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Laying Performance and Egg Quality of Bovans Brown Hens on Brewer's Spent Yeast-Based Diets

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Abstract

This study evaluated the effect of dried brewery spent yeast (BSY) as a protein source on the feed intake, body weight (BW) change, egg production, egg quality, and feeding cost in laying hens. One-hundred fifty Bovans Brown hens, aged 23-weeks, were randomly assigned to five dietary treatments. The control diet (T1) contained 0% BSY and 20% soybean meal (SBM), while diets T2, T3, T4, and T5 contained BSY at 5, 10, 15 and 20%, respectively, replacing SBM at 25, 50, 75 and 100%. The diets were formulated to meet the nutrient requirements of laying hens targeting nearly 2750 kcal/kg DM ME and 16.5% CP. *The inclusion of BSY in the diet did not affect feed intake (P>0.05), which ranged from 111 g/hen/day (T5) to 115 g/hen/day (T4). Moreover, egg weight (55-56 g) and feed conversion in dozens of eggs produced were not influenced by the diet (P>0.05). However, higher inclusions of BSY decreased (P<0.05) the total number of eggs laid per hen (90.6 in T1, 81.3 in T5), %lay (92.4 in T1, 83.0 in T5), and feed conversion in egg mass (2.23 in T1, 2.52 in T5. No significant differences were noted in laying performances, feed efficiency, and egg quality parameters between hens fed diets with 10% and 15% BSY. Final BW and BW gains were lowest (P<0.05) in hens on diets with 15% and 20% BSY. Egg quality parameters were not changed with up to 15% BSY inclusion. However, hens fed a 20% BSY diet exhibited a decrease (P<0.05) in egg albumen weight, egg yolk weight, and Roche color fan values, while egg weight remained unchanged. The cost per kg of feed or dozen eggs decreased with increase in the level of BSY. It is concluded that up to 15% dried BSY can be incorporated into the diet of laying hens as a low-cost protein source, partially replacing soybean meal.*

Keywords: Brewer's spent yeast, bovans brown, egg production, egg quality

Introduction

In Ethiopia, the poultry industry is growing rapidly as a profitable business venture and source of employment. This growth is primarily propelled by escalating demands for animal-source food (chicken meat and egg), driven by factors such as population growth, urbanization, rising incomes, and shifting lifestyle (Shapiro *et al*., 2015). However, the industry is highly challenged by inconsistent supply of high-quality and affordable production inputs. Feed is one of the crucial production inputs becoming increasingly important to ensure sustainable poultry production. It accounts for about 70-75% of total production costs in commercial poultry farming (Hartrich *et al*., 2021). The production and availability of poultry feed is affected by low supply and frequent price fluctuation of feed ingredients, resulting in increased prices of poultry products (meat and egg). A report has shown that the prices of major feed ingredients, such as grains and agro-industrial by-products increased by 50-213%, while the price of compound poultry feed increased by about 63-84% between 2016 and 2020 (Zegeye *et al*., 2023). This discrepancy of lower compound feed cost can be attributed to the use of less expensive feed ingredients or their bulk purchasing at lower cost.

Using locally available non-conventional feed resources to replace expensive feed ingredients used for commercial feed production reduces production costs and increases profitability. One such cheap and potential feed source is brewer's spent yeast (BSY), also known as brewery yeast slurry, readily available in Breweries. The BSY is obtained by removing yeast after the fermentation process in beer factories, and it is often disposed of as waste after being inactivated by organic acid application or heat treatment at 80°C (Heuzé *et al.,* 2018; Getu *et al*., 2018). Brewer's spent yeast is the second most abundant by-product of the Breweries, generating about 2-4 kg spent yeast per hectoliter of beer produced (Anca *et al*., 2017).

Brewer's spent yeast (*Saccharomyces cerevisiae*) is a valuable source of nutrients, including protein (39-56%), NFE (24.3-39%), minerals (mainly phosphorous-0.96-2% and potassium- 1.7%), and B vitamins, and is highly digestible (Heuzé *et al*., 2018; Tacon *et al*., 2009; Meseret *et al*., 2012). The estimated metabolizable energy (ME) values of BSY in poultry and pigs ranged from 2221 to 3013 kcal/kg (Heuzé *et al*., 2018; Chollom *et al,* 2017; Meseret *et al*., 2012; Yalcin *et al*., 2008). Brewers' spent yeast has an excellent amino acid profile with better lysine content (3.13%), but it is deficient in methionine and cystine (Heuzé *et al.*, 2018; Tacon *et al.,* 2009; Vieira *et al.,* 2016; Jacob *et al.,* 2019; Meseret *et al*., 2012; Jaeger *et al*., 2020). It also contains about 4-21% ribonucleic acid (RNA) (Jaeger *et al*., 2020), which may lead to the accumulation of uric acid in blood and tissues, thereby exerting a toxic effect in monogastric animals. Studies have shown that yeast (*Saccharomyces cerevisiae)* has unique "plus" factors that increase phosphorus availability (Brake, 1991) and reduce infectious disease incidence in broilers (Line *et al*., 1997). The nutrient composition of BSY varies with the type of substrate used and the extent and type of the fermentation process (Levic *et al*., 2010).

Brewers' spent yeast has been successfully incorporated into the diets of both ruminants and non-ruminants. Studies have shown that up to 5% dried BSY inclusion in the diet of laying hens did not adversely affect egg production, feed intake, feed efficiency, or serum cholesterol levels (Sacakli *et al.* 2013; Yalcın *et al.*, 2008). Moreover, its inclusion improved the performance and egg quality of Rhode Island Red, replacing up to 50% peanut seed cake (Meseret *et al.,* 2012).

Yeast and its derivatives are used as feed additives and alternatives to antibiotics due to their ability to promote growth, intestinal health, regulate immune response, and improve nutrient digestibility. The benefits of yeast and its derivatives in improving the performance and health of poultry have been well-documented (Bilal *et al*., 2022; Perricone *et al*., 2022; Spring, *et al.*, 2000; Fadl *et al*., 2020; Fu *et al*., 2019; Zhang *et al*., 2020; Lin *et al.*, 2023). However, feed use of BSY is majorly limited by high moisture content (10-14%DM), leading to increased transportation costs and storage challenges. Moreover, liquid BSY deteriorates over time, and its high ribonucleic acid (RNA) content poses toxicity risks (Ferreira *et al.*, 2010). Nevertheless, processing techniques such as sun-drying and ensiling have been used to improve the feed value of BSY (Boateng *et al*., 2015).

Brewer's spent yeast is produced in large quantities in Ethiopia, with about 360,758 hectoliters of liquid spent yeast generated by 12 breweries in 2016/17 (Getu *et al*., 2018). Moreover, Ahmad *et al.* (2022) reported that all breweries in the country collectively produced about 21,161 tonnes of BSY, equivalent to 2,328 tonnes of dry matter (DM) in 2021. Unfortunately, the inactivated spent yeast is mostly discharged as waste to the environment, and often causing disposal problem for the industry. Moreover, its current contribution to poultry feed production is negligible in the country. Given the periodic price fluctuations of traditional protein sources like soybean meal and the high-quality protein of BSY, the use of BSY in commercial poultry feed production is advantageous. To this end, a study was conducted to investigate the effect of dried BSY inclusion in the laying hens' diet on feed intake, BW change, egg production, egg quality, and economic benefits.

Materials and Methods

Preparation of Brewer's Spent Yeast

Heat-treated liquid BSY was obtained from the storage tank of Walia brewery (P.L.C) and transported to the research center using containers. Upon arrival, the solid portion of BSY was separated by washing it with water at a rate of 6:1 (water: liquid BSY, weight by weight) as described by Sharif *et al*. (2012) (Figure 1). This step not only separates the solid part from the liquid but also reduces the bitter taste of hops (*Humulus lupulus* L.) that might have an adverse effect on feed palatability and consumption (Yalcın *et al*., 2008). To wash BSY, a known volume of BSY was poured into a plastic barrel, and six times the volume of water was added to it and the mixture was thoroughly mixed. The mixture was then left undisturbed for at least 8 hours, during which the solid part settled at the substratum. The supernatant part was removed by tilting the barrels, and the residues were spread on clean plastic sheets and sun-dried until they became brittle (>90% DM) to ensure safe storage. The sun-dried BSY was manually ground to a size of 2 mm and then stored. The amount required for the entire experimental period was collected and processed in repeated batches. The nutritional composition, including the fatty acid profile of the sun-dried intact and washed BSY samples was assayed in the laboratory using standard procedures (AOAC, 2010).

Figure 1. Steps followed during processing the brewer's spent yeast.

Dietary Treatments and Design

The chemical compositions of feed ingredients and diets are indicated in Table 1 and Table 2, respectively. Five diets were formulated for laying Bovans Brown hens. The diets had varying levels (0, 5, 10, 15 and 20%) of sun-dried BSY replacing soybean meal at different rates (0, 25, 50, 75 and 100%) in T1, T2, T3, T4 and T5, respectively. The control diet (T1) was a commercial layer diet formulated from common poultry feed ingredients. All the treatment diets were formulated to nearly to meet the nutrient requirements of laying hens at 2750 kcal/kg DM ME and 16.5% CP (NRC, 1994) and prepared in mash form. Major, feed ingredients, except for layer concentrate with predetermined nutrient composition, underwent lab-analysis for chemical composition, while the metabolizable energy values were adopted from literature, including that of brewers' yeast and its amino acid profiles as detailed in the Poultry Production Manual from PTC^{+} in The Netherlands).

Table 1. Chemical composition (% DM) of major ingredients used in feed formulation

Ingredients	%DM	%CP	%EE	%CF	%Ca	%P	ME, Kcal/kg
Maize	89.7	8.40	4.40	2.30	0.04	0.30	3258
Wheat middling	90.2	15.60	3.60	9.20	0.11	1.15	1980
Soybean meal	89.2	43.50	6.50	6.50	0.30	0.65	2180
Nougseed cake	89.6	34.60	7.10	20.80	0.26	0.65	2400
Meat and bone meal	90.2	50.00	14.0 0	0.00	10.50	5.20	2830
*Layer concentrate	94.0	5.00	2.00	0.02	21.90	5.10	1250
BSY	92.01	42.05	1.13	2.30	0.27	0.76	2860

*total ash = 73.27%; Ca= 21.90; Total P= 5.10; *available* P =10.10; P dig.=8.20; Na= 4.80; total lysine=1; lysine dig=1.36; Methionine tot=6.5; Methionine dig.= 6.65; Methionine +cystine = 6.5; Methionine Cyst. Dig.= 6.7%; ME= 1250 Kcal/kg; Vit. A= 400,000 I.U; Vit. D3=120,000 I.U, Vit. E= 800 mg; Vit K3= 80 mg; Vit B1= 60 mg; Vit B2=240 mg; Vit B3=400 mg;Vit B6=200 mg; Vit B12 = 0.8 mg; Folic acid= 40 mg; Nicotinic acid=1200 mg; Choline chloride=14000 mg; Biotin= 4 mg; (mg/kg: Fe=1800;Cu= 800;Mn=2400; Zn=2800; I=80; Se=16)

Table 2. Ingredients and nutrient composition (%) of experimental feeds

Ingredients	T1	T2	T3	T4	T5
Maize	60	58.6	59.2	57.4	57
Wheat middling	3	4	2.2	3	2.8
Soybean meal 45/46	20	15	10	5	0
Brewers' spent yeast	0	5	10	15	20
Noug seed cake	5.2	5.6	7	8.3	8.5
Meat and bone meal	1.2	1	0.4	0.5	1.2
Salt	0.4	0.4	0.4	0.4	0.4
Limestone	6.7	6.9	7.1	7	7
Layer concentrate	2.5	2.5	2.5	2.5	2.5
Di-calcium phosphate	1	1	1.2	0.9	0.6
Total	100	100	100	100	100
Calculated nutrient composition					
Crude protein (%DM)	16.73	16.74	16.62	17.02	17.30
Metabolizable energy (kcal/kg)	2640.2	2652.3	2686.9	2712.1	2753.7
Fat (%DM)	6.64	4.34	4.05	3.84	3.66
Crude fiber (%DM)	4.04	3.97	3.9	3.99	3.8
Calcium (%DM)	3.56	3.62	3.68	3.58	3.58
Phosphorus (%DM)	0.75	0.75	0.75	0.72	0.71
Lysine (%DM)	0.8	0.82	0.84	0.88	0.92
Methionine (%DM)	0.45	0.46	0.47	0.48	0.49
Methionine+Cystine (%DM)	0.72	0.72	0.72	0.73	0.73

T1 = diet with 0% BSY; T2 = diet with 5% BSY; T3 = diet with 10% BSY; T4 = diet with 15% BSY; T5 = diet with 20% BSY;DM= dry matter

Management of Experimental Hens

One hundred and fifty-five, 21-weeks-old, Bovans Brown pullets were purchased from Alema Farms, a commercial poultry farm located in Bishoftu. The pullets were raised according to standard management practices (brooding, feeding, health, lightening) at the hatchery. Upon arrival at the research farm, the pullets were vaccinated against common viral diseases such as fowl pox, fowl typhoid and Lasota, as per their administration schedule. After two weeks of adaptation, the pullets were weighed and randomly grouped into 5 treatments of 30 animals each, with an average initial live weight of 1.54±0.034kg (mean±SD). Each treatment was then further divided into 3 sub-groups (replications) with 10 animals each, and the pullets were allotted to pens using a random number table in a completely randomized design. Each replicate was managed in a pen with a concrete floor bedded with tef straw, 5 laying nests/pen each with 30*35*40 cm (length, width, and height) dimension, and feeding and watering troughs. Provision of adequate floor space (6 hens/m^2), cleaned and disinfected pens, drinkers and feeders were ensured. The temperature inside the poultry house was at around 21°C during the experimental period. The research was approved by Addis Ababa University, College of Veterinary Medicine, and Agriculture for ethical relevance with an ethical clearance certificate reference issued as VM/ERC/23/06/13/2021.

The hens were fed three times a day at 8:00, 13:00 and 17:00 h and feed refusal was measured and recorded daily. Feed intake was determined as the difference between the amount of feed offered and leftovers. Hens in each pen were weighed in groups at the beginning and end of the experiment using a weighing balance (0.001). The weight change was computed by the differences. The actual feeding trial lasted for 14 weeks (23^{rd}–36^{th} weeks of age).

Egg Yield and Egg Quality Measurements

Eggs were collected, weighed, and recorded daily for each pen. Collection times were set at 8:00 and 11:00 in the morning, and 13:00 and 16:00 in the afternoon. The average weight of eggs was computed by dividing the total weight of eggs by the number of eggs laid per pen for that day. The egg production traits (HDEP (%lay) – hen day egg production; HHEP– hen house egg production) were computed as follows (Hunton, 1995).

$$\text{HDEP (\%/hen/day)} = \frac{\text{Total number of eggs produced on a day}}{\text{Total number of hens present on that day}} \times 100$$

$$\text{HHEP (\%/hen/day)} = \frac{\text{Total number of eggs laid on a day}}{\text{Total number of hens housed at the beginning of laying period}} \times 100$$

$$\text{Egg mass (g/hen/day)} = \text{HDEP\% X average egg weight (g)}$$

$$\text{FCR} = \frac{\text{g feed consumed}}{\text{g egg mass}} \text{ X 100} \quad \text{Or,} = \frac{\text{kg feed consumed}}{\text{Dozens of eggs laid}}$$

Egg quality was measured bi-weekly using 3 eggs randomly sampled per replicate (9 eggs/ treatment). Measurements were taken for the entire egg, shell, albumen, and yolk on the same date eggs were collected. Sample eggs were weighed, and their lengths and widths were measured using a digital caliper. Eggs were broken and contents were carefully poured into a Petri dish to avoid mixing of yolk and albumen. The shell, albumen, and yolk were separated and weighed. Shell thickness at the broad end, narrow end and middle of the egg was measured using a digital caliper and the average was calculated. The height of the thick albumen was also measured using a tripod micrometer after releasing the contents on a Petri dish. Yolk color was measured using a Roche color fan with pale to orange-yellow colors. The weights of egg, albumen, yolk, and shell were also taken. Haugh Unit was computed using the formula by Haugh (1937) = 100 log (H + 7.57 - 1.7 $W^{0.37}$), where, H = height of thick albumen (mm), W = Egg weight (g).

Cost of Feeding

This study considered only the economics of feeding and did not consider other variables important for all treatments. Since there was no record for the full production cycle, only feed and egg production variables were compared. The cost of feed ingredients, the amount consumed, and processing costs for BSY (transport, washing and drying) were used for calculations. Currently, Walia Brewery provides BSY to livestock farms free of charge. The total cost of feed consumed and the cost per dozens of egg production were computed, and all variables were estimated and presented on an individual hen basis (pen average).

Statistical Analysis

The data obtained were subjected to analysis of variance using Statistical Analysis System (SAS, 2011; version 9.3). Diets were sources of variation, while individual pens (3/treatment) were experimental units. When ANOVA declares significant, treatment means were separated using Tukey test ($\alpha = 0.05$).

Results and Discussion

Nutrient Composition of Brewer's Spent Yeast

The BSY used in this study had ~~a~~ higher level of protein but was low in fat and fiber contents (Table 3), which is in agreement with previous studies (Geberemariyam *et al.,* 2022; Chollom *et al.,* 2017; Sreeparvathy, and Anuraj, 2016; Mathias *et al*., 2015; Kabugo *et al.,* 2014; Meseret *et al*., 2012; LeMieux *et al.,* 2010). However, other studies have reported much higher protein contents (64.1 and 74.3% CP) of BSY, along with an excellent profile of B-vitamins and all essential amino acids (Vieira *et al.,* 2016; Jacob *et al.,* 2019). In this study, the brewers' spent yeast was found to be high in phosphorus but low in calcium, which is consistent with literature reports. Washing the BSY with water increased protein, Ca and P but reduced crude fiber, ash, and fat contents. The washed BSY had 4.32% more protein, 35% more Ca, and 100% more P than the unwashed BSY. However, washing reduced the ash content by 36.85%, crude fat by 17.52%, and fiber fraction by 14.81%, possibly due to the removal of water-soluble fractions. This decrease in certain nutrients may have led to an increase in others, which is consistent with Sharif *et al*. (2012) who observed an increase in protein but a decrease in ash contents of distillery sludge due to washing. In addition, BSY is rich in essential (unsaturated) fatty acids such as linoleic and oleic acids and saturated fatty acids (Figure 2). Given its high-quality protein and low fiber content, BSY is an alternative protein source for poultry.

Table 3. Chemical composition (%DM) of brewer's spent yeast collected from Walia brewery

BSY type	DM	CP	CF	Ash	EE	Ca	P
Unwashed	91.40	40.31	2.70	4.47	1.37	0.20	0.48
Washed	92.01	42.05	2.30	3.27	1.13	0.27	0.96

Note: Liquid BSY contained 11.2 % DM, CF= crude fiber, CP= crude protein, DM= dry matter, Ether Extract

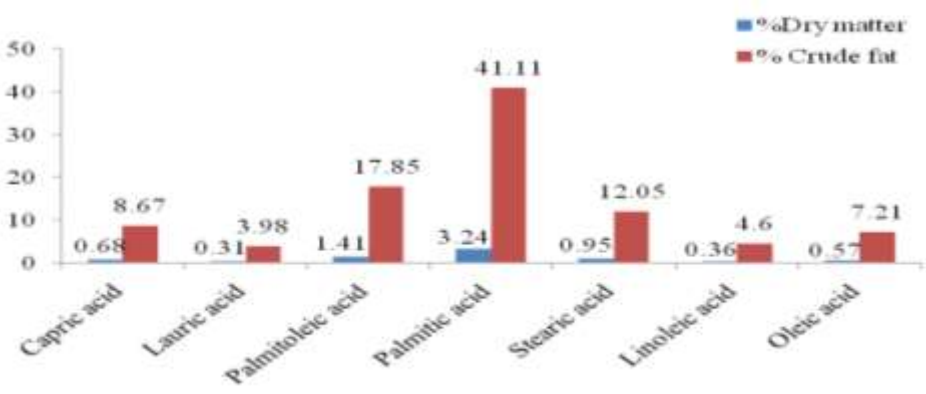

Figure 2. Fatty acid profile of brewer's spent yeast used in the experiment.

Feed Intake, Egg Yield and Feed Conversion Ratio

During the experimental period, the laying hens showed no signs of illness or mortality. Dietary treatments had no significant effect on feed intake and egg weight (P>0.05). However, 15% and 20% BSY diets decreased (P<0.05) egg production, egg mass, and feed conversion ratio (FCR) computed in egg mass compared to the control group (Table 4). Feed intake remained consistent across the treatments, ranging from 111 g/hen/day (T5) to 115 g/hen/day (T4), indicating that higher BSY levels did not alter the hens' appetite or feeding behavior. Contrarily, Meseret *et al*. (2012) observed increased feed intake in laying Rhode Island Red (RIR) chickens fed diets containing up to 20% BSY, replacing peanut seed cake. However, the decrease in FCR in egg mass indicates that higher BSY levels have impaired feed utilization efficiency into egg mass, leading to decreased egg mass values. This reduction in FCR with increased BSY levels may be attributed to the adverse effect of nucleic acid (RNA) contained in BSY on feed efficiency, as indicated by Ferreira *et al*. (2010), who noted that elevated RNA concentrations in the blood of mono-gastric animal can negatively affect performance. However, FCR computed per dozen eggs produced did not significantly vary among treatments (P>0.05), although its magnitude increased with higher BSY levels. This implies that while feed efficiency may affect egg mass production, it may not substantially affect the overall number of eggs produced per unit of feed consumed. In agreement, Meseret *et al*. (2012) reported that the inclusion of BSY in the diet of RIR hens did not affect feed efficiency when calculated per dozen eggs produced. In our study, the egg weights ranged from 55.0 g (T5) to 56.2 g (T4), with no significant variation observed among treatments (P>0.05).

Higher levels of BSY inclusions in the diet led to a significant decrease in egg production (P<0.05). Hen-day egg production (% lay) was highest in T1 (92.4%) and lowest in T5 (83%), corresponding to the total number of eggs laid per hen (90.6 in T1, 81.3 in T5) (P<0.05). Although there were no significant differences in egg production between hens fed 15% BSY and 20% BSY diets, a respective 8% and 10% reduction in HDEP was observed compared to the control group. Since no mortality was observed, HHEP and HDEP values were the same for all treatment. Contrarily, no difference in HDEP (84.8-87.9%) was observed among laying RIR chickens fed diets containing up to 20% BSY (Meseret *et al*., 2012), although egg weight increased significantly. The present HDEP values were higher than 51-70% reported for Bovans Brown parent stock during 21-52 weeks (Dawud *et al*., 2018), but within the range of the breeder's company report (70-92%) for the breed. The feed efficiency decreased significantly (P<0.05) with increased BSY (2.23 in T1 and 2.52 in T5). Contrarily to our findings, Park *et al.* (2020) observed enhanced egg production, egg weight, and egg mass in laying hens provided a diet supplemented with brewer's yeast hydrolysate. However, they found no significant differences in feed intake and feed conversion ratio compared to the group without supplementation.

Table 4. Feed intake, egg yield and feed conversion ratio of laying Bovans Brown hens fed diets containing brewer's spent yeast

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Daily FI (g/hen)	112.7	113.0	114.3	115.6	111.3	0.6	0.1454
Total FI (kg/hen)	11.1	11.1	11.2	11.3	10.9	0.1	0.1851
Eggs/hen/98day	90.6[a]	89.0[a]	86.0[ab]	83.4[b]	81.3[b]	2.8	0.0357
Egg weight, g	55.5	55.2	55.9	56.2	55.0	0.2	0.4375
HDEP/HHEP	92.4[a]	90.8[a]	87.8[ab]	85.1[bc]	83.0[c]	0.6	<.0001
Egg mass (g/hen)	51.3[a]	50.1[ab]	49.0[bc]	47.9[c]	45.7[d]	0.4	<.0001
FCR (FI/egg mass)	2.23[c]	2.29[c]	2.39[b]	2.48[ab]	2.52[a]	0.03	<.0001
FCR (FI/dozen eggs)	1.47	1.49	1.57	1.63	1.61	0.04	0.0987
Mortality (n)	0	0	0	0	0	0	-

[a-c] Means within a row without common superscripts are significantly different (P< 0.05). FI= feed intake; HDEP/HHEP = hen-day egg production/hen-house egg production; FCR= feed conversion ratio, SEM= standard error of mean, T1= diet with 0% BSY; T2= diet with 5% BSY; T3= diet with 10% BSY, T4= diet with15% BSY, T5= diet with 20% BSY

The egg production trend varied among treatments during the feeding period (Figure 3). The laying rate increased with the progress of the feeding period and dropped between 70% and 100% lay for all treatments. The control group had relatively higher weekly laying rates as compared to the groups on 15% and 20% BSY diets.

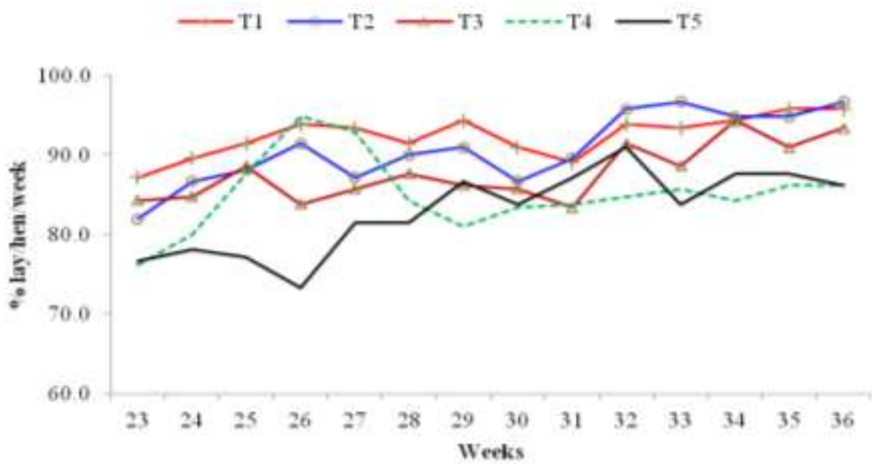

Figure 3. Average %lay (HDEP) of hens across the feeding period

Body Weight

There were significant differences in BW change of hens among treatments (P<0.05; Table 5). Final BW and weight change were lower (P<0.05) in T4 (1.613 kg, 48 g) and T5 (1.577 kg, 27 g) compared to the control and 5% BSY groups. However, there were no significant (P>0.05) differences in final body weights and weight gains among the 10% BSY, 15% BSY, and 20% BSY groups. The decrease in BW change observed in hens fed higher BSY levels could be due to its adverse effect on feed efficiency or an imbalance in amino acids with increased substitution of soybean meal. This contrasts with the findings of Meseret *et al*. (2012), who observed an increase in BW change in laying Rhode Island Red (RIR) chickens fed diets containing up to 20% dried BSY. On the other hand, Özsoy *et al*. (2018) observed no significant differences in BW change of laying hens supplemented with graded levels (0.05, 0.1, 0.2%) of yeast culture *(Saccharomyces cerevisiae)*, while feed intake decreased at the highest level. These variations in BW change of hens among the experiments may be attributed to differences in the type of brewer's yeast products used, feed composition, or breed and laying duration of hens.

Table 5. Effect of diets containing brewers spent yeast on body weight change of Bovans Brown chickens

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Initial BW, kg	1.547	1.508	1.547	1.565	1.546	0.019	0.3534
Final BW, kg	1.671^{a}	1.678^{a}	1.649^{ab}	1.613^{b}	1.577^{b}	0.023	0.0497
BW change, g	124.00^{ab}	170.67^{a}	102.33^{ab}	48.00^{b}	27.00^{b}	22.06	0.0062

$^{a-c}$ Means within a row without common superscripts are significantly different (P< 0.05). BW=Body weight; SEM= standard error of mean, T1=diet with 0% BSY; T2= diet with 5% BSY; T3= diet with 10%BSY; T4= diet with 15% BSY; T5= diet with 20% BSY

Egg Quality

The effect of diets based BSY on egg quality characteristic of the laying hen is presented in Table 6. Results revealed that most external and internal egg quality parameters did not differ significantly (P<0.05) with inclusion of BSY in the diet. However, the hens fed a diet containing 20% BSY showed significantly (P<0.05) lower albumen weight, yolk weight and Roch yolk color values compared to other treatments. On the other hand, the 15% BSY diet appeared to have a more positive effect on egg quality than on productivity. The Haugh unit values were not influenced by inclusion of BSY in the diet, all exhibiting excellent quality eggs as the values exceeding 72 are regarded as excellent quality (USDA, 2000). However, hens fed a 5% BSY diet produced eggs with significantly lower Haugh unit compared those on a 10% BSY diet (P<0.05). According to Meseret *et al*. (2012), eggshell thickness and Haugh unit remain unaffected, while Roch yolk color values improved in Rhode Island Red hens fed a diet containing BSY. Contrary to our results, significant improvements in albumen height, Haugh unit and eggshell thickness were reported in laying hens supplemented with brewer's yeast hydrolysate (Park *et al.,* 2020). Other research reports have also revealed a positive effect of yeast product supplementation on yolk weight and albumin weight (Yousefi and Karkoodi, 2007), eggshell weight and yolk weight (Ayanwale *et al.,* 2006) and Haugh unit and yolk diameter (Özsoy *et al.,* 2018). These differences can be due to variations in the type and form of feed ingredients and their percentage share in the diet, and the yeast source (live or dead yeast). Our findings of albumen weight and yolk weight closely match with the values (33.38 g and 14.19 g, respectively) reported for Bovans brown chickens (Dawud *et al.*, 2018).

Table 6. Effect of diets with brewer's spent yeast on egg quality traits of Bovans Brown chickens

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Egg weight (g)	56.36	57.34	56.15	57.91	55.29	0.59	0.1089
Egg length (mm)	54.16	54.22	54.35	55.12	54.20	0.31	0.1661
Egg width (mm)	42.51	42.01	42.00	42.60	41.76	0.29	0.2129
Shell thickness (mm)	0.44	0.45	0.44	0.44	0.45	0.01	0.8856
Shell weight (g)	7.69	7.86	7.72	7.67	7.70	0.11	0.7736
Egg shape index	78.53	77.50	77.32	77.30	77.13	0.47	0.2352
Albumen weight (g)	34.22^{ab}	34.46^{ab}	33.64^{ab}	35.07^{a}	32.92^{b}	0.47	0.0192
Albumen height (mm)	10.31	10.14	10.67	10.37	10.41	0.21	0.5340
Yolk weight (g)	13.63^{a}	13.45^{a}	13.28^{ab}	13.59^{a}	12.94^{b}	0.18	0.0505
Yolk width (mm)	38.81	38.57	38.46	38.39	38.23	0.21	0.3995
Yolk length (mm)	40.11	40.04	40.10	40.15	39.82	0.22	0.8391
Yolk height (mm)	16.58	16.32	16.11	16.39	16.04	0.19	0.2881
Yolk color score	9.20^{a}	9.26^{a}	9.28^{a}	8.78^{ab}	8.09^{b}	0.33	0.0504
Yolk index 1	41.39	40.83	40.22	40.86	40.31	0.53	0.5253
Haugh unit	96.59^{ab}	95.46^{b}	98.29^{a}	96.34^{ab}	97.17^{ab}	0.96	0.3152

$^{a-c}$ Means within a row without common superscripts are significantly different (P< 0.05). T1 = diet with 0% BSY; T2 = diet with 5% BSY; T3 = diet with 10% BSY; T4 = diet with 15% BSY; T5 = diet with 20% BSY, SEM= standard error of mean

Cost of Feeding

Incorporating dried BSY in laying hens' diets reduced the feed cost of egg production (Table 7). The cost per kg of experimental feeds was reduced by up to 16% with BSY inclusion at the expense of soybean meal. The feeding cost significantly (P<0.05) decreased from 309 Birr/hen (T1) to 255 birr/hen (T5), or from 41.42 birr/dozen eggs (T1) to 38.74 birr/dozen eggs (T5), representing a reduction of 17.4% and 6.5%, respectively, due to the BSY inclusion. Nevertheless, a slight increase (2.4%) in the magnitude of feed intake with up to 15% BSY inclusion, or a 1.3% decrease in feed intake with a 20% BSY diet did not inhibit the reduction in feeding cost. This indicates that although the egg production was low, as in the case of 20% BSY inclusion, it's possible to reduce the feeding costs, resulting in a proportional increase in gross margin. In agreement, previous studies indicate that supplementing laying hens with 450 ppm of yeast (*Saccharomyces cerevisiae)* cell wall (Koiyam *et al*., 2018), or its extract 0.1% mannan-oligosaccharides (Hassan and Ragab, 2006) is economically feasible, despite the benefits primarily resulted from increased egg production rather than from reduced feeding costs. Therefore, it's economically feasible to incorporate BSY into the diet of laying hens, partly replacing the expensive soybean meal. However, the low DM content and bulky nature of liquid BSY incurs high transportation and processing costs, demanding the use of technologies.

Table 7. Effect of different BSY inclusion levels in laying Bovans Brown chicken diet on production costs

Variables	T1	T2	T3	T4	T5	SEM	P-value
Total feed consumed (kg/hen)	11.05	11.07	11.2	11.32	10.91	0.11	0.1851
Total egg production (Dozen/ hen)	7.5	7.4	7.2	6.9	6.8	0.23	0.1879
BSY processing cost (birr/hen)*	0	16.5	16.5	16.5	16.5	-	-
Feed cost per hen/98days (birr)	308.98^{a}	296.86^{ab}	291.27^{bc}	280.03^{c}	255.14^{d}	2.78	<.0001
Feed cost per/Dozens of eggs (birr)	41.42	40.47	41.48	41.22	38.74	1.32	0.5788
Cost per kg feed (birr)	27.97^{a}	26.81^{b}	25.99^{c}	24.73^{d}	23.38^{e}	-	<.0001
% reduction in cost per kg feed	0	4	7	12	16	-	-

$^{a-c}$ Means within a row without common superscripts are significantly different (P< 0.05). T1 = diet with 0% BSY, T2 = diet with 5% BSY, T3 = diet with 10% BSY, T4 = diet with 15% BSY, T5 = diet with 20% BSY, SEM= standard error of mean, Cost per kg of dried BSY (processing) = 11.9 Birr (1USD = 49.5904 birr, as of Jan. 2022), * = includes BSY transporting, washing and drying

Conclusion

This study revealed that including dried BSY in the diet of laying Bovans brown during 23 to 36 weeks old did not affect feed intake, egg weight, FCR per dozen eggs and most egg quality traits. However, up to 10% BSY inclusion, live weight, laying performances and feed conversion in terms of egg mass were comparable to the control group. While 15% BSY and 20% BSY diets led to a reduced laying performance, there were no differences in laying performances, feed efficiency, or egg quality between hens fed 10% and 15% BSY diets. Remarkably, feeding cost decreased with increased BSY levels. Considering the positive effects on laying performances, egg quality, and feeding cost, it is concluded that incorporating up to 15% BSY in the diet of laying Bovans brown hens is beneficial. Further studies on BSY supplementation in chick diet to evaluate growth performance, and investigating cost-effective moisture removal mechanisms from intact BSY are imperative.

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