PERFORMANCE CHARACTERISTICS, ECONOMICS OF PRODUCTION AND BLOOD PROFILE OF BROILER CHICKS FED DIETS CONTAINING BREWER-DRIED GRAINS AS REPLACEMENT FOR MAIZE-SOYA

M. A. AKINSUYI *, AND T. A. DADA

*Department of Agricultural Technology, Ekiti State Polytechnic, Isan Ekiti.
*Email: akinmoseakin@gmail.com, +2348039138659

ABSTRACT

This study evaluated growth performance, economics of production and blood indices of broiler chicks fed diets in which brewer dried grain (BDG) partially replaced maize-soya as energy-protein ingredients. One hundred and twenty-day-old unsexed broiler chicks were randomly distributed to four dietary treatments. A control diet (T1) containing maize and soya as main energy and protein ingredients was formulated. BDG replaced 30%, 40%, and 50% of combined maize and soya in diets T1, T2, T3 and T4, respectively. Each treatment had three replicates of 10 birds, and the trial lasted for 28 days. Growth performance indices, body weight changes and feed intake were measured. Data were analysed using one-way analysis of variance (ANOVA). Results showed significant effects ($p < 0.05$) of BDG inclusion on growth performance and economic indices. The final body weight (FBW), daily weight gain (DWG) and daily feed intake (DFI) decreased with increasing replacement level of maize and soya with BDG. Birds had higher average FBW (g/bird), DWG (g/bird), Feedcost per kilogram feed (Fc/kg feed (₦)) and Feedcost per bird (Fc/bird (₦)) on 0% BDG diet. The FBW and DWG were significantly similar on 30% and 40% BDG replacement. Packed Cell Volume (PCV%), white blood cell (WBC $x10^3$/ul), Platelets ($x10^3$/ul), Lymphocyte (%), Heterophils (%), Eosinophils (%), Mean Corpuscular Volume (fl), Mean Corpuscular Haemoglobin Concentration (%) and Mean Corpuscular Haemoglobin (pg) were influenced by BDG. However, BDG had no effect on Haemoglobin (g/dL) and Red Blood Cell ($x10^6$/uL) concentrations. The study concludes that up to 40% of maize-soya can be economically replaced with BDG in broiler starter diets without adverse effects on growth or health.

Keywords: ***growth, blood, brewer dried grain, maize, broiler, cost***

INTRODUCTION

Maize and soya beans are the two most important cereal and legume grains that are used as energy and protein ingredients in poultry feed production. Energy sources, particularly maize, contribute the largest portion of poultry rations. Soya bean is an oilseed legume that is rich in protein and used for both human and animal feeding and for industrial purposes. The cake is the major source of protein for non-ruminant feeding. However, the cost of these grains has continually been on the increase (Bolu *et al*., 2012). It was reported by Esiegwu (2016) that soya beans can constitute about 20 - 30% of poultry rations. Poultry nutritionists now explore agro-industrial by-products that are of low cost and have the potential of providing energy and protein similar to that of maize and soya bean, respectively. The

Brewer dried grain (BDG) has become a widely used ingredient as animal feed due to its high protein content with a wide array of essential amino acids (Wang *et al*., 2001). Brewers' grains are obtained in wet form, and because they deteriorate easily, they are normally dehydrated, resulting in dried brewers' grains (DBG). According to Ashour *et al. (*2019), BDG is a product of fermentation that contains raw fibre fractions, ether extract, crude protein, amino acids, starch, minerals and vitamins. Some studies showed that BDG can be used for poultry feeds to some level (Odunukan *et al.,* 2016). The high moisture content and fibre levels are major constraints in the use of BDG by poultry. However, dried brewers' grain is high in crude protein and metabolizable energy. The nutritional content of brewers' grains varies depending on the grain used, the extent of the fermentation, and the type of fermentation process used. 24.20% protein, 3.90% lipid and 3.40% ash (Santos *et al.,* 2003). Adama *et al.,* (2007) reported that DBG from sorghum contains 31.60% CP, 7.80% CF, 13.70% EE, 16% ash and 3.07 Mcal/kg ME.

According to the National Research Council (NRC) (1994), standard brewers´ spent grain contains 25.30 % protein, 6.30 % fat, 92.00 % dry matter, and approximately 2080 kcal/kg metabolizable energy (ME). However, recent research has shown that BDG have slightly higher proximate values than the NRC (1994) values. Tikunesh *et al.* (2022) reported 25.40% crude protein and 2365 kcal/kg metabolizable energy (ME). Abd El-Hack *et al.* (2019) stressed that BDG can be used to reduce the quantity of maize grain and soybean meal in broiler chicken diets. Fasuyi *et al.* (2018) observed the highest weight gain at a 30% inclusion rate when ensiled brewery grain was fed to starting and growing broiler chickens. However, Ashour *et al.* (2019) used DBG at levels up to 120 g/kg in broilers from 7 to 42 days old and observed that there was no positive effect of BDG inclusion on growth performance. The trial by Kokol *et al.* (2012) revealed that there was no significant effect among treatment groups for live weight of broiler of 4 weeks of age when DBG was used as corn replacer at the levels of 0, 15, 30, 45 and 60%. However, improved weight gain and organ weights were recorded when biodegraded brewer's dried yeast was fed to broiler chickens up to a 20% level.

Blood indices provide valuable information about the health and physiological status of the birds. Conducting laboratory examinations of blood to assess its components is a crucial procedure that aids in diagnosing various diseases and dysfunctions. Blood analysis yields dependable results that can serve as valuable inputs for research studies focusing on nutrition, physiology, and pathology. Pandian *et al.* (2021) reported a normal range of 2.78 × 106/ul, 36.83%, and 12.13 g/dl, respectively, for RBC, PCV, and Hb of domestic birds. According to Aderolu *et al.* (2007), a 15% inclusion level of brewers' dried grains in broiler chickens had no toxic effect on their haematological parameters. Also, the findings of Bah *et al.* (2022) indicated that inclusion of brewer's dried grains (BDG), at 15% in broiler diets, did not negatively impact haematological indices. This study was conducted to evaluate the amount of BDG that could be used to replace maize and soya in poultry diet without a significant negative impact on the production performance and blood response of broiler chickens.

MATERIALS AND METHODS

Animals and Experimental Design

The research work was conducted at the Poultry Unit of the Teaching and Research Farm of Ekiti State Polytechnic, Isan Ekiti. Brewers' grains were obtained in wet form from a brewery in the Month of November, then transported and distributed on a concrete floor, and dried under the intensity of sunlight for three days with a minimum of 8 hours of sunlight per day. The material was turned over every two hours to ensure even drying and guard against mould build-up. The brewers' grains were dried to a safe moisture content of about 10%. The moisture content of Brewer's Dried Grains (BDG) was determined using the standard oven-drying method based on AOAC (Association of Official Analytical Chemists) procedures. The dried BDG were stored in sacs placed on a pallet.

A total of one-hundred-and-twenty-day-old broiler chicks were used for the experiment. Chick brooding was carried out on a floor pen in an open-sided wall building. Heat was provided from burning charcoal in pots. 24-hour lighting was achieved using an installed solar panel with bulbs. 30 birds were on each treatment diet, which was replicated three times, and each replicate consisted of 10 birds. Formulated diets were free of feed additives. Toxin binder was added at a rate of 1g/1000g feed. Chicks were placed on the experimental diets from day old to 28 days. There was feed and clean water for the birds to drink without restriction. Diet T1 had 0% BDG and served as the control diet. 30%, 40% and 50% of the calculated maize-soya (Maize + Soya) in the formulated control diet 1 was replaced with BDG in diets T2, T3 and T4, respectively (Table 1). The proximate composition of the tested diets is represented in Table 2. The growth performance parameters such as initial liveweight, final liveweight and daily feed intake were recorded for each bird. While daily weight gain, daily feed intake and Feed Conversion Ratio (FCR) were calculated as follows:

$$dfi\ (g/bird/day) = \frac{Feed\ Supplied - Residual\ Feed}{\text{Number}\ of\ Birds * Number\ of\ Days},$$

dfi = daily feed intake,

$$dwg\ (g/bird/day) = \frac{Final\ Body\ Weight - Initial\ Body\ Weight}{Number\ of\ Days},$$

dwg = daily weight gain,

$$FCR\ \left(\frac{g\ feed}{g\ gain}\right) = \frac{Daily\ Feed\ Intake}{Daily\ Weight\ gain},$$

FCR = Feed Conversion Ratio

At four weeks of age, blood samples were obtained from twenty-four birds at two birds per replicate for haematological indices. For Sample Collection, birds were properly restrained to minimise stress before blood samples were collected using a syringe withh an appropriate needle size of 3 ml and 23 gauge from the wing vein (brachial vein). Collected blood samples were immediately transferred into an EDTA tube to prevent clotting.

Collected blood samples were analysed for haemoglobin (Hb), packed cell volume

(PCV), RBC, and white blood cells (WBC) counts and their differential concentrations. The PCV was measured by a microhaematocrit capillary tube using a Haematocrit reader. The blood sample was centrifuged in a capillary tube, and PCV was read directly as a percentage. Hb concentration and RBC numbers were used to calculate the;

$$mcv = \left(\frac{h}{rb}\right) * 100\ (fl)$$

mcv = Mean Corpuscular Volume, h = Haemoglobin, rb = Red blood cell

$$mch = \left(\frac{h}{rb}\right) * 10\ (pg)$$

mch = Mean Corpuscular Haemoglobin, h = Haemoglobin, rb = Red blood cell

$$mchc = \left(\frac{h}{p}\right) * 100$$

Mchc = mean corpuscular haemoglobin oncentration, h = haemoglobin, p = pulse count volume

Table 1: Gross composition of Experimental diets of broiler starter fed brewer dried grain

	REPLACEMENT LEVELS			
Ingredients	0% BDG	30% BDG	40% BDG	50% BDG
Maize	66.50	50.00	44.89	37.79
Soybean meal	29.09	16.91	12.46	10.00
BDG	0.00	28.68	38.24	47.80
Bone meal	1.91	1.91	1.91	1.91
Limestone	0.15	0.15	0.15	0.15
Fish meal	1.50	1.50	1.50	1.50
Palm oil	0.00	0.00	0.00	0.00
Salt	0.25	0.25	0.25	0.25
L-Lysine	0.15	0.15	0.15	0.15
DL-Methionine	0.20	0.20	0.20	0.20
Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated Values				
Calcium **(mg/dl)**	0.86	1.05	1.10	0.81
Phosphorus **(mg/dl)**	0.56	1.71	2.09	0.43
Lysine (mg/kg)	1.13	0.76	0.63	0.97
Methionine (mg/kg)	0.55	0.43	0.40	0.56

BDG - brewer dried grain

Chemical Analyses

The test ingredients were analysed to obtain the proximate fractions (Table 2). Proximate composition of ingredients: maize, soybean, brewer dried grain and compounded experimental diets were determined as described by AOAC (2010). Table 2 shows the Proximate composition of ingredients:

maize, soybean, and brewer dried grain that were used in the formulation of diets.

Table 2: Proximate Composition of Test Ingredients

Parameters	MAIZE	SOYABEANS	BREWER DRIED GAIN
Crude Fat (%)	6.37	4.40	2.80
Ash content (%)	6.97	5.515	14.405
Crude fibre (%)	4.17	6.88	17.60
Crude Protein (%)	11.51	47.15	34.57
NFE (%)	71.33	36.06	30.63
ME (kcal/kg)	3461.08	3380.90	2948.08

Air Dry Basis, ME- Metabolisable energy, NFE - **Nitrogen Free Extract**

The Crude protein of maize (11.51%), soya beans (47.15%) and brewer dried grain (34.57%) were higher than those reported in the literature. The soybean meal CP content (47.15%) was higher compared to brewery dried grain (34.57%), and both were higher than the soybean meal CP content (39.8%) and brewery dried grain (25.40%) reported by Tikunesh *et al.* (2022). Brewer dried gran CP (34.57%) was higher than the 27.00% and 18.00% reported by Denstadli *et al.* (2010) and Ashour *et al.* (2019), respectively. Also, the metabolizable energy of soya beans (3380.90 kcal/kg) and brewer dried grain (2948.08 kcal/kg) was higher than those reported in literature, while the metabolizable energy of maize (3461.08 kcal/kg) used in this study was higher than the NRC (1994) values of (3420.00 kcal/kg) for poultry on dry matter basis and (3380.00 kcal/kg) on as-fed basis. The differences in the proximate values could be attributed to varietal sources and the freshness of the test ingredients used in the study.

Table 3: Calculated and Proximate composition of experimental diets

	REPLACEMENT LEVELS			
Ingredients	0% BDG	30% BDG	40% BDG	50% BDG
Calculated nutrient values				
Crude protein (%)	21.71	22.47	22.92	20.61
ME (kcal/kg)	3083.16	2954.24	2935.17	2904.69
Crude Fibre	4.79	8.14	8.24	8.63
Ether Extract	5.57	4.76	4.50	4.08
Analysed Proximate values				
Crude Protein (%)	22.00	21.44	21.25	20.75
Crude Fibre (%)	5.19	6.08	8.55	9.25
Ether Extract (%)	4.49	5.40	5.30	4.61
Ash (%)'	4.49	5.40	5.30	4.61
Nitrogen Free Extract	59.42	56.47	53.95	53.99
ME (kcal/kg)	3287.10	3235.37	3130.78	3057.81

Note – ME- Metabolisable energy, BDG – Brewer Dried Grain.

The calculated and proximate composition of experimental diets is presented in Table 3. The proximate data obtained were similar to the calculated values.

Statistical Analysis

The data generated were analysed using one-way analysis of variance (ANOVA) of the SAS (2008) software package for Windows. To separate significant differences among means, the Duncan Multiple Range Test of the same software was used.

RESULTS AND DISCUSSION

Growth performance characteristics of Broiler Starter fed brewer dried grain

Table 4 shows the performance characteristics of broiler starter fed brewer dried grain in replacement for maize and soya beans.

Table 4: Growth Performance Characteristics of Broiler starter fed varying inclusion levels of brewer dried grain

Parameters	REPLACEMENT LEVELS				SEM	p-value
	0% BDG	30% BDG	40% BDG	50% BDG		
Initial body weight (g/bird)	36.60	36.67	36.40	36.08	0.4673	0.9802
Final body weight (g/bird)	1367.30^{a}	1009.00^{b}	1008.13^{b}	925.50^{c}	51.4773	<.0001
Daily weight gain (g/bird)	47.53^{a}	34.72^{b}	34.71^{b}	31.77^{c}	1.8372	<.0001
Daily Feed Intake (g/bird)	72.67^{b}	74.38^{a}	72.54^{c}	70.31^{d}	0.4362	<.0001
FCR	1.53^{d}	2.14^{b}	2.10^{c}	2.21^{a}	0.0823	<.0001
Fc/kg feed (₦)	946.87^{a}	763.69^{b}	702.01^{c}	643.39^{d}	34.3207	<.0001
Fc/bird (₦)	1926.72^{a}	1590.42^{b}	1425.95^{c}	1266.56^{d}	73.7414	<.0001
Fc/weight gain/bird (₦)	40.54^{c}	45.79^{a}	41.36^{b}	39.87^{d}	0.6985	<.0001

Means within rows within parameters with different superscripts are significantly different (*P* < 0.05). ***FCR – Feed Conversion Ratio, Fc- Feed Cost, Dollar Exchange rate (₦1520/$1), SEM: Standard Error of*** **Mean**

There were significant *(P < 0.05)* effects of BDG replacement in the diets on all growth indices evaluated except the initial liveweight. The final body liveweight, daily weight gain, and daily feed intake decreased with the increasing replacement level of maize and soya with BDG. However, the final body weight (1009.00 g/bird, 1008.00 g/bird) and daily weight gain (34.72 g/bird, 34.71 g/bird) were significantly *(P < 0.05)* similar on diets 2 (30% BDG) and 3 (40% BDG) replacement level of maize and soya but were significantly *(P < 0.05)* lower than the values on control diet 1 with 0% BDG replacement level of maize and soya. The significantly higher final body weight and average daily weight gain observed for birds on diet 1 aligned with the findings of Tikunesh *et al.* (2022), who reported that average daily gain and final body weight were higher for starter broiler chicks on a diet without brewer dried grains.

The result showed that birds consumed more on diet 2 (30% BDG). The higher daily feed intake on diet 2 (30% BDG) did not translate to improved weight gain, and there were no significant differences in the final body weight and average daily weight gain between birds in diets 2 and 3. However, the

FCR showed varying values, with diet 4 having the highest value compared with diets 1 and 3. Daily Feed Intake (g/bird) decreased with increasing level of brewer dried grains in the diets. The reduced feed intake across the treatments could be an issue of acceptability and nutrient utilization due to higher fibre content, which, on the other hand, increased with increasing level of brewer dried grains in the diets. Therefore, diet 3 with lower average feed intake (72.54 g/bird) and FCR could be adjudged suitable for broiler chicks.

The economics of production in this study are shown in Table 4. Feed cost/kg feed (₦) expressed as the cost of producing a kg of feed across the treatment diet, reduced with increasing replacement level of maize and soya with brewer dried grains. This can be attributed to the low cost of BDG. The result also showed that Feed cost/bird (₦), i.e., cost of feed consumed per bird for the entire period of the experiment, reduced with increasing replacement level of maize and soya with brewer dried grains. However, Feed cost per unit weight gain, that is, the cost of feed for producing a unit kg of bird, did not follow a uniform pattern as it was significantly *($P < 0.05$)* higher on diet 2(₦45.79/bird) than on other treatment diets. Thus, it costs more to produce a bird on diet 1(0% BDG) and 2(30% BDG) than on diet 3(40% BDG). With higher feed cost and feed cost/bird (₦), diet 1 may not be economical for the production of broiler chicken. And, considering the significant *($P < 0.05$)* similarity of final body weight and daily weight gain on diets 2(30% BDG) and 3(40% BDG), with the lowest FCR, Feed cost/kg feed (₦) and Feed cost/bird (₦) on diet 3(40% BDG), it can be concluded that replacing 40% of conventional maize plus soya in compounded ration with brewer dried grains in starting broiler chicken feed did not impair growth negatively.

Haematological Parameters of Broiler starter fed varying inclusion levels of brewer dried grain. Table 5 shows the haematological indices of Broiler starter fed varying inclusion levels of brewer dried grain.

Table 5: Haematological Indices of Broiler starter fed varying inclusion levels of brewer dried grain

PARAMETERS	REPLACEMENT LEVELS				SEM	p-value
	0% BDG	30% BDG	40% BDG	50% BDG		
PCV (%)	20.00[ab]	18.00[c]	21.00[a]	19.00[bc]	0.3942	0.0114
Hb (g/dL)	6.20	5.50	6.90	5.50	0.2690	0.1993
RBC ($x10^6$/uL)	1.46	1.16	1.77	1.32	0.2153	0.8299
WBC ($x10^3$/ul)	20.25[a]	12.3[b]	10.50[c]	10.50[c]	1214.98	<.0001
Platelets ($x10^3$/ul)	213.00[a]	106.00[d]	115.00[c]	120.00[b]	13056.69	<.0001
Lymphocyte (%)	54.00[a]	49.00[bc]	50.00[b]	48.00[c]	0.71648	<.0001
Heterophils (%)	39.00[c]	44.00[a]	42.00[b]	45.00[a]	0.72043	<.0001
Monocytes (%)	3.00	4.00	2.00	3.00	0.29531	0.1014
Eosinophils (%)	3.00[bc]	2.00[c]	6.00[a]	4.00[b]	0.4905	0.0021
Basophils (%)	1.00	1.00	0.00	0.00	0.2539	0.2987
MCV(fl)	136.99[c]	155.17[a]	118.64[d]	143.94[b]	4.0051	<.0001

PARAMETERS	REPLACEMENT LEVELS				SEM	p-value
	0% BDG	30% BDG	40% BDG	50% BDG		
MCHC (%)	31.00^{b}	30.56^{b}	32.86^{a}	28.95^{c}	0.4670	0.0030
MCH (pg)	42.47^{b}	47.41^{a}	38.98^{c}	41.67^{b}	0.9412	<.0001

Means within rows within parameters with different superscripts are significantly different (*P* < 0.05). ***PCV- packed cell volume, Hb - Haemoglobin, RBC - Red blood cells, WBC - White blood cells. MCV- Mean Corpuscular Volume, MCHC - Mean Corpuscular Haemoglobin Concentration, MCH -Mean Corpuscular Haemoglobin***

The PCV (%), WBC ($x10^{3}$/ul), Platelets ($x10^{3}$/ul), Lymphocyte (%), Heterophils (%), Eosinophils (%), MCV (fl), MCHC (%) and MCH (pg) values were significantly influenced across the treatments (p<0.05). The Hb (g/dL), RBC ($x10^{6}$/uL), Monocytes (%) and Basophils (%) were not (p>0.05) affected by BDG inclusion in the diets. The PCV (%), WBC ($x10^{3}$/ul), Platelets ($x10^{3}$/ul) and Lymphocyte (%) were significantly higher in birds on diet 1 (Control) than on other diets while the Heterophils (%), MCV(fl) and MCH (pg) were (p<0.05) higher on diet 2 (30% BDG). The Eosinophils (%) and MCH (pg) were (p<0.05) similar on diets 1 (0% BDG) and 4 (50% BDG), while MCHC (%), Eosinophils (%) were (p<0.05) similar on diets 1 (0% BDG) and 2 (30% BDG) replacement levels. The WBC ($x10^{3}$/ul) was (p<0.05) similar on diets 3 (40% BDG) and 4 (50% BDG) replacement levels. The similarity in haematological parameters observed across treatments in this study is in consonance with the result of Tikunesh *et al.* (2022), who reported similar results (p>0.05) among each treatment diet in haematology parameters. These results indicated that BDG had no negative effect on the health of broiler chickens, considering that mortality did not occur across all the treatments.

The RBC count (1.16-1.77 10^{6}/ul) was lower than the RBC count (4.21-4.84 x $10^{6/}$ml reported for avian species (Campbell, 2013). However, the Hb (5.50 -6.90g/dl) was lower than the Hb (7.66-12.06g/dl) reported for broiler chicken by Odukoya et al. (2022). Low haemoglobin PCV levels may indicate anaemia.

Important differentials of WBC studied ranges are: Basophil (0.00 – 1.00%), Monocytes (2.00 - 3.00 %). Eosinophil (2.00 – 6.00 %) and Lymphocytes (48.00 – 54.00 %). The Monocytes (2.00 - 3.00 %) and Basophils (0.00 – 1.00%) recorded in this study fall within the Monocytes (2.00-3.67%) and Basophils (0.00 – 1.00%) reported for broiler by Asaniyan and Akinduro (2020). The non-significant effect of BDG on Hb (g/dl) and RBC ($x10^{6}$/ul) in the study agreed with the findings of Tikunesh *et al.* (2022), who reported that blood constituents assessed for haematological indices were not affected by replacing soybean meal with brewery dried grain.

CONCLUSIONS AND APPLICATION

The study concludes that;

1. Brewer Dried Grain can conveniently replace 40% of maize-soya in broiler starter diet without any negative effect on growth performance and health of the birds.
2. Incorporating BDG into broiler feed will reduce the overall cost of broiler production.

It thus implied that broiler production can be sustained with agro-industrial by-products such as BDG as an energy-protein ingredient.

ACKNOWLEDGEMENTS

We would like to appreciate the TETFund that provided the Institution-Based Research (IBR) grant for this study, as well as, the publication of the paper. Our appreciation also goes to the Management of Ekiti State Polytechnic, Isan Ekiti, which provided the enabling environment for the conduct of the Institution-Based Research.

REFERENCES

Abd El-Hack, M. E., Alagawany, M., Patra, A. K., & Abdel-Latif, M. A. (2019). Use of brewers dried grains as an unconventional feed ingredient in the diets of broiler chickens: A review. *Journal of Advances in Animal and Veterinary Sciences, 7*(3), 218–224. https://doi.org/10.17582/journal.aavs/2019/7.3.218.224

Adama, T. Z., Ogunbajo, S. A., & Mambo, M. (2007). Feed intake, growth performance and nutrient digestibility of broiler chicks fed diets containing varying levels of sorghum dried brewers' grains. *International Journal of Poultry Science, 6*, 592–598. https://doi.org/10.3923/ijps.2007.592.598

Aderolu, A. Z., Iyayi, E. A., & Onilude, A. A. (2007). Performance, organ relative weight, serum and haematology parameters in broiler finisher fed biodegraded brewers dried grain. *Pakistan Journal of Nutrition, 6*(3), 204–208. https://doi.org/10.3923/pjn.2007.204.208

AOAC. (2002). *Official methods of analysis of the Association of Official Analytical Chemists*. Association of Official Analytical Chemists.

Asaniyan, E. K., & Akinduro, V. O. (2020). Haematology and serum biochemistry of broiler chickens offered extracts of dried roselle plant (*Hibiscus sabdariffa*) calyx in drinking water. *Ife Journal of Science, 22*(3). https://doi.org/10.4314/ijs.v22i3.12

Ashour, E. A., Abd El-Hack, M. E., El-Hindawy, M. M., Attia, A. I., Osman, A. O., Swelum, A. A., Alowaimer, A. N., Saadeldin, I. M., & Laudadio, V. (2019). Impacts of dietary inclusion of dried brewers' grains on growth, carcass traits, meat quality, nutrient digestibility and blood biochemical indices of broilers. *South African Journal of Animal Science, 49*(3), 574–584. https://doi.org/10.4314/sajas.v49i3.18

Bah, U. J., Baburo, A. B., Dikko, I. M., & Bah, U. S. (2022). Haematological and serum biochemical parameters of broiler chickens fed different cereal grain by-products. *FUDMA Journal of Agriculture and Agricultural Technology, 8*(1). https://doi.org/10.33003/jaat.2022.0801.081

Bolu, S. A., Alli, O. I., & Esoula, P. O. (2012). Response of broilers to graded levels of distillers' dried grains. *Sustainable Agriculture Research, 1*(1), 147–150. https://doi.org/10.5539/sar.v1n1p147

Campbell, T. W. (2013). Processing the avian haematologic sample. In *Avian haematology* (pp. 8–9).

Denstadli, V., Ballance, S., Knutsen, S. H., Westereng, B., & Svihus, B. (2010). Influence of graded levels of brewers' dried grains on pellet quality and performance in broiler chickens. *Poultry Science, 89*, 2640–2645. https://doi.org/10.3382/ps.2010-00724

Esiegwu, A. C. (2016). The effect of replacing soya bean meal with cooked *Mucuna sloanei* meal on growth performance, carcass characteristics and blood indices of broiler finishers. *Journal of Tropical Agriculture, Food, Environment and Extension, 15*(1), 34–38. https://doi.org/10.4314/as.v15i1.7

Fasuyi, A. O., Aturamu, O. A., & Lawal, A. S. (2018). Part II: Economic analyses and the growth performance of broiler finisher (29–58 day) birds on high fibre-low protein industrial plant by-products. *Asian Journal of Advanced Research, 6*(3), 1–10. https://doi.org/10.9734/AJAAR/2018/40606

Kokol, C., Zaklag, U., Antyev, M., Akade, F. T., & Bab, A. M. J. (2012). Response of broiler finisher fed graded levels of brewers dried grain on carcass and internal organ characteristics. *Journal of Agricultural and Veterinary Science, 4*.

Mussatto, S. I., Dragone, G., & Roberto, I. C. (2006). Brewers' spent grain: Generation, characteristics and potential applications. *Journal of Cereal Science, 43*, 1–14. https://doi.org/10.1016/j.jcs.2005.06.001

National Research Council. (1994). *Nutrient requirements of poultry* (9th rev. ed.). National Academies Press.

Odukoya, S. O., Awodola-Peters, O. O., Yahaya, M. O., & Saka, A. A. (2022). Dietary effect of garlic (*Allium sativum*) supplementation on growth performance, blood profile, carcass characteristics, and cost benefit of broiler chicken. *Nigerian Journal of Animal Production, 49*(4), 58–67.

Pandian, C., Thanga Pandiyan, M., Sundaresan, A., & Omprakash, A. V. (2021). Haematological profile and erythrocyte indices in different breeds of poultry. *International Journal of Livestock Research, 293*, 89–92.

Santos, M., Jiménez, J. J., Bartolomé, B., Gómez-Cordovés, C., & del Nozal, M. J. (2003). Variability of brewer's spent grains within a brewery. *Food Chemistry, 80*, 17–21. https://doi.org/10.1016/S0308-8146(02)00229-7

SAS Institute Inc. (2008). *SAS for Windows* (Release 9.1) [Computer software]. SAS Institute Inc.

Tikunesh Zelalem, Ajebu Nurfeta, & Aberra Melesse. (2022). Effect of replacing soybean meal with brewery dried grain on growth performance, feed intake, carcass traits and blood haematology indices of Ross 308 broilers. *Livestock Research for Rural Development, 34*(10).

Wang, D., Sakoda, A., & Suzuki, M. (2001). Biological efficiency and nutritional value of *Pleurotus ostreatus* cultivated on spent beer grain. *Bioresource Technology, 78*, 293–300. https://doi.org/10.1016/S0960-8524(01)00002-5