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Effect of replacing soybean meal with brewery dried grain on feed intake, egg production and egg quality parameters of Bovans brown chickens

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Abstract

One hundred and fifty 18-weeks old Bovans brown layers were used to evaluate the effect of replacement of soybean meal with brewery dried grain on feed intake, egg production performance and egg quality parameters. Layers were fed a ration containing brewery dried grain at a level of 0% (T1), 6.5% (T2), 13% (T3), 19.5% (T4) and 26% (T5) by replacing the soybean meal. The experiment was arranged in a completely randomized design containing five treatments replicated thrice each of which lasted for 12 weeks. Data on feed intake, egg weight, and egg number were recorded on daily basis. Internal and external egg qualities were determined at weekly intervals using three eggs per replication. The egg weight was similar ($p>0.05$) among treatments. The total egg number per hen decreased with increasing levels of brewery dried grain. The total egg mass was greater ($p<0.05$) for T1 but lower ($p<0.05$) for T3, T4 and T5 which had similar ($p>0.05$) values with each other. The highest ($p<0.05$) hen-housed egg production was for T1. The total feed intake decreased ($p<0.05$) with increasing levels of brewery dried grain. However, feed conversion ratio for T3, T4 and T5 was greater ($p<0.05$) than T1 and T2. No consistent trend was observed in egg quality traits. Shell thickness for T1 was lower ($p<0.5$) than T3, T4 and T5. The internal egg quality parameters were similar ($p>0.05$) among treatments except yolk height and yolk color score. The yolk color score decreased ($p<0.05$) with increasing levels of brewery dried grain. The highest marginal rate of return was obtained by including higher level of BDG (26%) and decreased with decreasing level of BDG. In conclusion, inclusion of up to 26% brewery dried grain in the diet of Bovans brown layers reduced egg production, although economically profitable with similar effect on internal egg qualities.

Key words: brewery dried grain, egg mass, egg production, egg quality, egg weight, feed conversion ratio

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INTRODUCTION

The demand for food of animal origin is expected to increase in developing countries because of escalation in human population, urbanization and income improvements especially in urban areas (Abdullah et al., 2011). The poultry sub-sector is one of the major protein sources that can meet the rising demand for protein of animal origin, attributed to the high rate of reproduction and feed conversion efficiency. Moreover, the sub-sector has the potential to create both rural and urban employment and generate income at various economic levels (Tekalegn et al., 2017). However, the productivity per unit of bird and the contribution of this sector to the national economy is low in developing countries such as Ethiopia. Availability, quality and market price of the conventional energy and protein sources are factors that limit the productivity of poultry in the tropics, including Ethiopia (Aberra et al., 2011; Atawodi et al., 2008).

Monogastric animals like poultry are markedly affected when the use of cereal products as livestock feeds is increasingly unjustified economically, where feed cost for poultry accounts for about 70% of the total production cost (Birhanu et al., 2021). The bulk of the feed cost arises from protein concentrates. Prices of conventional protein sources, especially soybean meal, have increased in recent times and it is becoming uneconomical to use in poultry feeds under smallholder production systems (Melesse et al., 2013). The profit from poultry production can be attained by minimizing feed cost which accounts for more than half of the total cost of production.

Therefore, using alternative feed resources in poultry ration is one of the best options for successful poultry production (Zewedu and Berhanu, 2014). These alternative feed ingredients could be brewery dried grains (DBG). 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) wch calls for an assesment of brewery dried grain produced in Ethiopia for poultry and other livestock species. It is available at low cost throughout the year, and it is produced in large quantities (Mussatto et al., 2006). The availability of brewery plants creates a great opportunity for utilizing these agro-industrial by-products in poultry as protein sources (Meseret et al., 2012). It is rich source of digestible fiber with good amino acids, B- vitamin and phosphorus but low in other minerals (Gebremedhin et al., 2020). According to Mussatto et al. (2006), DBG contains other nutrients, including minerals, vitamins and amino acids.

Fresh brewer's grain is a cheap (compared with soybean), non-conventional protein source that is becoming increasingly available to urban and peri-urban dairy farms in Ethiopia. In the year 2016/17, the annual total wet brewery spent grain (WBG) production from the twelve beer factories in Ethiopia was estimated at 26,723 tons DM (Getu et al., 2021). Brewery by-product decellulosed mixture proteins contain considerably higher levels of methionine (1.5%), tyrosine (3.5%) and valine (4.8%) compared to soybean meal proteins. As reviewed by Mussatto et al. (2006) proteins from non-conventional feed, such as brewery-dried grain and soybean meal, are mutually complementary. Brewer's grains from the brewing industry have crude protein (CP) ranging from 145 to 374 g kg^{-1} of dry matter (DM) (Del Río et al., 2013; Westendorf et al., 2014), and can be used as a lower cost replacement for soybean meal. Soybean (*Glycin max*) is an oil seed legume that is rich in protein and used for both human and animal feeding and for industrial purposes. It is the major source of protein for non-ruminant feeding, constituting about 20 - 30% level of inclusion in poultry ration (Esiegwu, 2016). Hence, this study was designed to evaluate the effect of dried brewery grain inclusion as a replacement to soybean in poultry diet on feed intake, laying performance, and egg quality using Bovans brown layer chickens and evaluate the profitability of the inclusion of brewery dried grain in layers diet.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Gondar University poultry farm, located 12°36' 0" N & 37°28' 0''E or 12.6 Latitudes and 37.45 Longitude with an altitude of 2200.45 m above sea level. The area's annual mean minimum and maximum temperature vary between 12.3-17.7°C and 22-30°C, respectively, with an annual average temperature of 19.7°C. The area receives a bimodal rainfall, with the average annual precipitation of 1000 mm (Tikunesh et al., 2022).

Experimental rations and treatments

Five experimental diets were formulated using Win feed software. The brewery dried grain (BDG) was purchased from Gondar Dashen Beer Company, and the remaining feed ingredients were purchased from the nearby local market. The BDG was air-dried by spreading on a polyethylene plastic sheet for about four days. The BDG, maize grain (MG), noug seed cake (NSC), and soybean meal (SBM) was hummer milled to 5 mm sieve size and stored until required for formulation of the experimental rations. The brewery dried grain was included at a rate of 0%, 6.5%, 13%, 19.5 % and 26% of soybean meal, representing T1 (control), T2, T3, T4 and T5, respectively (Table 1). The dietary treatments were formulated to be iso-caloric and iso-nitrogenous with 2800-2900 kcal ME kg^{-1} DM and 16-17% CP (NRC, 1994) to meet the nutrient requirements of the layers. The proportions of the experimental diets were determined after nutrient analysis based on the nutrient content of the ingredients (Table 1).

Table 1. Proportion of ingredients and chemical composition of the treatment diet (starting from 20 wks of age)

Ingredients and chemical composition	T1	T2	T3	T4	T5
Maize	48	46.7	47.2	47.7	48
Noug seed cake	4.7	6	6.5	6.5	6.5
Soybean meal	26	19.5	13	6.5	0
Wheat short	12	12	11	10.5	10.2
Brewery dried grain	0	6.5	13	19.5	26
Limestone flour	8	8	8	8	8
Vitamin premix*	0.8	0.8	0.8	0.8	0.8
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Chemical composition					
Dry matter (%)	91.8	91.6	91.5	91.2	91.0
Crude protein	17.8	17.8	17.8	17.8	17.8
Ether extract	3.5	3.4	3.3	3.4	4.2
Ash	9.8	9.98	10.2	11.4	11.8
Crude fiber	9.2	9.2	9.5	9.8	10.0
Nitrogen free extract	55.2	55.3	55.3	55.3	55.6
Calcium	3.2	3.3	3.2	3.4	3.4
Phosphorus	0.6	0.6	0.6	0.6	0.6
Metabolizable energy (kcal kg^{-1} DM)	2871	2871	2871	2870	2871

*Supplied in amount per kilogram diet: vitamin A, 5000 IU; vitamin D3, 4500 ICU; vitamin E, 88 IU; thiamine HCl, 10 mg; riboflavin, 10 mg; Ca pantothenate, 30 mg; niacin, 120 mg; pyridoxine HC1, 10 mg; folic acid, 5 mg; menadione, 10 mg; biotin, .5 mg; vitamin B, 2 , 10 jug; and butylated hydroxytoluene, 1 g.

Experimental design and management of layers

The layers were kept in deep litter pens covered with 10 cm depth barely straw as a bedding 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 150 Bovans brown of 20 week old layers with similar body weight were used in a completely randomized design. The layers were randomly allocated into 5 treatments. Each treatment comprised 30 layers and each treatment group was further subdivided into 3 replicates of 10 layers. 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 a.m. and 4:00 p.m. (local time, GMT +3) and clean tap water was available at all times. The experiment lasted 12 weeks.

Management of pullets

The company where pullets were purchased already vaccinated pullets against major poultry viral and bacterial diseases including Marek's disease, Newcastle, infectious bursal disease (Gumburo), fowl typhoid and fowl pox diseases. After arrival, the chicks were weighed and randomly distributed to the already prepared experimental pens with a dimension of 3 m^2 (2×1.5 m) per replicate. The concrete floor was covered with wood shavings at a depth of 5 cm. The pullets were fed with pullet and pre-lay rations until the age of 20 weeks. They were then fed with layer rations starting from the 20^{th} weeks of age until end of the experiment. Clean water and feed were provided *ad libitum* throughout the experimental period.

Chemical analysis

Representative samples were taken from each of the feed ingredients used in the experiment and analyzed before formulating the actual dietary treatments. Samples were also taken for chemical analysis from each treatment ration. Feed samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash using the method of the AOAC (1990). The calcium and phosphorus content of the ingredients were determined by atomic absorption spectrophotometer method as described in AOAC (2005). Metabolizable energy (ME) of the experimental diets was determined by indirect method according to Wiseman (1987) as follows:

$$\text{ME (Kcal kg}^{-1}\text{ DM)} = 3951 + 54.4\text{ EE} - 88.7\text{ CF} - 40.8\text{ Ash}$$

Table 2. Chemical composition of feed ingredients and treatments diets (DM %)

Chemical composition	Maize grain	Noug cake	Soybean meal	Wheat bran	Dried brewery grain
Dry matter (%)	91.0	94.0	91.9	92.0	92.0
Crude protein	10.6	32.3	39.8	17.6	25.4
Ether extract	5.9	7.51	8.4	4.31	6.1
Ash	4.9	12.8	6.5	4.4	9.8
Crude fiber	3.8	17.5	5.7	9.4	13.9
Nitrogen free extract	65.6	23.8	27.1	56.3	45.5
Calcium	0.14	0.72	0.48	0.1	0.76
Phosphorus	0.35	1.09	0.78	0.68	0.37
Metabolizable energy (kcal kg^{-1} DM)	3735	2285	3637	3175	2560
Treatments	T1	T2	T3	T4	T5
Dry matter	91.8	91.6	91.5	91.2	91.0
Crude protein	17.8	17.6	17.8	17.4	17.6
Ether extract	3.5	3.41	3.32	3.43	4.2
Ash	9.8	9.9	10.2	11.4	11.8
Crude fiber	9.2	9.2	9.5	9.8	10.0
Nitrogen free extract	55.2	55.3	55.3	55.3	55.6
Calcium	3.2	3.3	3.2	3.4	3.4
Phosphorus	0.6	0.6	0.6	0.6	0.6
Metabolizable energy (kcal kg^{-1} DM)	2871	2871	2871	2870	2871

T1 = ration containing 0% BDG as an inclusion; T2 = ration containing 6.5% BDG as an inclusion; T3 = ration containing13% BDG as an inclusion; T4 = ration containing 19.5% BDG as an inclusion; T5= ration containing 26% BDG as an inclusion

Feed intake

A measured amount of feed was offered in the morning (between 7.00 and 8.00 a.m.) and late afternoon (between 4.00 and 5.00 p.m.) and refusals were always collected and weighed the following morning before feed is offered. Feed intake on group basis was then computed by subtracting the feed refusal from that of feed offered.

Egg production

Eggs were collected twice a day from each pen (10:30 a.m. and 4:00 p.m. local time). The sum of the two collections along with the number of birds alive on each day was recorded and summarized at the end of the experiment. Since there was no mortality recorded, hen-housed egg production was calculated by considering the number of hens that were housed initially.

Performance variables and egg quality

$$\%\ of\ Hen-housed\ egg\ production = \frac{Total\ number\ of\ eggs}{Number\ of\ hens\ initially\ housed\ \times number\ of\ days\ in\ lay} \times 100$$

Egg weight and mass

Egg weight was determined on weekly basis and the average egg weight was calculated. Total egg mass was computed by multiplying the average egg weight with total number of eggs produced. Daily egg mass per hens was computed by dividing the total egg mass by the number of hens that were initially housed and total number of days in which the hens were in lay.

Feed conversion ratio (FCR)

Feed conversion ratio per egg mass was computed by dividing the total feed intake with total egg mass.

$$FCR\ (kg\ feeding\ egg\ mass) = \frac{Total\ feed\ intake\ (kg\ hen^{-1})}{Total\ egg\ mass\ (kg\ hen^{-1})}$$

Egg quality parameters

Any broken, cracked, thin-shelled, without shell, or deformed eggs laid were recorded and isolated. These data were used to calculate the percentage of laid and viable eggs. Egg quality parameters were measured for each replicate. Egg quality parameters to be measured were egg weight, shell thickness, egg yolk color albumen height, and yolk height and diameter. An electronic scale at 0.001 g sensitivity was used to weigh the eggs' albumen, yolk and shell weights. After weighing the eggs were broken and accurately divided into three components: shell, yolk, and albumen. The yolk and albumen were weighed immediately after breaking; while the shell was dried at room temperature for water evaporation from the solid substance and weighed. Egg length and width were measured using a digital caliper. Egg shape index was then computed from egg width per egg length. For quality measurement, three eggs per replication (nine eggs per treatment) were randomly taken weekly and the average was computed for each quality parameter for the replicate. The shell thickness is the average of the thickness taken from the narrow end, center and broad end points of the egg and was measured using a digital caliper. Albumen and yolk heights were measured by tripod micrometer meter device. The yolk color was compared with a roche colour fan consisting of 15 colored plastic strips, with one rated as very pale yellow to a deep intense reddish orange. Haugh unit was calculated according to the method described by Haugh (1937) as:

$$HU = 100 \log (H + 7.6 - 1.7\, W^{0.37})$$

Where, HU= Haugh unit (g)
H = Albumin height (mm)
W = weight of egg

The yolk diameter was measured using a digital caliper and the yolk index was computed by the following formula.

$$Yolk\ index = \frac{Yolk\ height\ (mm)}{yolk\ diameter\ (mm)} \times 100$$

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, other costs being similar among treatments. The net return (NR) was calculated by subtracting total variable cost (TVC) from total return (TR). The change in net return (ΔNR) was computed by subtracting change in variable cost (ΔTVC) from change in total return (ΔTR). The marginal rate of return (MRR) quantifies the increase in net return associated with each additional unit of expenditure. This is expressed as percentage using the following equation:

$$MMR\ (\%) = \frac{\Delta NR}{\Delta TVC} \times 100$$

Data management and analysis

Data on feed intake, body weight, feed conversion ratio, egg production and egg quality parameters were subjected to one-way ANOVA by fitting treatment diets as fixed factors. The general linear model (GLM) procedures of SAS (SAS, 2012) were used to analyze the collected data and treatment means were compared using Duncan multiple range test at 5% significance level. The statistical model used was:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

Where:
Y_{ij} = the observation in the ij^{th} treatment
μ = the overall mean measurement across all treatments
τ_i = the effect of the i^{th} treatment, and
ε_{ij} = the random error

RESULTS AND DISCUSSION

Feed intake and egg production performances

As indicated from the result there was a significant difference ($p<0.05$) in feed intake among treatments. The highest ($p<0.05$) feed intake was observed in T5 and the lowest in T1. Results from the present research were similar to the reports of Mafeni and Fombad (2001) who indicated that feed intake increased as the brewery dried grain level increased up to 30% in breeder chicken ration. Also, Meseret et al. (2012) reported that 40% brewery dried grain inclusion level resulted in high feed consumption in layer’s diet. Since birds eat to meet their energy requirements (Harms et al., 2000; Leeson et al. 2001), birds ate more diet (as in T5), of the treatment containing 26% brewery dried grain compared to the other treatments. The fiber content of was the highest in T5 followed by T4 and the least for T1 (control). Fiber has been proved to affect the diet's physical texture and increase birds' feed intake to meet energy needs. Contrary to the current report Zewdu and Berhan, (2014) reported similarity in mean feed intake when brewery dried yeast was included up to 30% of the starter ration. Similarly, Meseret et al. (2012) observed no significant difference in feed intake of chicken fed on a ration containing up to 25% brewery dried grain. As the level of BDG increased ($p<0.05$) there was a reduction in hen housed egg production. Higher feed intake reduced feed efficiency and depressed egg production of birds that are fed on rations with high levels BGD, which could be attributed to high fiber levels in the diets. High fiber diets could result in less availability of active ingredients of for the birds. The birds, therefore, ate more to satisfy their energy requirement for production and maintenance. It was observed, too, that higher feed intake of birds on high levels BDG did not support higher egg production. Birds on high levels of fiber diets consumed much feed but produced lesser number of eggs (Obidimma et.al., 2010).

The low fiber content in T1 and T2 favors the increments of egg production. In agreement with the current report Gebremedhin et al. (2020) reported a significant decrease in HDEP at 30% brewery spent grain inclusion level which might be due to the high fiber content of the treatment. The egg weight was similar among treatments which is consistent with the reports of Fakhraei et al. (2010) but in contrast to Yangtul et al. (2013) and Mafeni and Fombad (2001) who observed significant progressive increment in egg weight as BSG level increases to 30%. A higher ($p<0.05$) feed conversion ratio (FCR) was observed in hens reared in T3, T4 and T5 compared with those of T1 and T2 diets. Higher feed conversion ratio means low feed efficiency which was obtained at higher inclusion level of brewery dried grain. Similarly, Mafeni and Fombad and (2001) reported that 20% to 30% BDG inclusion increased feed required to produce a dozen of eggs. Naulia (2002) reported 14.56% inclusion of groundnut cake resulted in better feed conversion ratio than 22.9 and 31.44% of inclusion levels. The result from the present study, however, disagreed with the reports of Kevin et al. (2006) who reported reduced feed conversion ratio at 40% levels of BDG inclusion.

Table 3. Feed intake and egg production performance of Bovans brown layer chicken fed with brewery dried grain as a replacement to soybean meal

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	P value
Final body weight (g)	1682	1681	1683	1683	1682	16.2	0.985
Total egg number per hen	77.5^a	73.3^b	70.4^c	67.4^d	66.6^d	29.1	0.0001
Average egg weight (g)	62.4	61.6	60.3	60.4	61.2	10.2	0.2761
Total egg mass (kg hen^{-1})	4.7^a	4.5^b	4.2^c	4.2^c	4.1^c	0.15	0.0001
Hen-housed egg production	86.1^a	81.4^b	78.2^c	74.9^d	74.0^d	35.9	0.0001
Total feed intake (kg hen^{-1})	9.92^e	9.95^d	9.99^c	10.01^b	10.1^a	3.0	0.0001
FCR (kg feed kg^{-1} egg mass)	2.1^c	2.2^b	2.4^a	2.5^a	2.4^a	0.04	0.0001

SEM = standard error of mean; BDG= brewery dried grain; T1= ration containing 0% BDG as an inclusion; T2 = ration containing 6.5% BDG as an inclusion; T3 = ration containing13% BDG as an inclusion; T4 = ration containing 19.5% BDG as an inclusion; T5= ration containing 26% BDG as an inclusion.

External egg quality parameters

Egg length, egg width, egg shape index and shell thickness were significantly different (Table 4). Shell thickness in T2, T3, T4 and T5 was higher ($p<0.05$) than T1. The lower shell thickness in T1 compared with other treatments might be due to the calcium content of brewery dried grain for the treatment diets which was higher than the control. Uchegbu *et al.* (2011) observed similar egg shell thickness (0.39 mm) for Bovans Whites fed diets containing combination of brewery dried grain, jack bean and cassava root meal. The egg thickness in the current experiment was lower than the egg shell thickness (0.39 mm) reported by Sinha *et al*. (2017) for Rhode Island Red. Niraj *et al*. (2014) also reported higher egg shell thickness (0.41 mm) for Rhode Island Red fed under intensive management. Egg shell thickness is important quality parameters for table egg and is affected by calcium and phosphorus contents of the diet. Eggs with low-quality shells contribute to economic losses in the production of eggs for consumption (Sinha et al., 2018). The egg length in T1 was higher ($p<0.05$) than in the other treatment with a similar value. Egg length and width depend on the weight of the egg. In the current study higher egg weight was obtained in T1 but not significantly different from others. The highest egg weight was related to the highest egg length and width for T1 compared to the other treatments (Table 5). Dzungwe et al. (2018) found strong correlation between egg weight, egg length and width. The egg length ranged between 53.91 and 56.43 mm in the current experiment, which is in line with the report by Ahmedin and Mangistu (2016) where the average mean egg length was 56.4 for Bovans brown layer breed. The highest ($p<0.05$) egg width was for T1 and T2 and there was no significant difference in the shell weight values. The highest shape index was obtained in T5. The range of shape index in the current experiment (77.35-79.07 mm) is higher than that reported by Duman et al. (2016; 72-76 mm). Liswaniso et al. (2020) reported egg shape index of 76 mm which is within the range of values in the current experiment in layers fed free range or scavenging type.

Table 4. External egg quality for Bovans brown layers fed on BDG as a replacement for soybean meal

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	P value
Dry shell weight (g)	6.23	6.15	6.03	6.04	6.12	0.102	0.2761
Shell thickness (mm)	0.33^{b}	0.35^{ab}	0.35^{a}	0.35^{a}	0.35^{a}	0.0004	0.0481
Egg length (mm)	56.43^{a}	55.43^{ab}	54.52^{bc}	54.10^{c}	53.91^{c}	2.359	0.0001
Egg width (mm)	43.9^{a}	43.3^{ab}	42.5^{bc}	41.9^{c}	42.6^{bc}	2.362	0.0023
Egg shape index (%)	77.74^{b}	78.07^{ab}	77.91^{ab}	77.35^{b}	79.07^{a}	2.882	0.0434

SEM = standard error of mean; BDG= brewery dried grain; T1= ration containing 0% BDG as an inclusion; T2 = ration containing 6.5% BDG as an inclusion; 13 = ration containing13% BDG as an inclusion; T4 = ration containing 19.5% BDG as an inclusion; T5= ration containing 26% BDG as an inclusion

Internal egg quality parameters

Albumen and yolk weight and height, as well as Haugh unit, yolk width and index were similar ($p>0.05$) among treatments (Table 5). The similarity of egg quality characteristics may suggest that brewery dried grain can replace soybean meal in Bovans brown layer ration without affecting egg quality parameters. The yolk height for T1 was greater than that of T3 but similar with other treatment groups. The range of yolk height (17.03-17.33 mm) in the current experiment is lower than the results (17.84 mm and 17.41 mm) reported by Dessalew et al. (2015) for Bovans and Isa browns under village production system. The range of the albumen height (6.71-6.83 mm) in the current experiment is comparable to that reported by Yonas et al. (2019) with mean albumen height of 7.1 mm for Bovans brown breed. Haugh unit (81.60-82.4) in the current experiment is similar to the reported values by Niraj *et al.* (2014; 82.15) for the similar breeds. However, the current finding is lower than the result (87.45) reported by Tadesse et al. (2015) the same breed. Consistent with the current finding Mafeni and Fombad (2001) reported similarity in Haugh unit by including up to 30% brewery dried grain in the diet of breeder chickens. On the other hand, Egg yolk color is a very important factor in consumer satisfaction and influences human appetite (Oke et al., 2014; Nigussu et al., 2019) with a preference for golden yellow to orange (Hasin et al., 2006). The average value of albumen weight, albumen height, Haugh unit, yolk width and yolk index did not vary among treatments. Yolk color score decreased with increasing levels of BDG, the highest value corresponding to T1. The mean yolk color scores of the treatments in this study ranged between 4.5 and 5.5 which could be less satisfying for consumers in many parts of the world (Senbeta et al., 2015) including Ethiopia (Dessalew et al., 2015) where the preference is for deeper yellow yolk color. From this research it can be concluded that the replacement of BDG with soybean meal did not affect most of the internal quality of eggs from the Bovans brown layer hens and hence can be used as replacement of soybean meal up to 26% as safe level.

Table 5. The effect of replacement of soybean meal with BDG on internal egg quality parameters

Parameters	Treatment						
	T1	T2	T3	T4	T5	SEM	P value
Albumen weight(g)	37.43	36.93	36.17	36.27	36.73	3.68	0.2761
Albumen height (mm)	6.83	6.81	6.82	6.71	6.80	0.076	0.6511
Yolk weight (g)	18.72	18.47	18.08	18.13	18.37	0.92	0.1503
Yolk height (mm)	17.33^{a}	17.15^{ab}	17.03^{b}	17.15^{ab}	17.19^{ab}	0.10	0.0780
Yolk width(mm)	39.30	39.41	39.38	39.32	39.23	3.56	0.9988
Yolk index	44.19	43.61	43.33	43.56	43.91	4.48	0.7831
Haugh unit	82.20	81.96	82.43	81.60	81.64	3.08	0.5559
Yolk color score	5.54^{a}	5.05^{b}	4.87^{c}	4.69^{d}	4.53^{e}	0.03	0.0001

SEM = standard error of mean; BDG= brewery dried grain; T1= ration containing 0% BDG as an inclusion; T2 = ration containing 6.5% BDG as an inclusion; T3 = ration containing13% BDG as an inclusion; T4 = ration containing 19.5% BDG as an inclusion; T5= ration containing 26% BDG as an inclusion

Partial budget analysis

The highest marginal rate of return was obtained by including higher level of BDG (26%) and decreased with decreasing level of BDG (Table 6). Including up to 26 % BDG had better economic advantage and with similar effect on egg quality compared to the control. Regarding profitability analysis Mafeni and Fombad (2001) revealed similar results indicating the cost of feed required to produce a kg of egg output was progressively reduced with increasing levels (0, 10, 20, and 30%) in the ration. Hence, the use of BDG 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. In agreement with the current finding Ngele et al. (2011) reported that incorporation of spent sorghum residue at 30% level reduced the total feed cost and cost of feed per kg weight gain in Japanese quails. Also, Swain et al (2012) reported that incorporation of 10% BDG in the diet of Japanese quails significantly reduced the feed cost per kg and the feed cost per kg of weight gain. Cost of production and feed cost per kg decreased with increasing BDG levels (Abd El-Hack et al., 2019).

Table 6. Economics of brewery dried grain for layer

Variable	T1	T2	T3	T4	T5
Total feed consumed in kg per head	9.92	9.95	9.99	10.02	10.06
Total feed cost per head (Birr)	148.8	139.3	129.87	120.24	110.66
Labor cost (Birr)	-	30	60	90	120
Total variable cost (Birr)	148.8	169.3	189.87	210.24	230.66
ΔTVC (Birr)	-	20.5	41.07	61.44	81.86
Total egg produced per head	77	73	70	67	66
Gross income (TR) (Birr)	420	414	402	390	378
Net income (NI)(Birr)	271.2	244.7	212.13	179.76	147.34
ΔTR (Birr)	-	-26.5	-59.07	-91.44	-123.86
ΔTVC (Birr)	-	20.5	41.07	61.44	81.86
ΔNR (Birr)	-	-6	-18	-30	-42
MRR (%)	-	29.268	43.828	48.828	51.307

CONCLUSIONS

In conclusion, inclusion of up to 26% brewery dried grain in the diet of Bovans brown layers has resulted in reduced egg production, although economically profitable with no significant effect on internal egg qualities.

Conflicts of interest

Authors declare that they have no conflicts of interest regarding the publication of this paper with the Journal of Science and Development.

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