to other treatments. The apparent digestibility differs (P<0.05) among the treatment groups in crude protein, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre, hemicellulose and cellulose. The cost of feed/kg gain, favored Brewers' Dried Grain, followed by Sorghum Spent Grain. The most expensive was the control diet. It was concluded that, at 15% inclusion level, both BDG and SSG are well utilized and they can be a better substitute for maize in conventional broiler feed ration, however, the cost value of the feed ingredients at the time of purchase will determine the preference.**

Keywords – **Performance Characteristics, Nutrient Digestibility, Brewers' Dried Grain, Sorghum Spent Grain (*Burukutu* Residue), Broilers.**

I. Introduction

The influence and the rate of expansion of broiler production in Africa are due to its economic benefits which include, the improvement in income and the quality of living of the citizens [1, 2, 3]. However, in Nigeria, protein malnutrition is still a recent issue [4] due to the high cost of livestock production which has limited the capacity of an average Nigerian to consume adequate animal protein quantity. The reason could be drawn from the common knowledge that feeds constitute the most expensive input in animal production, and a reduction in its cost will vividly reduce the overall production outlay and increase the profit margin of the farmer [5]. Olorede *et al.,* [6] had earlier suggested the use of cheap, less competed, locally and easily available agro-industrial products, also known as unconventional feedstuffs, for poultry diets.

In the past, malted barley has been used to produce Brewers Spent Grain (BSG) and this received great attention in the field of animal production, however, in Nigeria, where sorghum production has replaced the importation of barley malts as the main grit material, the resultant effect is the production of Sorghum Spent Grain (SSG). The material properties of SSG are therefore expected to differ substantially from those of BSG due to inherent differences in their raw materials and the processing methods [7]. In addition, due to the sources of grains, research comparison that deals with the use of brewers' grains in poultry diets are sometimes inconsistent with previous research data. Brewers Dried Grain (BDG) which in some articles is referred to as BSG, is an excellent source of by-pass protein and digestible fibre with a good amino acid profile, high mineral and vitamin B content [8]. Although, the nutritional content of BDG varies depending on the grain used (barley, wheat, rice, or corn), an inclusion rates of 2% to 20% in diet have been recommended for both broilers and layers, [9]. Ankra *et al*., [10] for example, stated that 15% inclusion level of SSG treated with plantain peels ash extract in the diets of broiler chickens (Starter and Finisher) had no adverse effects on the growth performance and carcass quality. Therefore, this research assumed 15% inclusion level as the basis of comparison between BDG and SSG, with no enzymatic or alkali treatment to recommend a more easily adaptable and adoptable farmer friendly feed ingredient preparation.

The cost of production is not the only concern to nutritionists, but the consideration for the nutrient requirement which is a major factor in raising broilers [11] because the performance of the birds depends to a great extent on the provision of adequate nutrients by the formulated diets for various productive purposes [12]. However, it is also important to stress the limitation in the use of these agro-industrial wastes due to the amount the animals will voluntarily consume considering the bulkiness, low digestible nutrients and high content of crude fibre in the feed. In addition, the gut dimensions of the animals limit the quantity of fibrous materials that they can consume due to the lack of digestive framework that can elaborately digest such feed [1, 13].

This study therefore aims at comparing the utilization of brewers dried grain and sorghum spent grains at the same level of inclusion on the performance characteristics of broiler chickens while lowering the cost of production.

II. Materials and Methods

Experimental Site

The experiment was carried out at the Teaching and Research Farm of the University of Ibadan, Ibadan, Nigeria. The region is characterized by a fairly uniform temperature, moderate to heavy seasonal rainfall and high relative humidity.

Procurement and Drying of Test Ingredients

Brewer's dried grain (BDG) was obtained from the Nigerian Breweries Plc, Ibadan, Nigeria while Sorghum Spent Grain (SSG) was procured from a local alcohol producing mill at the Army Barracks Ojoo, Ibadan, Nigeria. The two ingredients were transported to the experimental site where both were sundried for 4 and 8 days respectively in bright sun-light to about 10% moisture content.

Formulation of Experimental Diets

Three experimental diets were formulated with control diet containing neither BDG nor SSG. Each of the other two diets contained either 15% inclusion of BDG or SSG. The starter phase lasted for 2 weeks after brooding while the finisher phase lasted for 4 weeks. The diets are summarized below:

1. CTRL: Control Diet.
2. 15% BDG: Diet containing 15% Brewers' Dried Grain.

3. 15% SSG: Diet containing 15% Sorghum Spent Grain.

Calorie/Protein ratio was calculated by: Metabolisable Energy (kcal/kg) ÷ Crude Protein.

Experimental Animals Design and Management

A total of 105, day-old broiler chicks (*Abor acre*), purchased from the CHI Farms, along Lagos/Ibadan Express way, Nigeria, were used for the experiment. They were brooded in one of the brooding pens at the University of Ibadan Teaching and Research brooding unit. The pen was divided into 5 brooding sections of 3.0m x 4.0m dimension, each housing 22 chicks. The brooding lasted 14 days during which all the chicks were fed the control diet only. They were thereafter weight-balanced and randomly divided into 3 treatment groups, each replicated 5 times. Each of the 5 replicates had 7 birds such that there were 35 birds per treatment. The birds, reared intensively on deep litter housing system, were fed with broiler starter for 2 weeks. At the end of the 2 weeks (4 weeks of age), the birds were subsequently fed with broiler finisher for 4 weeks. The design was a randomized complete block design.

Vaccination

Vaccines were administered at prescribed intervals. The chicks were given intraocular vaccination against New Castle disease at 4 days old. At 2 weeks old, they were given 1st Gumboro vaccine. At 3 weeks of age, the chicks were given coccidiostat and 1st Lasota vaccine. At 4th and 5th week, second Gumboro and Lasota were given to the birds respectively. They were also treated with Tylodox antibiotics when symptoms of chronic respiratory disease (CRD) were observed.

Cost Analysis

The cost analysis was computed as all the costs incurred throughout the experiment. This included: cost of day-old chicks; cost of feeding; cost of transportation, cost of medication and general cost of management including sanitation cost.

Digestibility Study

At the end of 8th weeks, one bird per replicate was randomly selected to make a total of 15 birds (5 birds per treatment) taken for the digestibility study to a clean and disinfected metabolic cages. 3 days of acclimatization were observed after which feed was withdrawn from the birds for 12 hours (7.00pm - 7.00am) before the commencement of the study. During the study, collection bags were placed underneath each cage while a known quantity of feed was given to each bird. Excreta collection was done daily for a period of 5 days. The daily excreta voided for each bird was dried overnight at 55^{o}C. The birds were fasted again to terminate the digestibility study. The dried excreta were analyzed according to AOAC [14].

Chemical and Proximate Composition

The proximate analysis of the test ingredients and the formulated diets were conducted according to the methods of AOAC [14].

Statistical Analysis

Statistical analysis was done using the analysis of variance procedure of statistical analysis software [15].

III. Results and Discussion

Table 1 shows the chemical composition of the treatment feed fed to broilers in both the starter and the finisher phase. The crude fibre of BDG was 18.00 while that of the SSG was 14.00%. This follows the same trend with hemicellulose (16.55; 11.88 %) and cellulose (16.71; 13.79 %) for BDG; SSG respectively. The NDF (37.55; 42.88 %) and the ADL (14.29; 17.21 %) were however lower for the BDG compared to the SSG.

Table 1. Chemical Composition of Feed Samples Fed to Broilers.

Content (% DM)	Test Feed			Starter Diet				Finisher Diet		
	BDG	SSG		CTRL	15% BDG	15% SSG		CTRL	15% BDG	15% SSG
DM (% as fed)	86.67	86.00		86.50	87.02	86.59		88.00	88.67	89.33
CP	25.04	25.59		22.75	23.41	22.97		19.95	21.54	22.31
CF	18.00	14.00		6.00	7.02	6.00		10.00	14.00	14.11
Ash	7.00	8.00		7.00	6.00	7.00		7.00	6.00	7.00
EE	9.02	8.00		7.00	7.40	8.02		12.00	11.04	11.34
NFE	40.94	44.41		57.25	56.17	56.01		51.05	47.42	45.24
NDF	37.55	42.88		14.36	12.49	12.86		15.01	14.20	13.12
ADF	21.00	21.00		10.00	12.00	11.00		8.04	12.00	10.00
ADL	14.29	17.21		4.00	8.33	5.00		6.37	5.50	6.00
HEM	16.55	11.88		4.36	0.49	1.86		6.97	2.20	3.12
CELL	16.71	13.79		6.00	3.67	6.00		1.67	6.50	4.00

CTRL = Control; BDG = Brewers' dried Grain; SSG = Sorghum Spent Grain; (S) = Starter; (F) = Finisher; DM = Dry Matter; CP = Crude Protein; CF = Crude Fibre; EE = Ether Extract; NFE = Nitrogen Free Extract; NDF = Neutral Detergent Fibre; ADF = Acid Detergent Fibre; ADL = Acid Detergent Lignin; HEM = Hemicellulose; CELL= Cellulose.

Table 2 shows the gross composition of the diets fed to broilers. Except the control that has neither BDG nor SSG, both the starter and the finisher phases had 15% inclusion of either BDG or SSG. The starter phase diet contained 2% palm oil inclusion but the finisher phase does not. This was done primarily to balance the protein and energy requirement of the birds in each phase.

Table 2. Gross Composition of Diets Fed to Broilers.

Feed Ingredients (%)		Starter Diet				Finisher Diet		
		CTRL	15% BDG	15% SSG		CTRL	15% BDG	15% SSG
Maize		48.00	43.33	43.33		60.26	53.65	53.65
Wheat Offal		8.81	-	-		6.00	-	-
BDG		-	15.00	-		-	15.00	-
SSG		-	-	15.00		-	-	15.00
GNC		5.00	4.00	4.00		1.50	1.50	1.50
SBM		30.50	30.00	30.00		28.00	27.00	27.00

Fish Meal		2.50	2.50	2.50		1.00	1.00	1.00
Palm Oil		2.00	2.00	2.00		-	-	-
Limestone		1.00	1.00	1.00		1.00	1.00	1.00
DCP		1.50	1.50	1.50		1.50	0.13	0.13
Methionine		0.14	0.12	0.12		0.19	0.17	0.17
Salt		0.30	0.30	0.30		0.30	0.30	0.30
Premix		0.25	0.25	0.25		0.25	0.25	0.25
		100.00	**100.00**	**100.00**		**100.00**	**100.00**	**100.00**
Calculated Analysis								
Crude Protein		23.11	23.22	23.22		20.08	20.06	20.06
ME (Kcal/kg)		2906.85	2841.82	2841.82		2901.48	2802.50	2802.50
Lysine		1.25	1.26	1.26		1.20	1.20	1.20
Methionine		0.50	0.50	0.50		0.50	0.50	0.50
Calorie/ Protein Ratio		125.78	122.00	122.39		144.50	139.68	139.68
Cost per Kg of Feed		-	-	-		84.79	75.50	72.80

Premix: Vit. A 8000iu, Vit. D3 2000iu, Vit. E 5iu, Vit. K 2mg, Riboflavin 4.20mg, Vit. B12 0.01mg, pantothenic acid 5mg, Nicotinic acid 20mg, Folic acid 1mg, Choline 300g, Mn 56mg, Fe 20mg, Cu 10mg, Zn 50mg and Co 1.25mg. CTRL = Control; BDG = Brewers' Dried grain; SSG = Sorghum Spent Grain.

In Table 3, broilers fed SSG starter diet had lower ($P<0.05$) final weight (626.43g) compared to both the control (700.26g) and the BDG (683.54g) fed diets despite their similar initial weights and feed intake. The BDG and the control were not significantly ($P>0.05$) different from each other. This could be due to the presence of 'tannin' in SSG. Tannin is an anti-nutritional component of SSG which usually gives rises to a dry astringent sensation in the mouth [16]. It affects amino acid availability and also gives rise to bitter taste, thereby reducing feed intake [17]. The amount of tannin differs among the different species of sorghum and a high content tannin in sorghum can depress growth [18]. The lighter weight recorded in the SSG at the end of the starter phase also indicated a low feed efficiency, unlike BDG which had a similar feed efficiency with the control. This suggests that, BDG, unlike SSG, can be converted easily to edible meat as effectively as the control [19].

Table 3. Performance Characteristics of Broilers Fed 15% BDG and 15% SSG Based Diets.

		2-4 Weeks (Starter)					**5-8 Weeks (Finisher)**			
		CTRL	**15% BDG**	**15% SSG**	**SEM**		**CTRL**	**15% BDG**	**15% SSG**	**SEM**
Initial Wt.(g)		223.52	221.33	229.29	2.96		700.26^{a}	687.14^{a}	626.43^{b}	5.49
Final Wt.(g)		700.26^{a}	683.54^{a}	626.43^{b}	5.48		2256.47	2284.52	2203.33	17.92
Avg. Wt. Gain (g)		476.74^{a}	462.21^{a}	397.14^{b}	5.47		1556.21	1597.38	1576.90	16.41
Feed Intake (g)		1022.43	1033.57	1010.31	7.51		4007.83^{b}	4420.00^{a}	4286.19^{a}	26.89
Feed Eff.		0.47^{a}	0.45^{a}	0.39^{b}	0.03		0.39	0.36	0.37	0.03

Feed cost (N/Kg)		-	-	-	-		84.79^{a}	75.50^{b}	72.80^{b}	2.70
Total Feed (Kg/bird)		-	-	-	-		5.02	5.37	5.22	0.18
Feed cost/bird (N/bird)		-	-	-	-		425.65^{a}	405.44^{ab}	380.02^{b}	3.79
Wt. Gain (Kg/bird)		-	-	-	-		2.15	2.03	1.97	0.07
Feed cost/ Kg gain		-	-	-	-		197.98^{a}	176.28^{b}	192.90^{a}	2.89
Mortality (%)		0.00	0.00	0.00	0.00		5.71^{a}	2.86^{b}	2.86^{b}	0.01

a.b * Means along the same row with different superscript (s) are significantly different ($p<0.05$). Wt. = Weight, Avg. = Average CTRL = Control; BDG = Brewers' Dried Grain; SSG = Sorghum Spent Grain. SEM = Standard Error of Mean Feed Cost covers 3^{rd} to 8 weeks.

There were no differences among the three diets in their feed intake during the starter phase. It is assumed that each of the diets supplied an adequate amount of calorie in relation to their quantity as a reflection of the amount of feed consumed by the animals. Jurgens [20] had earlier stated that the protein and the energy requirements of animals are two principal components that must be met before considering the minerals, vitamins and dietary fibre in any feed formulation. The reason for the similar feed intake may also be attributed to the attractive aroma of both test ingredients. Ferket and Gernat, [21] noted that 'smell' is one of the factors that improve feed intake, although, birds are less sensitive compared to mammals. Also, the presence of palm oil in the diets could be a reason. Ekpo *et al*., [19] painted a picture of high palatability and feed intake in birds that consumed diets containing palm oil. The addition of palm oil to diets in this research was also to reduce dustiness in the diets among other factors which may include the assurance of no deficiencies in essential long chain fatty acid [22]. Oluponna *et al*., [23] who worked on the BDG sourced from International Brewery, Ilesha, Nigeria, observed that the low fibre contents and smooth texture of BDG could contribute to its high feed intake, however, in this research, the chemical composition of the two formulated starter test diets showed similar values of 7.02 and 6.00% and 14.00 and 14.11% for the CF of the finisher phase for BDG and SSG respectively.

The availability of amino-acids is an important factor when assessing the nutritive value of a feed. Aderolu *et al*., [24] noted that, different diets may be formulated to have the same percentage of crude protein, yet the quality of the protein may differ due to variations in the availability of essential amino acids. Etuk *et al*., [25] also ascertain this, that, protein nutrition is basically amino-acid nutrition. Protein is very important for tissue growth and development [26]. If non-structural protein (NSP) is broken down into small molecules, it can be digested and utilized leading to increased nutrients and protein accretion. The protein accretion implies growth and it also explains the variations in the weight of birds [8]. This research showed that, the crude protein digestibility of both control (73.92%) and BDG (79.49%) were higher than SSG (67.20%) explaining the mobilization of more proteins for tissue growth [1]. This also complement the report of Udedibie and Enang [22] that BDG is rich in crude protein, about 28%, although in this research, it was 25.04%. Finishing broilers on either high or optimum protein levels support muscle development especially breast muscles irrespective of whether the starter proteins were high, low or optimum [26]. The ability of protein to form complexes with tannin reduces protein digestibility and the bioavailability of certain divalent minerals (by causing abnormality in intestinal absorption of amino acids) often leading to large excretion of nitrogen [27]. These protein-tannin complexes were also observed by Akinmutimi and Okwu, [28] who noticed unavailability of protein for proteolytic enzymes digestion.

At the end of the finisher phase, the feed intake of control (4007.83g) was lower ($P<0.05$) than both BDG (4420.

00g) and SSG (4286.19g). This might probably be due to the change in the taste and palatability of the control feed which initially at the starter phase had the inclusion of palm oil [21]. Udedibie and Enang [22] also mentioned the importance of taste and flavor of palm oil in poultry diet in addition to its rich energy content.

The feed intake of birds on BDG and SSG were also high as a result of meeting the dietary energy level. McDonald *et al*., [12] stated that most animals consume that quantity of feed needed to satisfy their energy requirements until their digestive tract can no longer accommodate the bulk of the diet. Birds are known to increase their feed intake when the energy and protein values are diluted but the extent to which this can be done is checked by the capacity of the gut [24]. Jurgens [20] also reported that the feed intake of animals on diet containing low energy concentration is high whereas, that of animals fed high-energy diets is low. All the diets in this experiment were formulated to be isocaloric. In line with the observation of Madubuike and Obidimma [8], it was observed that feed intake of birds reduced as the energy density of feed increased, which points at the better feed utilization of the control diet.

The high content of lignin in a diet could limit both intake and utilization. Lignin is not only indigestible in itself, but it also lowers the digestibility of other nutrients [17]. Although, certain quantity of fibre is necessary for all species of livestock for proper functioning of gastro-intestinal tract and for proper digestion of feed [8], however, the high crude fibre in diets might have resulted in the alteration of the physico-chemical properties of the diet and might have affected their viscosity, transit time and nutrient absorption in the intestine [17].

Table 4 shows the apparent digestibility of the birds. There were no significant differences (P>0.05) among all the treatment diets in terms of dry matter, ether extract, ash, and acid detergent lignin. For the crude protein (CP), the range was between 67.20% and 79.49% where SSG had significantly (P<0.05) lower CP digestibility compared to the control and BDG. For the crude fibre (CF), SSG was significantly (P<0.05) lower than the BDG although both were not significantly (P>0.05) different from the control. The NFE digestibility of BDG (74.86%) was significantly (P<0.05) higher than the control (59.83%) and the SSG (60.36%). The acid detergent fibre (ADF) follows the same trend with the NFE digestibility records where BDG (29.60%) was significantly (P<0.05) higher than the control (18.41%) and the SSG (19.30%). The hemicellulose digestibility follows the same trend with the CP digestibility. However, for cellulose digestibility, the control diet (33.16%) was significantly (P<0.05) lower than both the BDG (53.39%) and the SSG (49.14%). According to Taiwo *et al*., [29], if despite the high digestibility of nutrients, a diet recorded poor weight gain and FCR, it could probably be due to poor nutrient retention. Aro *et al*., [30] also stated that the poor digestibility of some nutrients can explain the inferior nutrient utilization of such diet group when compared with others. The results on BDG and SSG in this experiment are different as high digestibility of nutrients were reflected on the feed efficiency and final weight. The final weights of SSG at the end of the starter and finisher phases were lower compared to BDG and the control, however, the final weights of the 3 treatments were not significant (P>0.05) at the finisher phase. It is worth noting that feed consumption and ultimate utilization of feed may be affected independently or in combination by alteration in texture, colour, taste and odour of the diets [31].

The cost analysis (feed cost/ kg gain) showed that BDG (176.28) was the least expensive (P<0.05), followed by SSG (192.90), the control was the most expensive (197.98). The feed cost/ kg gains of control however, was not significantly (P>0.05) different from the SSG. Ijaiya *et al*., [32] stated that diets are formulated to promote the desired intake of all nutrients and to improve growth rate at reasonable cost. The reason for the exorbitant outlay (cost of feed/kg live weight gain) of SSG in comparison with BDG is seen to have resulted from the weight gain (kg/bird) which is lesser than that of BDG. The increase in cost of feed per kg weight gain may be attributed to the increase in feed intake, the poor efficiency of the feed and the poor weight gain [1]. The cost per weight gain of birds fed BDG was the least indicating that, it took less cost to gain the same weight with control [33]. However, a lower feed efficiency which leads to increase in the cost of feeding, places a bird at a disadvantage which is the case for SSG. In determining the best treatment in a nutritional experiment, feed cost per kg gain is often used, as it considers the cost of production with regards to feed efficiency [1]. The cost benefit result showed that there was a beneficial effect of replacing maize with BDG and SSG, since profit is a single index that determines the economic value of keeping birds [4]. These encouraging performance in relation to cost would therefore lend credence to the opinion shared by Ani *et al*., [1] and Olorede *et al*., [6] that research efforts in developing countries should be directed towards the use of non-conventional agricultural by-products.

Table 4. Apparent Digestibility of Broilers Fed 15% BDG and 15% SSG.

%	CTRL	15% BDG	15%SSG	SEM
Dry Matter	63.82	67.50	65.73	1.56
Ether Extract	71.88	74.37	75.78	1.73
Crude Protein	73.92^{a}	79.49^{a}	67.20^{b}	0.68
Crude Fibre	67.27^{ab}	78.15^{a}	54.51^{b}	2.65
Ash	45.63	44.37	43.34	0.97
NFE	59.83^{b}	74.86^{a}	60.36^{b}	1.03
NDF	38.12^{a}	28.62^{ab}	18.88^{b}	1.73
ADF	18.41^{b}	29.60^{a}	19.30^{b}	1.43
ADL	15.71	17.59	13.56	0.74
Hemicellulose	58.36^{a}	57.36^{a}	49.28^{b}	2.97
Cellulose	33.16^{b}	53.39^{a}	49.14^{a}	2.54

a, b, c * Means along the same row with different superscript (s) are significantly different ($p<0.05$). CTRL = Control; BDG = Brewers' Dried Grain; SSG = Sorghum Spent Grain. SEM = Standard Error of Mean.

The result on mortality showed that there was no mortality in the starter phase of the birds however, in the finisher phase, two birds died among the birds on the control diet while 1 bird died in each of BDG and SSG. Therefore, the mortality of the birds on control diet (5.71%) was significantly ($P<0.05$) higher than the BDG (2.86%) and the SSG (2.86%). This suggests that the mortality is not as a result of the test diets since the mortality of the control diet was higher than the values of the test diets but rather, as a result of coccidiosis, based on their symptoms. Also, no mortality was observed in the starter phase when the birds were younger with weaker GIT framework.

IV. Conclusion

It was therefore concluded that, both Brewers' Dried Grain and Sorghum Spent Grain are good substitute for maize at 15% inclusion level however, Brewers' Dried Grain was better utilized compared to Sorghum Spent Grain from the starter to finisher phase in broiler production. They can therefore be included in broiler diet to low-

-er the cost of production thus improving the income of the farmer.

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