



## Effects of Dietary Brewery Spent Grain Inclusion on Egg Laying Performance and Quality Parameters of Bovans Brown Chickens

### ■ Author(s)

Gebremedhn B<sup>i</sup> <https://orcid.org/0000-0001-8589-7571>  
Niguse M<sup>i</sup> <https://orcid.org/0000-0001-7918-6044>  
Hagos B<sup>i</sup> <https://orcid.org/0000-0002-4429-179X>  
Tesfamariam T<sup>i</sup> <https://orcid.org/0000-0001-6892-5438>  
Kidane T<sup>i</sup> <https://orcid.org/0000-0002-7453-4908>  
Berhe A<sup>i</sup> <https://orcid.org/0000-0003-3038-9638>  
Gebresilassie L<sup>i</sup> <https://orcid.org/0000-0002-4391-5396>  
Gebreegziabher L<sup>i</sup> <https://orcid.org/0000-0001-8155-8150>  
Gebremariam T<sup>i</sup> <https://orcid.org/0000-0002-2672-861X>  
Gebremeskel Y<sup>i</sup> <https://orcid.org/0000-0001-5327-3588>

<sup>i</sup> Department of Animal, Rangeland and Wildlife Sciences, Mekelle University, P.O.Box: 231, Tigray, Ethiopia.

<sup>ii</sup> Department of Animal Science, Wukro Agricultural Polytechnic college, Tigray, Ethiopia.

<sup>iii</sup> Tigray Region Women Affairs Office Head.

### ■ Mail Address

Corresponding author e-mail address  
Gebremedhn Beyene  
Department of Animal, Rangeland and Wildlife Sciences, Mekelle University,  
P.O.Box: 231, Tigray, Ethiopia  
Phone: 251-966280075  
Email: [gebremedhnb2008@gmail.com](mailto:gebremedhnb2008@gmail.com)

### ■ Keywords

Bovans brown, brewery spent grain, egg quality, productivity, profitability.



### ABSTRACT

Poultry rations are composed mainly of conventional cereal grains and proteins. Using non-conventional agro-industrial by-products may reduce the cost of production and thereby improve productivity. A study was conducted to evaluate the effect of dietary brewery spent grain inclusion on egg laying performance, quality parameters of bovans brown and profitability of the rations. A total of 200 pullets with similar body weight and age were randomly distributed to five treatments with four replications. The treatments were brewery spent grain (BSG) inclusion of 0, 10, 20, 30 and 40% levels for T1, T2, T3, T4 and T5, respectively. The CP and ME contents of treatment rations were 16.54-17.04% and 2871-2903 kcal/kg DM, respectively. Inclusion of the BSG in the layers ration did not affect dry matter intake, feed conversion efficiency and hen-day egg production (58.79, 57, 56.11, 55.11 and 54.13% (SEM=0.92)). Likewise, the inclusion of the BSG in the diets did not affect (albumen, yolk, shell) quality. However, feed cost decreased with the increasing level of the BSG in the rations because of its lower purchasing price. To conclude, a 40% inclusion of BSG in the diet of layers does not affect the production and the quality of the eggs and it can be economically profitable.

### INTRODUCTION

In Ethiopia, poultry production is popular in urban (66%) and rural (53%) areas (Biro *et al.*, 2010). The total chicken population in the country is estimated to be 59.5 million, being 90.85 percent of the indigenous breed, 4.76 percent of the hybrid breed and 4.39 percent of the exotic breed (CSA, 2017). However; the economic contribution of the sector is still not proportional to the huge numbers of chicken; for instance the estimate of egg and poultry meat production is about 40,000 and 60,480 ton respectively (Faostat, 2013). This is due to the presence of many technical, organizational and institutional constraints (Fisseha *et al.*, 2010). The availability in terms of quantity and quality and cost of feed is one of the major limitations to livestock production systems in Sub-Saharan Africa (Alemayehu & Yayneshet, 2011). In Ethiopia scarcity of poultry feed is the major problem and the expected economic returns from chicken are very low. The price of feed sources is the determining factors for the profit margins in poultry production. Therefore, utilization of alternative feed resources in poultry ration is a best option for successful poultry production (Zewdu & Berhan, 2014). These alternative feed ingredients can be the non-conventional feed sources like brewery spent grains. Brewery spent grain is the by-product remaining after fermentation of the grain, during the beer making process. The by-product varies nutritionally from plant to plant and depending upon the type of substrate (barley, wheat, corn, etc.), extent of fermentation and type of fermentative process (Levic *et al.*,



2010). It is available at low or no cost throughout the year, and it is produced in large quantities (Mussatto *et al.*, 2006). The availability of brewery plants creates great opportunity for utilizing these agro-industrial by-products in poultry as protein sources (Meseret *et al.*, 2012). They are rich sources of digestible fiber with good amino acids, B- vitamin and phosphorus but low in other minerals (Hosseini *et al.*, 2010). Every year a large amount of brewery by-product is produced in Ethiopia. However, the by-product has not yet been extensively utilized for egg type poultry. Small amounts of the product is utilized as dairy cattle feed and large volume is accumulated at the production sites which causes disposal and public health problems (Zewdu & Berhan, 2014). The residue from production of 100 liters of beer is about 20 kg fresh matter residue with 80 % moisture content (Briggs *et al.*, 2004). Considering Ethiopia's nationwide beer production capacity of about 5.8 million hectoliters, 1.16 million metric tons of brewery spent grain (BSG) can be produced. Particularly, Raya beer has the capacity to produce 0.71 million hectoliters of beer and 14.2 million kg of BSG (Ethiopian-Reporter, 2015). Therefore; effective utilization and development of dietary formulations which allow locally available new ingredients such as brewery by-products is the most appropriate strategy as an alternative animal feed (Zewdu & Berhan, 2014). Hence, this study was designed to evaluate the effect of dried brewery grain inclusion in poultry diet on laying performance, egg quality using Bovans Brown layers and evaluate the profitability of the inclusion of brewery dried grain in layers diet.

## MATERIALS AND METHODS

### The study site

The experiment was conducted at Mekelle University poultry farm, 783 km north of Addis Ababa, Ethiopia. The site is located at 13° 28' N latitude and 39° 29' E longitude with an altitude ranging of 2150 – 2250 meter above sea level. The mean annual rainfall and temperature of the area is 680 mm and 17 °C, respectively (Alemayehu & Yayneshet, 2011).

### Experimental rations and treatments

Five experimental diets were formulated using feedwin software and the brewery dried grain was included at a rate of 0%, 10%, 20%, 30 % and 40% level for T1 (control), T2, T3, T4 and T5, respectively. The feed ingredients used in the formulation of the different experimental rations were brewers spent

grain (BSG), maize grain (MG), wheat short, noug seed cake (NSC), soybean meal (SBM), vitamin premix, salt and limestone. The brewery spent grain (BSG) was purchased from Raya Beer share company and the rest feed ingredients were purchased from nearby local market. The wet brewery grain was open air dried by spreading on Polyethylene plastic sheet for 4 consecutive days. To ensure uniform drying the brewers spent grain was turned and mixed up 5 – 6 times a day to break large particles. BSG was kept in air tight bags after drying. BSG, MG, NSC, and SBM were hummer milled to 5 mm sieve size and stored until required for formulation of the experimental rations. The chemical composition of the feed ingredients used for formulation of dietary ration was determined before formulation of the dietary treatments. The five dietary treatments were formulated to be iso-caloric and iso-nitrogenous with 2800-2900 kcal ME/kg DM and 16-17% CP (NRC, 1994) to meet the nutrient requirements of the layers. The proportion of the experimental diets was determined after nutrient analysis based on the nutrient content of the ingredients (Table 1).

**Table 1** – Proportion of ingredients (%) and analyzed chemical composition of the treatment ration

Ingredients	Treatment diets				
	T1	T2	T3	T4	T5
BSG	0.00	10.00	20.00	30.00	40.00
Wheat short	25.00	21.00	17.00	14.00	10.70
Soybean meal	7.00	5.00	2.00	2.00	0.00
Maize	34.50	34.20	36.20	36.20	39.00
Noug seed cake	24.20	20.50	15.50	8.50	1.00
Limestone	8.00	8.00	8.00	8.00	8.00
Salt	0.50	0.50	0.50	0.50	0.50
Vitamin premix	0.80	0.80	0.80	0.80	0.80
Total	100	100	100	100	100

BSG= Brewery spent grain; T1= ration containing 0% BSG; T2 = ration containing 10% BSG; T3 = ration containing 20% BSG; T4 = ration containing 30% BSG; T5= ration containing 40% BSG

### Experimental design and management of Bovans Brown layers

The layers were kept in deep litter pens covered with 10 cm deep barely straw as litter material. Before the commencement of the actual experiment, the pens, feeders, drinkers and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites. A total of 200 Bovans brown of 20 week-old layers with similar body weight were used in a completely randomized design (CRD). The layers were randomly allocated into 5 treatments. Each treatment comprised 40 layers and each treatment group was further subdivided into 4 replicates which comprised 10



layers in each. The layers were adapted to experimental diets for 7 days before the commencement of data collection. Feed was offered twice a day at 08:00 and 16:00 hours and clean tap water was available at all times. The experiment lasted 12 weeks.

## Data collection and measurements

### Chemical analysis

Representative feed samples were taken and subjected to proximate method of AOAC (1990) to determine dry matter (DM), crude protein (CP), crude fiber (CF), Ether extract (EE) and total ash content. The nitrogen was determined by using the Kjeldhal procedure and CP was computed by multiplying the nitrogen (N) content by 6.25. The metabolizable energy (ME) value was determined indirectly following the method given by Wiseman (1987) as follows: ME (Kcal/kg DM) = 3951 + 54.4 EE – 88.7 CF – 40.8 Ash. The calcium and phosphorus content were determined by atomic absorption spectrophotometer. Chemical analyses were carried out in duplicate.

### Feed intake and feed conversion efficiency

Weighed amount of feed was provided to the experimental birds twice a day at 08:00 and 16:00. Feed offered and refused per pen was recorded daily. The amount of feed consumed was determined as the difference of the feed offered and the feed refused. Feed offered and refused were sampled daily per pen and pooled per treatment for the entire experimental period for chemical analysis. Hens were weighted at the start and end of the experiment and body weight change was calculated as the difference between the final and initial body weight.

Feed conversion efficiency was determined per replicate by dividing daily grams of eggs laid by daily grams of feed intake in DM.

$$i.e. FCE\% = \frac{DLE(g)}{DFI(g)} * 100$$

### Egg production

Eggs were collected 3 times a day at 08:00, 13:00 and 17:00 hrs from each pen. The sum of the collections along with the number of birds alive on each day were recorded and summarized at end of the period. Eggs collected daily were weighted for each pen and average egg weight was computed by dividing the total egg weight to the number of eggs collected. Hen-day and hen-housed egg production were calculated following the method given by Hunton (1995).

$$\% \text{ Hen-day egg production} = \frac{\text{Number of eggs collected per day}}{\text{Number of hens present on that day}} \times 100$$

$$\% \text{ Hen-housed egg production} = \frac{\text{Number of eggs collected in the period}}{\text{Number of hens housed} \times \text{number of days}} \times 100$$

### Egg quality measurements

A total of 9 eggs per treatment (i.e. 3 eggs per replicate) were randomly taken weekly starting from the 5<sup>th</sup> week to the 12<sup>th</sup> week of the experimental period for egg quality analysis. Then the average was computed for each quality parameters for the replicate. Egg quality parameters, such as egg weight, shell weight, shell thickness, yolk weight, albumin weight, yolk height, albumin height, yolk index, yolk color and Haugh unit were measured. Egg shell thickness was measured using electronic digital caliper. Egg shell weight, albumen weight and yolk weight were measured by sensitive balance. Haugh unit measurement technique was used to relate the weight of the eggs with the height of thick albumen. Haugh unit was calculated according to the method described by Haugh (1937) formula as:

$$\text{Haugh unit (HU)} = 100 \log (\text{AH} + 7.6 - 1.7\text{EW}^{0.37})$$

Where: AH = Albumen height and  
EW = Egg weight

Yolk diameter and height were measured using ruler and electronic digital caliper, respectively after separation of the yolk from the albumen. The weight of the yolk was measured using sensitive balance of 0.005-3 kg capacity. Yolk index was estimated in percentage, taking the ratio of their respective heights to the average diameter (breadth and length) using the following formula.

$$\text{yolk index}\% = \frac{\text{Yolk height (cm)}}{\text{Yolk diameter (cm)}} \times 100$$

Yolk color measurement was made after the removal of the the yolk's membrane, the whole yolk was thoroughly mixed, and a yolk sample was taken on a piece of white paper and compared with Roche fan measurement strips.

### Partial budget analysis

To estimate and compare the economic feasibility of including brewery spent grains in layers diet, partial budget analysis was employed according to Upton



(1979). The partial budget was calculated as the difference between the feed costs incurred during the experimental periods and sale of the eggs. The net return (NR) was calculated by subtracting total variable cost (TVC) from total return (TR). The change in net return ( $\Delta NR$ ) was computed by subtracting change in variable cost ( $\Delta TVC$ ) from change in total return ( $\Delta TR$ ). The marginal rate of return (MRR) quantifies the increase in net return associated with each additional unit of expenditure. This is expressed by percentage as:

$$MRR\% = \frac{\Delta NR}{\Delta TVC} \times 100$$

The variable costs were the same for all treatments except the feed cost. The feed costs were calculated based on the market price of each ingredient and percent of inclusion. While the cost of brewery spent grain included the factory price, transport and processing costs. Market price of the eggs during the experimental period was considered as total return.

### Statistical analysis

The collected data were subjected to analysis of variance (ANOVA). Except yolk color, which was

analyzed by logistic regression, all other parameters were statistically analyzed using general linear model procedure of SAS (SAS, 2008). Significant difference ( $p \leq 0.05$ ) between treatments means were separated using Tukey's Studentized Range Test (HSD) method. The model used for statistical analysis was:

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

Where:  $Y_{ij}$  = responsible variable

$\mu$  = over all means

$T_i$  =  $i^{\text{th}}$  treatment effect ( $i = 1, 2, 3, 4, 5$ )

$e_{ij}$  = is a random error

## RESULTS

### Chemical and nutritional composition of BSG and the treatment diets

The result, as illustrated in (table 2), showed BSG has a lower CP content by 5.39% but a higher ME level by 2.25% compared to NSC. BSG has the lowest ash but the highest P content among the feed ingredients. Besides, BSG has higher CF level than all the other feed ingredients except NSC.

**Table 2** – Chemical composition of ingredients used in formulation of dietary treatment rations.

Chemical Composition	Feed ingredients				
	BSG	NSC	MG	WS	SBM
DM (%)	92.80	92.10	90.20	90.30	93.10
CP (% DM)	28.10	29.70	8.53	15.70	37.80
EE (% DM)	4.35	9.21	5.20	3.20	7.30
Ash (% DM)	4.25	8.30	5.92	6.10	7.93
CF (% DM)	14.30	16.10	4.10	8.90	6.30
Ca (% DM)	0.25	0.51	0.03	0.06	0.33
P (% DM)	0.94	0.33	0.27	0.35	0.85
ME (Kcal/kg)	2745.83	2685.31	3628.67	3086.77	3465.77

DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; Ca= calcium; P= phosphorus; ME = metabolizable energy; BSG=brewery spent grain; NSC=noug seed cake; MG=maize grain; WS=wheat short; SBM=soybean meal.

Similar levels of CP and ME were revealed by the results among all the treatments in the range of 16.54-17.04% and 2871-2903 kcal/kg respectively.

However, a slight continuous decrease in both can be noticed as the level of BSG increases across the treatments (table 3).

**Table 3** – Chemical composition of treatment diets containing different proportions of brewery spent grain

Chemical composition	Treatments				
	T1	T2	T3	T4	T5
DM (%)	91.83	91.93	92.00	92.09	92.18
CP (% DM)	17.04	17.00	16.74	16.72	16.54
Ash (% DM)	6.17	5.83	4.48	5.12	4.75
EE (% DM)	5.39	5.14	4.87	4.51	4.20
CF (% DM)	8.17	8.32	8.48	8.43	8.43
P (% DM)	0.32	0.37	0.41	0.47	0.52
Ca (% DM)	3.38	3.37	3.36	3.34	3.32
ME (kcal/kg DM)	2903	2889	2874	2873	2871

DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; P = phosphorous; Ca = calcium; ME = metabolizable energy; BSG= brewery spent grain; T1= ration containing 0% BSG; T2 = ration containing 10% BSG; T3 = ration containing 20% BSG; T4 = ration containing 30% BSG; T5= ration containing 40% BSG



### Feed intake and body weight change

The differences in feed intake due to the treatments were non-significant ( $p>0.05$ ). However, there was a tendency of increase in feed intake as the level of BSG increases. The highest feed intake was recorded for T5. Similarly, no significant difference was found in body weight change and due to the treatments while a slight continuous increase in body weight change was noticed from T1 to T5 (table 4).

### Egg production performance, egg weight, egg mass and feed conversion efficiency

As indicated in (table 4), both hen day egg production (HDEP) and hen housed egg production

(HHEP) showed no significant difference due to the treatments ( $p>0.05$ ). HDEP and HHEP value in all of the respective treatments were equal because of zero mortality during the 90 days experimental period. A continuous slight decline in values of HDEP and HHEP were noticed as the BSG level increased along T1, T2, T3, T4 and T5. Similarly, egg weight and egg mass showed no significant difference due to the treatments. The highest egg weight (52.09g) and egg mass (30.63g/hen/day) was T1 while the lowest values for T5 showed a percentage reduction of 2.03 and 9.86 respectively. Consequently, feed conversion efficiency continuously reduced along the treatments from T1 to T5 though the differences were non-significant.

**Table 4** – Dry matter intake, body weight gain and egg laying performance of Bovans Brown hens fed ration containing different levels of brewery spent grain

Treatment Parameters	T1	T2	T3	T4	T5	SEM	p-value
DMI (g/bird/day)	88.91	89.04	89.26	89.92	90.19	0.42	0.1866
Initial BW (g/bird)	1410	1415	1420	1412.67	1408.33	2.05	0.9192
Final BW (g/bird)	1506.3	1514	1522	1531.3	1540.7	2.13	0.2309
BW gain (g/bird)	96.3	99	102	118.7	132.3	2.54	0.4210
AD gain (g/bird)	1.07	1.1	1.13	1.32	1.47	0.27	0.4210
Total egg/hen	52.91	51.30	50.50	49.60	48.70	0.87	0.5309
HDEP (%)	58.79	57	56.11	55.11	54.10	0.92	0.5309
HHEP (%)	58.79	57	56.11	55.11	54.10	0.92	0.5309
Egg weight (g)	52.09	51.87	51.7	51.26	51.03	0.37	0.1918
EM (g/hen/day)	30.63	29.56	29.01	28.25	27.61	0.66	0.3129
FCE (g egg /g feed)	34.45	33.20	32.50	31.42	30.61	0.072	0.2487

AD=average daily; DMI = dry matter intake; BW = body weight; FCE=feed conversion Efficiency; HDEP = hen-day egg production; HHEP = hen-housed egg production; EM = egg mass; SEM = standard error of mean; BSG= brewery spent grain; T1= ration containing 0% BSG; T2 = ration containing 10% BSG as an inclusion; T3 = ration containing 20% BSG as an inclusion; T4 = ration containing 30% BSG as an inclusion; T5= ration containing 40% BSG as an inclusion.

### Egg quality

As indicated in (table 5), none of the egg quality parameters showed significant differences due to the treatments. Shell weight tended to reduce as the

level of BSG increased. The highest shell weight was obtained in T1 (5.90) while the lowest (T5) showed a 5.42% reduction. The highest haugh unit is 92.96 for T4 and the treatments did not have any significant

**Table 5** – Egg quality parameters of Bovans Brown hens fed ration containing different levels of brewery spent grain

Parameters	Treatments					SEM	p-value
	T1	T2	T3	T4	T5		
Sample Egg weight (g)	52.34	51.42	50.94	50.32	50	0.67	0.5506
Shell weight (g)	5.9	5.83	5.74	5.66	5.58	0.18	0.0902
Shell thickness (mm)	0.34	0.33	0.33	0.33	0.32	0.062	0.7060
Albumen height (mm)	7.95	8.04	8.09	8.15	8.1	0.36	0.9912
Albumen weight (g)	30.75	30.07	29.79	29.33	29.15	0.65	0.8039
Yolk height (mm)	15.35	15.42	15.52	15.61	15.7	0.28	0.6822
Yolk weight (g)	15.69	15.52	15.41	15.33	15.27	0.39	0.9171
Yolk color score	3.74	4.10	4.14	4.36	4.36	0.35	0.5276
Yolk diameter (cm)	3.65	3.61	3.58	3.53	3.5	0.15	0.3401
Yolk index	0.42	0.43	0.43	0.44	0.45	0.057	0.1703
Haugh unit	91.37	92.10	92.49	92.96	92.79	0.86	0.9654

SEM = standard error of mean; BSG= brewery spent grain; T1= ration containing 0% BSG as an inclusion; T2 = ration containing 10% BSG as an inclusion; T3 = ration containing 20% BSG as an inclusion; T4 = ration containing 30% BSG as an inclusion; T5= ration containing 40% BSG as an inclusion



effect. Similarly, yolk weight showed no significant difference due to the treatments but only a tendency to reduce as the level of BSG increased from T1 to T5.

### Partial economic analysis

The profitability analysis, as indicated in (table 6), showed the highest MRR=22.86 for T5. The MRR continuously increased as the level of BSG increased from 10% in T2 to 40% in T5. Feed cost/dozen egg was

the lowest in T5 showing a 21.35% reduction from the highest in T1. The decrease in feed cost between the control diet (6.60 birr per kg feed) and the diet with 40% inclusion level (4.50 birr per kg feed) represents a 31.19% reduction in the cost of feed which will be of great benefit to beneficiaries. The increase in egg sale/feed cost was continuous as BSG level increased along T1 to T5. The highest egg sale/feed cost 3.41 of T5 is by 27.24 percent higher than the lowest 2.68 of T1.

**Table 6** – Economics of inclusion of brewery spent grain in the layers ration

Variable	Treatments				
	T1	T2	T3	T4	T5
Total feed consumed (kg)	271.25	274.78	277.85	281.65	285.47
Total feed cost/ treatment (birr)	1776.83	1590.17	1413.73	1262.67	1086.79
Labor cost (for processing BDG) (birr)	0	50	100	150	200
TVC (birr)	1776.83	1640.17	1513.73	1412.67	1286.79
Feed cost/kg (Birr)	6.6	6.0	5.4	5.0	4.5
Total egg produced	1587	1539	1515	1488	1461
Gross income (TR)(birr)	4761	4617	4545	4464	4383
Net income ( NI) (birr)	2984.17	2976.83	3031.27	3051.33	3096.21
ΔTR (birr)	-	-144	-216	-297	-378
ΔTVC (birr)	-	-136.66	-263.1	-364.16	-490.04
ΔNR (birr)	-	-7.34	47.1	67.16	112.04
MRR (%)	-	5.37	17.90	18.44	22.86
Dozens of egg	132.25	128.25	126.25	124	121.75
Feed cost/dozen egg (birr)	13.44	12.79	11.99	11.39	10.57
Egg sale/Feed cost (birr)	2.68	2.81	3.00	3.16	3.41

Birr is Ethiopian currency; egg sale=3birr/egg; trt= treatment; BSG= brewery dried grain; T1= ration containing 0% BSG as an inclusion; T2 = ration containing 10% BSG as an inclusion; T3 = ration containing 20% BSG as an inclusion; T4 = ration containing 30% BSG as an inclusion; T5= ration containing 40% BSG as an inclusion.

## DISCUSSION

### Chemical and nutritional composition of BSG and the treatment diets

The BSG used in this study has a DM=92.80%, CP=28.10%, EE=4.35%, CF=14.30% Ash=4.25% and ME=2745.83 kcal/kg. In comparison, (NRC, 1994; Demeke, 2007; Fărcas *et al.*, 2014; Zewdu & Berhan, 2014; John, 2015) reported a DM content of 92.00%, 91.80%, 94.30%, 91.01%, 93.17% for BSG respectively. The CP content of BSG revealed in this study is higher than what is reported by (Fărcas *et al.*, 2014) (18%), (John, 2015) (23.67%), (Demeke, 2007) (24%), (Swain *et al.*, 2013) (25%), (Heuze *et al.*, 2015) (25.8%), (Briggs *et al.*, 2004) (27%) and (Mafeni & Fombad, 2001) (27.7%) when placed in ascending order and in between the range (28-30% ) reported in (Mussatto *et al.*, 2006). The EE of BSG as revealed by the current result is 4.35% which is low compared to (Swain *et al.*, 2013) (5.06%), (Demeke, 2007) (6.30%), (Mafeni & Fombad, 2001) (7.20%), and (John, 2015) (8.91%) but higher than 3.06% reported in (Zewdu & Berhan, 2014). Mafeni & Fombad (2001) and John

(2015) reported ash content of BSG 3.80% and 3.86% respectively while the current study found a higher ash level of (4.25%) in close to agreement with (Briggs *et al.*, 2004) 4-5%, and (Zewdu & Berhan, 2014) (4.79 %). In contrast, Swain *et al.* (2013) reported an ash content of 7.50% for BSG. The CF level of BSG in this study (14.30%) is comparable to the values in (NRC, 1994) (15%), (Briggs *et al.*, 2004) (15.30%), and (Mafeni & Fombad, 2001) (15.70%) but by far lower than in (John, 2015) (39.2%). The closeness of CF level of BSG and NSC (16.10%) in this study seems to have helped the comfortable replacement of much of the NSC with BSG up to the 40% inclusion level without significant effect on egg production performance and egg quality. In reflection to the above discussed chemical composition variables, the ME content of BSG according to this study is 2745.83 kcal/kg which is higher than what was reported in (Demeke, 2007) (2510 kcal/kg) and (Heuze *et al.*, 2015) (2200 kcal/kg). The variation in nutrient content of BSG among different sources is attributed to the type of raw material (barley, maize, wheat,...), type of fermentative process and extent of fermentation (Levic *et al.*, 2010), barley



variety, time of harvest, characteristics of hops and other adjuncts added and brewery technology (Santos *et al.*, 2003). All the diets are in agreement with the recommendations of (NRC, 1994) 16-17% for CP and 2800-2900 kcal/kg for ME. The Ca contents of all the diets are comparable to (Leeson & Summers, 1997) and (Jacob *et al.*, 2000).

### **Feed intake and body weight change**

As indicated in the results, there was no significant difference in DM intake between the treatments. The positive correlation stated in (Demeke, 2007) between feed intake and digestibility could suggest the digestibility of the diet containing 40% BSG is not significantly lower than the control and the lower inclusion levels, this could be attributed to fairly low crude fiber level of the BSG and the diets.

The current result showed no significant difference in average body weight changes (BW gains AD gains), and consequently in final body weights as the initial body weights were similar to begin with ( $p>0.05$ ). This result agrees with (John, 2015) up to 30% inclusion level. However, (López *et al.*, 1981) alerted on a body weight loss due to 45% BSG inclusion level. The current result could be justified by the similar dry matter intakes and possible amino acid balance in all the treatments which both determine growth rate of chicken.

### **Egg production performance, egg weight, egg mass and feed conversion efficiency**

The HDEP and HHEP of each treatment are the same for the absence of any mortality during the experiment. There was very slight and non-significant reduction on hen day egg production as the level of BSG increases along the treatments up to 40% inclusion level. This result is in disagreement with (Mafeni & Fombad, 2001) that reported a significant decrease in HDEP at 30% BSG inclusion level while partially replacing maize and cotton seed cake possibly leading to a higher crude fibre level unlike the current study. However, a 30% (John 2015) and 40% (Onwudike, 1981) BSG inclusion level were also tolerated in support of the current result.

The role of NSC in supplementing the amino acid balance of BSG has to be recognized in agreement with (Demeke, 2007) to make the 40% level tolerable while all the soyabean is taken out from the T5. The essential amino acid such as lysine and methionine content of BSG may need some complementary as confirmed by this study to completely replace soyabean meal,

what is regarded as among the best and the most conventional protein source for laying hens.

In this study the comparable CF level of BSG and NSC could have contributed to non-significant difference in feed intake, presumably digestibility and the resulting egg production performance due to the diets at 40% inclusion level of BSG. The relatively lower level of BSG in four of the diets (T1 up to T4) may have contributed to the lack of adverse effect when it is completely missed from the T5. A reduction in wheat short level progressively from T1 to T5 presumably didn't create significant energy gap confirming the role of BSG as a good source of energy for layers and partly due to the slight increase in Maize grain to maintain iso-calorie between the diets.

The average egg weight of the treatments (1.80–1.84 ounces) as presented in table 4 are in between medium (1.70 ounces) and large (2 ounces) in reference to USDA classification as cited in (Jacob *et al.*, 2000). The egg weight along the treatments shows a similar trend as the hen day egg production in support of (Fakhraei *et al.*, 2010) but in contrast to (Onwudike, 1981) ( $p<0.05$ ) and (Mafeni & Fombad, 2001) that saw a significant progressive increment in egg weight as BSG level increases to 30%. In the current study, the similarity of the diets makes ruling out a different egg protein synthesis pattern among the treatments possible. The slight decline in energy and protein level as the BSG level increases in the treatments seems to negatively correlate with the slight increase in feed intake to compensate for the reducing energy level (McDonald *et al.*, 1995), and to positively correlate with egg weight in agreement with (Mafeni & Fombad, 2001).

The similar level of CF along the treatments could have made digestibility not to significantly reduce due to higher BSG inclusion levels in contrast to (Mafeni & Fombad, 2001). The progressive slight non-significant increase in feed intake on one hand and a similar but opposite direction move for egg production has led to a progressively lower, statistically non-significant, feed conversion efficiency as the level of BSG inclusion increases from 0% to 40% in agreement with (Onwudike, 1981; Mafeni & Fombad, 2001; Olajide *et al.*, 2013).

### **Egg quality**

The variation in external (shell characteristics) and internal (albumin and yolk characteristics) egg quality parameters due the treatments was not significant ( $p<0.05$ ). Considering the higher BSG



inclusion levels haven't affected feed intake and egg production significantly may lead to the expectation of no significant difference to egg quality parameters as well. In the report of (Mafeni & Fombad, 2001), a 30% BSG inclusion levels significantly reduced hen day egg production while not significantly affecting egg quality parameters. In addition, (Lopez *et al.*, 1981) reported a reduction in egg shell quality at 45% BSG inclusion level while tolerated the 30% inclusion level in agreement with (John, 2015) including for other egg quality parameters. All the treatment diets contained beyond the recommended Ca:P ratio (6:1) in (Van Eekeren *et al.*, 2006). The amino acid balance of BSG seems to be commendable as in NSC including its high content of the limiting essential amino acids lysine and methionine (Scott *et al.*, 1982). These seems to be responsible for the lack of significance difference in egg quality and egg production performance as the level of BSG inclusion increased to 40% as a protein source as supported by (Roberts, 2004). Besides, (Anyanwu *et al.*, 2006) in agreement, reported HU and albumen height are not affected at 37.5% BSG inclusion level. The HU of the eggs in all treatments of this study are above 72, an AA grade according to USDA (USDA, 2000). The average egg shell thickness and yolk index of the treatments are  $\geq 0.32$  and 0.42-0.44 respectively which are comparable to the results of (Uchegbu *et al.*, 2011b). The mean yolk color scores of the treatments in this study ranged between 3.7 and 4.4 which are lesser to satisfy much of the consumer preference in many parts of the world (Leeson & Summers, 1997) including in Ethiopia (Tadelle *et al.*, 2003) where the preference is for deeper yellow yolk color.

### Partial economic analysis

As indicated in Table 6, the highest marginal rate of return is obtained by including higher level of BSG (40%) and decreased with decreasing level of BSG. Including up to 40% BSG had better economic advantage without affecting the nutrients supply, laying performance and egg quality.

Regarding profitability analysis, Mafeni & Fombad (2001) revealed similar results indicating the cost of feed required to produce a kg of egg output was progressively reduced for 0, 10, 20, and 30% levels of BSG in the ration. Hence, the use of BSG up to 40% is possible as an alternative to conventional feeds in the diets of egg laying hens to reduce cost of feed specifically and cost of egg production in general.

The study revealed indeed that 40% BSG inclusion is a tolerable level without causing significant reduc-

tion to egg production performance and egg quality parameters of chickens. It can be inferred that higher inclusion level of BSG is tolerable while BSG is replacing a protein source than an energy source like maize as that allows maintaining the crude fiber level of the diets at a tolerable level. A layers' ration can be most profitable with 40% BSG inclusion level that strengthens the argument for prime relevance of BSG as alternative protein source for chickens.

### ACKNOWLEDGEMENTS

We would like to extend our acknowledgement to Mekelle University for covering costs to undertake this research. The authors are very grateful to Raya Beer share company factory for facilitating the supply of the brewery spent grain.

### REFERENCES

- Alemayehu T, Yaynesht T. Comparative Chemical Composition Evaluation of Local Brewery and Liquor By-Products Made from Different Ingredients. *Journal of Drylands* 2011;4(2):307-309.
- Anyanwu G, Uchegbu M, Gwadia W, Mpieri F, Durunna C. Effect of total replacement of maize with brewer's spent grain and maize offal on performance of laying hens. *International Journal of Natural and Applied Sciences* 2006;2:268-271.
- AOAC - Association of Official Analytical Chemists. Official methods of analysis. 13<sup>th</sup> ed. Washington;1990.
- Birol E, Asare-Marfo D, Ayele G, Mensa-Bonsu A, Ndirangu L, Okpukpara B, et al. Investigating the role of poultry in livelihoods and the impact of avian flu on livelihoods outcomes in africa [discussion paper]. Washington: International Food Policy Research Institute; 2010.
- Briggs DE, Brooke SP, Stevens R, Boulton C. *Brewing science and practice*. Cambridge: Woodhead Publishing Limited; 2004.
- CSA - Central Statistical Agency. Report on livestock and livestock characteristics (Private peasant holdings). Addis Ababa: Agricultural Sample Survey; 2017. v.2.
- Demeke S. Comparative nutritive value of Atella and industrial brewers grains in chicken starter ration in Ethiopia. *Livestock Research for Rural Development* 2007;19(1).
- Ethiopian-Reporter. Ethiopia: raya to hit bars supermarkets. Washington: All Africa; 2015.
- Fakhraei J, Loutfollahian H, Shivazad M, Chamani M, Hoseini S. Reevaluation of lysine requirement based on performance responses in broiler breeder hens. *African Journal Agricultural Research* 2010;5:2137-2142.
- Fărcas A, Tofană M, Socaci S, Mudura E, Scrob S, Salanță L, et al. Brewers' spent grain – A new potential ingredient for functional foods. *Journal of Agroalimentary Processing and Technology* 2014;20(2):137-141
- Faostat. Food and agriculture organization of the United Nations. Rome: Fao; 2013 [cited 2018 Jan 5]. Available from: <http://faostat3.fao.org/faostat-gateway/go/to/download/Q/QC/S>.





- Fisseha M, Azage T, Tadello D. Indigenous chicken production and marketing systems in Ethiopia: characteristics and opportunities for market-oriented development [working paper, 24]. Addis Ababa: ILRI; 2010.
- Haugh PR. The Haugh unit for measuring egg quality. *United States Egg Poultry Magazine* 1937;43:522-555.
- Heuze V, Tran G, Sauvant D, Lebas F. *Brewers grains*. Feedipedia; 2015. Available from: <http://feedipedia.org/node/74>.
- Hosseini SJ, Nassiri MH, Kermanshahi H. The influence of different levels of brewers spent grain and enzyme on performance and digesta viscosity of broiler chicks. *Journal of Animal and Veterinary Advances* 2010;9:2605-2612.
- Hunton P. *Egg production, processing and marketing*. Tokyo: World Poultry Science; 1995. p.457-480.
- Jacob JP, Miles RD, Mather FB. *Egg quality [PS 24]*. Florida: Institute of Food and Agricultural Sciences, University of Florida; 2000.
- John M. Palm kernel meal and brewer's dried grain improve laying performance of Japanese quails (*Coturnix coturnix japonica*) without affecting egg quality characteristics. *Journal of Animal Science Advances* 2015;5:1430-1436.
- Leeson S, Summers J. *Feeding programs for broilers*. In: Leeson S, Summers J. *Commercial poultry nutrition*. 2<sup>nd</sup> ed. Guelph: University Books; 1997. p.207-254.
- Levic J, Djuragic O, Sredanovic S. Use of new feed from brewery by-products for breeding layers. *Roman Biotechn Letters* 2010;15:5559-5565.
- López D, Carmona F, Pascual LM. Evaluation of brewer's dried grains in the diets of laying hens. *Animal Feed Science Technology* 1981;6(2):169-178.
- Mafeni M, Fombad R. Brewer's grains from Cameroon brewery in breeder chicken rations: effect on productive and reproductive performance. *Tropicalist* 2001;19:61-64.
- McDonald P, Edwards RA, Greehalgh JFD. *Animal nutrition*. 5<sup>th</sup> ed. Harlow: Longman Group; 1995.
- Meseret G, Berhan T, Tadello D. Effects of replacing peanut seed cake with brewery dried yeast on laying performance, egg quality and carcass characteristics of Rhode Island Red chicken. *International Journal of Poultry Science* 2012;11:65-72.
- Mussatto S, Dragone G, Roberto I. Brewer's spent grain: generation, characteristics and potential applications. *Journal of Cereal Science* 2006;43:1-14.
- NRC - National Research Council. *Nutrient requirements of poultry*: 9<sup>th</sup> ed. Washington: The National Academies Press; 1994.
- Olajide R, Akinsoyinu AO, Iyayi E, Afolabi KD. The effect of brewers dried grains supplemented by enzyme on performance of Isa-brown laying hens. *PoljoPrivreda* 2013;19:65-69.
- Onwudike O. The use of brewers dried grains by laying hens. *Nutrition Reports International* 1981;24(5):1009.
- Roberts JR. Factors affecting egg internal quality and egg shell quality in laying hens. *The Journal of Poultry Science* 2004;41:161-177.
- Santos M, Jiménez J, Bartolomé B, Gómez-Cordovés C, Del Nozal M. Variability of brewer's spent grain within a brewery. *Food Chemistry* 2003;80:17-21.
- SAS Institute. *SAS user's guide: statistics*. Version 9.2. Cary: SAS Institute; 2008.
- Scott ML, Nesheim MC, Young RJ. *Nutrition of chicken*. 3<sup>rd</sup> ed. New York: M.C. Scott and Associates Ithaca; 1982.
- Swain B, Naik P, Chakurkar E, Singh N. Effect of Feeding Brewers' Dried Grain on the Performance of Japanese Quail Layers. *Indian Journal of Animal Nutrition* 2013;30:210-213.
- Tadello D, Kijora C, Peters K. Indigenous chicken ecotypes in Ethiopia: growth and feed utilization potentials. *International Journal of Poultry Science* 2003;2:144-152.
- Uchegbu MC, Herbert U, Ogbuwu IP, Nwaodu CH, Esonu BO, Udedibie ABI. Performance and egg quality characteristics of layers fed diets containing combinations of brewers dried grains, jack bean and cassava root meal. *Revista Científica UDO 156 Agrícola* 2011b;11(1):155-160.
- Upton M. *Farm management in Africa: the principles of production and planning*. Cambridge: Cambridge University Press; 1979.
- USDA - United States Department of Agriculture. *Egg-grading manual [Agricultural Marketing Service, 75]*. Washington: Department of Agriculture; 2000. 56p.
- Van Eekeren N, Maas A, Saatkamp H, Verschuur M. *Small-scale poultry production in the tropics*. Wageningen: Agromisa Foundation; 2006.
- Wiseman J. *Feeding of non-ruminant livestock*. London: Butterworth and Co.; 1987.
- Zewdu W, Berhan T. The effect of feeding different levels of brewer's dried grain yeast mixture on the performance of white leghorn chicks. *International Journal of Livestock Research* 2014;5:10-14.

