Review Article

Use of Brewers Dried Grains as an Unconventional Feed Ingredient in the Diets of Broiler Chickens: A Review

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Abstract | Dried Brewers grains (DBG), a brewery by-product that, may offer a suitable cheap replacer for traditional feedstuffs (e.g., corn and soybean meal). A variety of essential nutrients are present in BDG which are required in feed formulation for poultry. It is composed of around 20% crude proteins, 6% ether extract, 15% crude fiber and 4% ash. Besides, it is fairly rich in essential amino acids; 0.9% lysine, 0.4% methionine, 0.4% tryptophan, 1.2% phenylalanine, 1.1% threonine as well as 1.6% valine. As a result, the concentrations of protein and amino acids are greater in BDG than in maize. However, the use of BDG in poultry feeds has some constraints such as high moisture and fiber contents. The high moisture content of wet brewers' grains (about 80%) increases its bulkiness. So, efficient sun-drying is recommended to avoid nutrient losses of the by-product. Due to presence of high fiber content in BDG, it is mainly used as a cattle feed. But, there are also many studies, which explored the use of BDG in poultry diets. The present review article highlights the nutritional value of BDG as an untraditional feedstuff in broiler diets and its impacts on growth performance.

Keywords | Brewers dried grains, Broilers, Growth, Carcass, Economics

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INTRODUCTION

Feeding cost represents at least 65% of total cost for poultry production. Reducing feed cost is one of the important targets in poultry production. The increasing feed costs and limited quantities of animal protein sources available for use in poultry feeds have compelled to substitute plant proteins for some proportion or all of the animal protein in a diet (Alagawany et al., 2015; Alagawany and Attia, 2015). Therefore, a considerable attention has been given to use un-conventional feedstuffs such as agro-industrial byproducts in formulating poultry diets to achieve a suitable efficiency of utilization and economic efficiency of production (Abd El-Hack et al., 2015, 2017a, b; Saeed et al., 2017).

A dried Brewers grain (DBG) is a brewery byproduct. The residue is obtained from barley, wheat, maize, rice and oat. It contains the insoluble materials remaining after the process of soaking, mashing and boiling with water which includes crude fiber (CF) fractions, ether extract (EE), crude protein (CP) and starch (Areghore and Abdulrazak, 2005; Khalili et al., 2011; McCarthy et al., 2013; Radzik-Rant et al., 2018). The BDG or spent grains can be fed to livestock wet or after drying (Peña and Posadas, 2016). Because the wet grains deteriorate easily, the product is usually dried to obtain the BDG. Spent grain or BDG contains 93% dry matter (DM), 22.4% CP, 19.1% CF, 4% ash, 48.6% nitrogen free extract (NFE), 2360 kcal/kg of metabolizable energy (ME), and 6.2% EE (Longe and Adetolla, 1983). Therefore, DBG (up to 5%) can be incorporated into the rations of quail layers by partial replacement of soybean meal, maize and de-oiled rice bran to improve egg production, productivity and higher profit margin (Swain et al., 2013). On the same context, several studies indicated that total cost of production and feed cost per Kg decreased with increasing BDG levels (Adama et al., 2007; Fasuyi et al., 2018).

BDG is high in CP and ME and consequently could be used to reduce the quantity of maize grain and soybean meal used in broiler chicken diets. However, BDG or brewery waste dryer use is limited in poultry diets because of its high fiber content. Some studies showed that BDG can be used for poultry feeds to some extent (Parson et al., 1983; Noll et al., 2001; Odunukan et al., 2016). The present review article aimed to provide a spotlight on the nutritional value of BDG as an unconventional feedstuff in broiler diets and its impacts on growth performance, carcass characteristics, nutrient digestibility, blood constituents and economics.

Agro-Industrial By-Products in Poultry Nutrition

In the field of poultry industry, it is important to find alternative inexpensive feedstuffs to the commonly used ingredients in poultry diets. Many of these by-products have some constraints for their use in the ration such as: low energy, low availability of amino acids and high fiber content and high bulker presence of anti-nutritive factors (Ishibashi and Ohta, 2000). However, these limitations may be overcome by chemical, physical and biological treatments of the feeds, using an optimum proportion in diets or supplementing with the limiting amino acids; methionine and lysine. The use of industrial by-products internationally has continued to be of interest to feed manufacturers and nutritionists, and many of them are generally used as feed ingredients. The most prominent by-products of plant origins come mainly from oil seed mills and brewing industries (Adama et al., 2007; Fasuyi et al., 2018).

Chemical Composition and Nutritional Value of BDG

Wet brewers' grains after brewing process contain 77–81% moisture (Mussatto et al., 2006). Therefore, they can be fermented and deteriorated rapidly as a result of microbial activity. The nutrient content of DBG differs substantially depending upon the plant maturity, processing as well as the additives used during the brewery industry (Santos et al., 2003); Generally, DBG is rich in protein and fibre (about 20 and 70%) , respectively.

DBG contains 25.3% CP, 6.3% EE and around 2080 Kcal/kg ME and is also a good source of B vitamins (NRC, 1994). In the study of Swain et al. (2012), DBG contains 25% CP, 5.06% EE, 17.8% CF, 7.5% total ash and 1.5% acid insoluble ash. Denstadli et al. (2010) stated that DBG contains 20.9% CP, 9.0% EE, 34.3% non-starch polysaccharides, 3.0% total ash and 8.1% starch. The oven-dried DBG contains, besides fibre, 24.2% protein, 3.9% lipid and 3.4% ash (Santos et al., 2003). The DBG from sorghum contains 31.6% CP, 7.8% CF, 13.7% EE, 16% ash and 3.07 Mcal/kg ME (Adama et al., 2007). Fasuyi et al. (2018) reported that DBG contains 87.5 dry matter, 22.1% CP, 7.6% EE, 53.3% nitrogen free extract, 4.7% total ash,12.3% crude fiber and 2485 kcal-kg metabolizable energy.

As reviewed by Mussatto et al. (2006), DBG contains other nutrients including minerals, vitamins and amino acids. The minerals include calcium, phosphorus, potassium, sulphur, sodium, magnesium, iron, manganese, selenium, copper, and cobalt, all in concentrations lower than 0.5%. The vitamins include (mg/kg): choline (1800), niacin (44), pantothenic acid (8.5), riboflavin (1.5), thiamine (0.7), pyridoxine (0.7), folic acid (0.2), and biotin (0.1), and; protein bound amino acids include leucine, valine, alanine, serine, glycine, glutamic acid and aspartic acid in the largest amounts, and tyrosine, proline, threonine, arginine, and lysine in smaller amounts. Cystine, histidine, isoleucine, methionine, phenylalanine, and tryptophan can also be present. The average chemical composition and nutritive value of BDG are shown in Table 1.

Impacts of BDG on Broilers

Body weight and body weight gain: Effect of DBG levels on the growth of broiler chicks has received much attention by several research workers. Lopez and Carmona (1981) prepared basal diets containing 0, 10, 20, 30 and 40% DBG replacing wheat and soybean meal for broiler chickens. Three separate periods (0–4, 4–8 and 8–12 weeks of age) were considered. Body weight gain decreased during periods 0-4 and 4-8, when using over 20% DBG, and period 8-12, when using over 30%, but final body weight was decreased only in period 4-8. Onifade and Babatunde (1998) used three different levels (10, 20 and 30%) of BDG in broiler chicken diets and found that growth rate was similar up to 20% of BDG in diets. Kokol et al. (2012) evaluated the effect of DBG at the levels of 0, 15, 30, 45 and 60% as corn replacer on the growth performance of Anak 2000 of broiler of4 weeks of age. They found that there was no significant effect among treatment groups for live weight. Also, Ironkwe and Bamgbose (2011) replaced maize grains with different levels of DBG (0, 25, 50, 75

Table 1: Chemical composition and nutritive value of Brewers Dried Grains (Santos et al., 2003; Mussatto et al., 2006; Swain et al., 2012).

Main analysis	Unit	Average
Dry matter	% as fed	91.0
Crude protein	% DM	25.8
Crude fibre	% DM	15.8
NDF	% DM	56.3
ADF	% DM	21.9
Lignin	% DM	5.4
Ether extract	% DM	6.7
Ether extract, HCl hydrolysis	% DM	8.6
Ash	% DM	4.6
Starch (polarimetry)	% DM	7.8
Gross energy	MJ/kg DM	19.7
Minerals		
Calcium	g/kg DM	2.7
Phosphorus	g/kg DM	5.7
Potassium	g/kg DM	2.9
Sodium	g/kg DM	0.3
Magnesium	g/kg DM	2.6
Manganese	mg/kg DM	47
Zinc	mg/kg DM	89
Copper	mg/kg DM	19
Iron	mg/kg DM	130
Amino Acids		
Alanine	% protein	4.8
Arginine	% protein	4.1
Aspartic acid	% protein	5.9
Cystine	% protein	1.8
Glutamic acid	% protein	19.9
Glycine	% protein	3.4
Histidine	% protein	1.8
Isoleucine	% protein	4.2
Leucine	% protein	8.2
Lysine	% protein	3.1
Methionine	% protein	1.5
Phenylalanine	% protein	5.3
Proline	% protein	8.8
Serine	% protein	4.0
Threonine	% protein	3.2
Tryptophan	% protein	1.2
Tyrosine	% protein	3.5
Valine	% protein	4.8
Secondary Metabolites		
Tannins, condensed (eq. catechin)	g/kg DM	1.4
AMEn poultry	MJ/kg DM	9.2

and 100%) to evaluate the response of 4 weeks old broiler birds. Results indicated that the use of BDG in broiler finisher diets up to 50% could be incorporated for efficient performance. Aghabeigi et al. (2013) evaluated the impact of a gradual replacement (0, 5, 10, 15, 20 and 25%) of soybean meal with DBG on performance in broiler chickens. Body weight gain and feed efficiency of bird's diet supplemented with 25% DBG was deteriorated compared to other levels at grower phase. They suggested that 20% inclusion of DBG at grower phase and 5% inclusion of BDG at finisher phase support beneficial results on broilers performance when soybean meal is replaced in the diets. Moreover, Alabi et al. (2014) investigated the effect of DBG (0 or 25%) replacing maize grains supplemented with four levels of different commercial enzymes on growth activities of Arbor Acres broilers from 1 to 56 d of age. Weight gain values showed a significant decrease when DBG inclusion is increased without enzyme supplementation. . Furthermore, Wondifraw and Tamir (2014) evaluated the effect of BDG yeast mixture; 80% BDG and 20% brewer's dried yeast (BDGY) at levels (0, 6%, 12%, 18%, 24%, and 30%) on the performance of white leghorn chicks of. Daily BW gain and feed efficiency were decreased in chicks fed 24 and 30% BDGY compared to other levels. They concluded that 18% BDGY is favorable to be used in laying rations. A study conducted by Esonu et al. (1999) suggested that diet having 30% maize-sorghum based BDG replacing maize showed similar performance compared to that of control group with only maize reducing the total cost of production of broilers. Feeding of BDG at 20% level (replacing maize and soybean meal) did not affect body weight gain of Vanaraja chicks at 9 weeks of age (Swain et al., 2012). In the study of Denstadli et al. (2010), BDG at 30 and 40% (replacing maize and soybean in the diets) reduced BW gain of broilers at 33 d, but BDG with 10 and 20% levels had similar performance as that of control group. Adama et al. (2007) incorporated four levels of sorghum BDG up to 40% replacing maize and groundnut cake in broiler chicken diets, and reported that growth rate was similar up to 20% and thereafter it decreased. From the above studies, it is apparent that BDG could safely replace maize and vegetable protein up to 20% with similar energy and protein concentrations. The level of 10% dry brewery residue can be used inbroiler diets without any detrimental effects on growth performance, development and metabolism of the broilers (Parpinelli et al., 2017).

Feed intake and feed conversion ratio: In an early, study on growing chickens, Ademosun (1973) concluded that the level of BDG should not exceed 10 and 30% in starter and grower diets respectively on the basis of BW gain, feed intake and efficiency. Onifade and Babatunde (1998) incorporated three different levels (10, 20 and 30%) of BDG in broiler chicken diets and found that feed intake increased with increasing levels of BDG, but feed efficiency was similar at 10% level, but decreased at the higher concentrations of BDG in diets. In the study of Adama et al. (2007), feed intake was similar up to 20% and thereafter it increased up to 40% level, and likewise feed to gain ratio was similar up to 20% level, but increased thereafter. Higher intake by broiler chickens in some studies is likely due to preferable aroma of the BDG. Denstadli et al. (2010) found that feed conversion ratio (FCR) differed significantly in the control group (1.45) versus groups fed diets with 30 and 40% BDG (1.65 and 1.69, respectively), but had similar FCR at 10 and 20% levels (1.48 and 1.51). Ironkwe and Bamgbose (2011) evaluated the effect of BDG at level of 0%, 25%, 50%, 75% and 100%respectively on growth performance of broiler chickens. They found that the daily feed intake decreased in response to high level of BDG, with the highest intake in 100% maize and the least value in 100% BDG.

Friesen et al. (1992) reported that the FCR was increased due to the use of BDG in poultry diets Aghabeigi et al. (2013) evaluated the impact of gradual replacement of soybean meal with 0, 5, 10, 15, 20 and 25% BDG on performance in broiler chickens. Feed intake value in 0 and 5% BDG groups was increased compared to other groups, but feed conversion ratio was not affected by BDG inclusion at the finisher phase (24 to 42 d). FCR of chicks fed the diet incorporated with 10% BDG was similar to those fed the basal diet, but FCR of birds fed 20% BDG increased significantly (Swain et al., 2012). Similarly feeding of 5% or 30% BDG did not affect the FCR of broilers at finisher stage (Esonu et al. 1999). In the study of Lopez and Carmona (1981), basal diets containing 0, 10, 20, 30 and 40% BDG replacing wheat and soymeal meal for broiler chickens decreased in feed efficiency during periods 0-4 and 4-8, when using 20% or more BDG, and period 8-12, when using 30% or more. Neither food intake nor dressing percentage was affected. Lower feed intake by birds at high concentrations of BDG might result from high amount of fiber present in BDG.

DBG contains high concentration of non-starch polysaccharides and some tannins which interfere with the feed utilization inhibit the absorption of essential nutrients and digestive enzymes *in-vitro* and *in-vivo*, decreasing the efficiency of feed utilization Lacassagne et al. (1998). BDG contains high concentrations of fiber. Thus, adding of enzymes could improve the utilization of BDG. In this regard, Alabi et al. (2014) studied the effect of (0 or 25%) BDG supplemented with four levels of different exogenous enzyme on performance, nutrient absorption and gut health of Arbor acres broilers. They found that feeding of BDG supplemented with commercial enzymes improves all parameters compared to those without commercial enzyme.

Carcass traits: Lopez and Carmona (1981) used BDG at levels of 0, 10, 20, 30 and 40% in broiler chicken diets and found that insignificant differences in average dressing percentage with up to 20% inclusion level. They observed that when 20% inclusion level or more BDG was used, there were significantly reduced abdominal fat pad and meat tissue with no effect on bone tissue. Also, Chumpawade et al. (2008) showed that the use of BDG in broiler diets did not affect the carcass cuts. Kokol et al. (2012) evaluate the effect of BDG at the levels of 0%, 15%, 30%, 45% and 60% replacing maize on carcass and internal organ characteristics of broiler chickens. The results showed no significant difference among treatment groups for dressed weight, head, neck, chest, lungs, shanks, thorax, back, and internal organs expressed as percentage of live weight. Alabi et al. (2014) investigated the effect of dietary BDG at 0 or 25% level supplemented with exogenous enzyme on performance, nutrient absorption, gut heath, and carcass characteristics of Arbor acres broilers. The authors reported that gizzard size increased, which was likely due to the more grinding activities needed for the increased fibre content of the diet resulting in increased musculature. Similarly, Denstadli et al. (2010) reported that relative gizzard weight significantly increased with increasing levels of BDG in diet up to 30%. The liver weight increased in the birds fed BDG without enzyme supplementation.

Digestibility Coefficient

Denstadli et al. (2010) reported a significant reduction in the protein digestibility as BDG replaced the wheat and soy-based control diet, probably due to the insoluble properties of the BDG protein (Hordein) forming protein aggregates during the mashing process. Adama et al. (2007) incorporated four levels of sorghum BDG up to 40% replacing maize and groundnut cake in broiler chicken diets, and reported that digestibility of all nutrients (DM, CP, EE, NFE and ash) decreased with increasing levels of BDG, but generally was comparable up to 20% levels of BDG. Aghabeigi et al. (2013) evaluated the impact of a gradual replacement of soybean meal with 0, 5, 10, 15, 20 and 25% BDG on protein digestibility in broiler chickens. The ileal protein digestibility was recorded on samples slaughtered at d 42. The ileal digestibility of protein increased significantly with inclusion of 10% BDG in diet compared to0,5, 15 and 20% BDG supplemented groups. Reduced ileal energy digestibility was due to high concentration of insoluble fiber in BDG (Denstadli et al. 2010). Because high fiber in BDG can reduce digestibility, Chesson (2001) suggested that the use of enzyme in diets containing BDG increased amino acids digestibility and protein absorption. Interestingly, BDG inclusion increased on starch digestibility, which was probably related to the coarse fiber particles in BDG because inclusion of coarse fiber particles may stimulate gizzard development and resulting in increased starch digestibility (Denstadli et al., 2010). The apparent ash availability decreased gradually due to inclusion of BDG in the diets, which are attributed to the complexation between fibrous structures of the BDG and minerals (Denstadli et al., 2010).

Economics

Adama et al. (2007) analyzed feed cost in the diets incorporated with four levels of sorghum BDG up to 40% replacing maize and groundnut cake, which was certainly lower for the BDG diet, and cost per unit of body weight gain was lower all BDG gain with lowest cost for the 40% BDG diet. Ironkwe and Bamgbose (2011) replaced maize with BDG at 0%, 25%, 50%, 75% and 100% in the diets of 28 d old broilers chicks and reported that the highest intake was noted for birds fed 100% maize and the least value of intake and cost from birds fed 100% BDG., it decreased as the BDG increased in the diet. Cost per kg weight gain also showed a similar trend, and the most favorable feed cost per kg weight gain was obtained for birds on diets containing 50, 75 and 100% BDG. Overall, though BDG decrease feed efficiency and weight gain above 10 to 20% level, it is apparent that inclusion of BDG in diets would decrease feed cost per unit of body weight gain and profits for the producers. On the other hand, no significant differences were observed in broiler chickens fed diet supplemented with BDG when the rearing cost and selling price as well as the cost of feed per kg of diet were investigated (Adeniji et al., 2015).

CONCLUSIONS

The use of BDG is a good source for protein and amino acids than corn. However, it is difficult to compare research findings regarding the use of BDG in poultry diets because of the different sources and types of the grains used during brewing process. For broiler chickens, inclusion rates of 5 to 10% of the diets. The major limitation to the use of this byproduct in poultry rations is its high fiber content. The high fiber content resulted in lower digestibility of the rations containing high amounts of BDG. A few researchers have indicated that enzyme supplementation can improve the nutritive value of BDG in poultry diets, particularly broiler starter diets.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTION

ME AbdEl-Hack and M Alagawany collected literature and drafted the manuscript. A Patra, M Abdel-Latef, and EA Ashour provided a technical help in the write-up of this review. M Alagawany and ME Abd El-Hack, M Arif, MR Farag and K Dhama reviewed and performed the final check. All the authors read and approved the final manuscript.

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