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CHEMICAL COMPOSITION OF SOYBEAN MEAL AND ITS EFFECTS ON NUTRIENT DENSITY, EGG PRODUCTION, AND BLOOD PARAMETERS IN BOVANS BROWN LAYERS

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ABSTRACT: Soybean meal (SBM) is an essential protein source in poultry diets. However, data on the variability of its chemical composition from Ethiopian processing plants and its optimal inclusion levels in layer diets are limited. This study aimed to assess the nutritional quality of locally sourced SBM from the Amhara Region and evaluate the effects of different levels of SBM inclusion on production performance, egg quality, and blood parameters in laying hens. The chemical composition of SBM samples from 11 regional processing plants was initially analyzed. Subsequently, a 12-week feeding trial was conducted using 120, 34-week-old Bovans Brown layers. The hens were randomly assigned to one of five dietary treatments in a completely randomized design (CRD). The treatments consisted of a commercial control diet and four experimental diets containing 15%, 20%, 25%, and 30% SBM. Each treatment was replicated three times, with eight hens per replicate. Significant variation ($P < 0.05$) was observed in the chemical composition of SBM samples from different processors. Crude protein ranged from 38.42 to 43.52%, ether extract (1.23 - 5.27%), crude fiber (5.58 - 7.35%), and metabolizable energy (3348.3 - 3594.8 kcal/kg DM). Dietary crude protein concentration increased with higher SBM inclusion from 14.74% to 17.56%. An inclusion level of 20% SBM was identified as optimal, resulting the highest hen-day egg production (89.72%) and net return (446.63 ETB), with no adverse effects on egg quality and hematological parameters remaining within normal ranges. This study concludes that there is significant variation in the chemical composition of locally processed SBMs, highlighting the need for pre-use nutritional evaluation. Under the experimental conditions, a 20% SBM inclusion level is regarded as acceptable and optimal for mid-laying hens.

Keywords: Chemical composition, Egg production, Egg quality, Nutrient density, Soybean meal.

INTRODUCTION

Ethiopia's poultry sector is undergoing a transitional phase, with efforts underway to shift from traditional backyard systems toward more intensive and commercialized production. This transition requires urgent attention to several key challenges, particularly the quality, consistency, and affordability of poultry feed (MoA, 2023). Among the major feed ingredients, soybean meal (SBM) plays a central role as a primary protein source. Recognizing this, the 2022 National Poultry Development Strategy outlined a ten-year plan emphasizing large-scale production of essential feed ingredients like soybeans (MoA, 2023). In response to rising demand for cooking oil and the expansion of multi-million-dollar edible oil processing industries, soybean cultivation has increased significantly, especially in the Amhara Region (Mussema et al., 2022). According to CASA (2023), the region accounted for 265,263 hectares of soybean cultivation and 753,600 metric tons of production, approximately 39% of the national output. As a result, Amhara is emerging as a major hub for both soybean production and oil processing, generating increasing volumes of SBM as a by-product.

Soybean meal (SBM) is a widely used protein ingredient in poultry feed formulation. Its high protein content (44–49% CP), balanced amino acid profile, and bioavailability make it a benchmark for other plant-based protein sources and a key complement to cereal grains in poultry diets (Banaszkiewicz, 2011). However, its nutrient profiles is highly variable, largely due differences in processing methods (Tangendjaja, 2020; Pope et al., 2023). Despite the growing availability of SBM, no studies in Ethiopia, particularly in the Amhara Region, have evaluated its chemical composition or optimal dietary inclusion levels in poultry feed. This gap limits the ability of producers to formulate cost-effective and nutritionally balanced rations based on locally available ingredients.

This study aimed to evaluate the chemical composition of SBMs in the Amhara region and assess the effects of varying inclusion levels on diet nutrient density, production performance, egg quality, blood hematology, and serum cholesterol in Bovans Brown layers.

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MATERIALS AND METHODS

Soybean meal samples collection

Soybean meal (SBM) samples were collected from 11 oil processing plants in the Amhara regional state. The plants were located in Bahir Dar (6), Enjbara (2), Bure (1), Debre Markos (1), and Debre Brehan (1). Each plant was visited once, and a representative sample was obtained by compositing multiple sub-samples from different bags. All sub-samples were collected and stored in sturdy, airtight plastic bags and each composite sample was then ground to a homogeneous particle size (1 mm sieve) for laboratory analysis.

Feed formulation

The SBM selected for the feeding trial was mechanically extracted and sourced from a processing plant chosen based on its demonstrated capacity for consistent, year-round production, established supply chain partnerships, and a market strategy focused on meeting local demand. Experimental diets were formulated with varying SBM inclusion levels (15%, 20%, 25%, and 30%), assuming a daily feed intake of 120 g per hen using Win Fed (2.8) computer software. A locally available commercial layer diet (from Mara animal feed processing industry) was used as a control treatment to serve as a practical benchmark for evaluating the performance and nutritional adequacy of the experimental diets. This approach allows for a direct comparison between standard feeding practices commonly used in the study region and scientifically formulated diets with varying levels of soybean meal inclusion. The composition and proportions of feed ingredients used in the experimental diets are detailed in Table 1.

Table 1 - Ingredient proportion of the different treatments (as-fed basis)

Feed ingredient	15% SBM	20% SBM	25% SBM	30% SBM
White Maize Grain	55	54	50	50
Soybean Meal	15	20	25	30
Noug seed cake	15	11	10	5
Bone meal	4	4	4	4
Limestone, ground	9	9	9	9
L-lysine-HCL	0.5	0.5	0.5	0.5
DL-Methionine	0.5	0.5	0.5	0.5
Vit and Min Premix	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5

Laboratory chemical analysis

Prior to laboratory analysis, all soybean meal (SBM) and feed ingredient samples used in the feeding trial were prepared in triplicate per sample by oven-drying at 105°C for 3 hours and grinding to pass through a 1 mm sieve. The samples were then analyzed for dry matter (DM), crude fiber (CF), total ash, ether extract (EE), and crude protein (CP) according to AOAC (2000) procedure. The Metabolizable energy (ME) content of the experimental diets was calculated by the equation adopted from Wiseman (1987): $ME\left(\frac{Kcal}{kg}DM\right) = 3951 + 54.4EE - 88.7CF - 40.8\,ash$

Management of experimental hens

This experiment was conducted at the Bahir Dar University poultry farm in Ethiopia. A total of 120 Bovans Brown hens, 34 weeks of age, were used. The hens were randomly assigned to one of five dietary treatment groups in a completely randomized design (CRD), containing 24 hens per treatment. Each treatment group was further divided into three replicates, each containing eight hens. Hens were housed in pens measuring 2 m^2, which were bedded with 5 cm of teff (*Eragrostis tef*) straw. Prior to the placement of the hens, all sanitary measures were applied to the experimental house. Feed was offered twice daily (morning at 8:00 AM and afternoon at 2:00 PM), and refusals were collected and weighed the following day, while clean drinking water was supplied *ad libitum* throughout the experimental period. Following placement, a one-week adaptation period was provided to allow the hens to acclimate to the experimental diets before formal data collection began. Data on production performance, egg quality, and blood hematology and chemistry parameters were collected over a 12-week period. During the trial, the average ambient temperature ranged from a minimum of 18.9 °C to a maximum of 32.36 °C.

Production performance parameters

Daily feed intake (FI) per replicate was calculated as the difference between the amount of feed offered and the amount refused. Body weight (BW) was measured individually at the start and end of the trial, and body weight change

(BWC) per replicate was determined by subtracting the initial weight from the final weight. Eggs were collected twice daily from each pen to monitor egg production. The hen-day egg production (HDEP) rate was calculated as the average daily percentage per replicate, using the formula (Hunton, 1995): $\% \text{ HDEP} = \frac{\text{No of eggs collected per day}}{\text{No of hens present that day}} \times 100$

Daily egg weight (EW) per replicate was measured immediately after collection. Average EW was obtained by dividing the total weight of eggs by the number of eggs laid. Egg mass (EM) per pen was calculated as follows (North, 1984):

$$EM = \%HDEP \times EW$$

Feed conversion ratio (FCR) was calculated per replicate as the total feed intake divided by the total egg mass produced during the experimental period.

Egg quality parameters

A total of 30 eggs (six per treatment, two per replication) were randomly sampled at two-week intervals for quality analysis, with replicate means calculated from sample averages for each parameter. Eggs were weighed (w), broken on a flat tray, and shells separated from membranes for weight measurement. Shell thickness was determined with a digital caliper, averaging measurements at three points (air cell, equator, and sharp end). Yolk color was evaluated using a Roche color fan, while albumen height (h) and yolk height were measured with a tripod micrometer. Haugh unit (HU) value for each replicate was calculated by using the formula given by Haugh (1937):

$$HU = 100 \log10 \left(h + 7.57 - 1.7w0.37\right)$$

Economic analysis

The economic viability of graded SBM inclusion in Bovans-Brown layer diets was calculated using a method developed by Upton (1975), considering feed formulation costs and egg prices. Total feed intake was multiplied by ingredient costs, while egg revenue was calculated using local market price of eggs in Bahir Dar, Ethiopia, during the study period. Net return was derived as total revenue minus feed costs.

Measurements of blood parameters

At the end of the experiment, approximately 3 mL of blood was collected from the wing veins of 15 randomly selected hens (three hens per treatment) between 8:00 AM and 11:00 AM after the night's fast. The hematology analysis was performed with an automated hematology analyzer (BC- 5800, Mindray, China) after blood samples were deposited in K3-EDTA heparinized tubes, serum samples were analyzed for total cholesterol (COL), low-density lipoprotein (LDL), and high-density lipoprotein (HDL) after being separated by centrifuging (3,000 rpm, 15 min).

Statistical analysis

All data were analyzed using the GLM procedure of SAS (9.4, Cary, NC). For SBM proximate composition, the main effect of the model was the fixed effect of the edible oil processing plant. The effect of feeding different levels of SBM was analyzed using the following model: $Yij = \mu + Ti + eij$. Where: Yij = represents the jth observation (experimental unit) taken under treatment I; μ = overall mean; Ti = feed effect; eij = random error. When the mean was significant, the least significant difference (LSD) test was used to make pairwise comparisons between treatment means. Statistical significance was set at $P < 0.05$.

RESULTS AND DISCUSSION

Chemical composition of SBMs

The proximate composition of the 11 SBM samples varied significantly ($P < 0.05$) in all parameters (Table 2). Significant variations ($P < 0.05$) were noted among the processing plants in CP content, ranging from 38.42 to 43.52%. However, the CP content of the current study is relatively lower compared to the world's market standard, which ranges from 44 to 49% CP (Banaszkiewicz, 2011). This may be due to differences in both the origin and variety of soybean used to produce the SBM (Ibáñez, et al., 2020; Ateye et al., 2025), and the differences in processing conditions during the production of the SBM (Karr-Lilienthal et al., 2005). Typically, the soybean processing industries conduct crude fat analysis to determine the oil content of SBM. The solvent-extracted SBM samples contained significantly lower ($P < 0.05$) EE within the range of 1.23-1.87% compared to mechanically extracted SBM, which contained higher ($P < 0.05$) EE content within a range of 2.41- 5.27%, indicating more oil is extracted by solvent (hexane). Grieshop et al. (2003) also reported that SBM samples from mechanical extraction installation contained higher ($P < 0.05$) lipid content than SBM from solvent extraction plants as determined by both crude fat and acid-hydrolyzed fat analyses.

The analyzed CF values ranged from 5.58 to 7.35%, which indicated that the meals were non-dehulled. Depending upon the processing methods used, crushing and removal of the hulls decrease the fiber content of the meal. Therefore, hulled SBM is higher in CF content than dehulled soybean meal. Dehulled soybean meals normally contain a maximum of 3.5% CF, while non-dehulled soybean meals contain 6-7% CF (Tangendjaja, 2015). The metabolizable energy (ME) content observed in this study ranged from 3348.3 to 3594.8 kcal/kg DM. These values are within the range reported by Li et al. (2015), who reported ME values between 3405.8 and 3840.8 kcal/kg. Notably, mechanically extracted SBM samples exhibited higher ME values than solvent-extracted SBMs, which can be attributed to residual oil content remaining after mechanical extraction, thereby increasing the energy value of the meal.

Table 2 - Chemical composition of SBMs from eleven edible oil processing plants

Processing plants	DM	CP	EE	CF	ASH	NFE	ME (Kcal/kg DM)
1	93.81[a]	42.75[bc]	3.65[c]	7.08[b]	1.85[de]	38.47[bc]	3446.1[d]
2	89.29[d]	41.03[e]	2.86[de]	5.58[i]	1.6[e]	38.21[c]	3546.4[b]
3	92.08[b]	41.7[d]	2.63[ef]	7.35[a]	2.29[cd]	38.09[c]	3348.3[f]
4	93.45 [a]	43.52[a]	4.93[a]	6.42[c]	2.65[abc]	35.93[f]	3541.6[b]
5*	87.61[e]	40.5[e]	1.23[h]	5.7[h]	2.99[a]	37.18[de]	3390.3[e]
6	93.31[a]	42.9[b]	2.41[f]	6.3[ed]	1.92[de]	39.78[a]	3444.9[d]
7	90.77[c]	43.31[ab]	3.06[d]	6.27[e]	2.89[ab]	35.24[f]	3443.4[d]
8*	87.11[e]	38.42[f]	1.87[g]	5.68[hi]	3.14[a]	38.01[cd]	3421.5[de]
9	89.6[d]	38.47[f]	5.27[a]	5.84[g]	3.06[a]	36.96[e]	3594.8[a]
10	92.83[ab]	41.06[e]	4.14[b]	6.07[f]	2.47[bc]	39.09[ab]	3537.1[b]
11	92.13[b]	42.27[cd]	3.85[bc]	6.37[cd]	2.44[bc]	37.21[de]	3495.8[c]
SEM	0.499	0.372	0.259	0.118	0.115	0.283	15.888
P value	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001

Means within the same column with different [a-i] superscripts are significantly different (P < 0.05). Whereas values with the same superscripts not differ significantly (P > 0.05). Processing plants with a [*] superscripts represent solvent extracted SBM whereas the others are mechanically extracted SBM. 1: Abay; 2: Nile; 3: Rafa; 4: Reach Land; 5: Emy; 6: Meheret; 7: Sky; 8: WA; 9: Unison; 10: TOP; 11: MSA.

Nutrient composition of treatment diets

Data in Table 3 shows that different soybean meal inclusion levels significantly (P < 0.05) affect the nutrient density of the formulated experimental diets (T2-T5). The nutritional concentration of feed is crucial in the poultry industry as it affects laying performance and profitability (Kim and Kang, 2022). Dietary ME and CP are key nutritional parameters in layer hen diets. In this study, CP increased proportionally with higher levels of SBM inclusion and the highest ME value (3265.42 kcal/kg DM) was recorded at the 30% SBM inclusion level. This increase is attributed to the nutritional richness of SBM, which is characterized by its high protein content, digestible oil, and carbohydrate components. In contrast, the commercial control diet CP content was lower than that of the experimental diets with 20%, 25%, and 30% SBM inclusion, while its ME was higher. This aligns with the findings of Negash (2020), who reported that commercial layer feeds in Ethiopia often have variable nutritional content, with CP levels ranging from 10.91% to 17.90% and ME values between 1364 and 2746 kcal/kg DM, frequently falling below recommended benchmarks.

Table 3 - Chemical composition of feed ingredients and experimental diets (on a dry matter basis)

Processing plants	DM	CP	CF	EE	ASH	NFE	ME (Kcal/kg DM)
T1 (Control)	88.73[c]	15.01[c]	3.65[e]	1.94[c]	4.96[d]	63.16[a]	3530.51[a]
T2 (15%SBM)	91.14[b]	14.74[d]	6.24[a]	4.17[a]	10.59[c]	55.39[c]	3192.08[c]
T3 (20%SBM)	91.04[b]	16.03[b]	5.06[c]	1.29[e]	11.07[b]	57.58[b]	3120.25[d]
T4 (25%SBM)	91.51[ab]	17.43[a]	5.98[b]	1.62[d]	11.19[b]	55.28[c]	3051.56[e]
T5 (30%SBM)	92.06[a]	17.56[a]	4.61[d]	3.69[b]	11.71[a]	54.49[d]	3265.42[b]
SEM	0.384	0.393	0.314	0.387	0.833	1.055	55.161
P value	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Means within the same column with different [a-e] superscripts are significantly different (P < 0.05). Whereas values with the same superscripts do not differ significantly (P > 0.05).

Egg production performance

This study indicated that the groups fed on the treatment containing 20%SBM (16%CP & 3120.25 of ME/kg of DM) had higher production performances than the groups fed on the control diet which had higher ME and low CP (3530.51 Kcal/kg DM ME and 15.01CP) and the groups fed on 30%SBM which had higher CP and ME (17.56 CP and 3265.42 Kcal/kg DM ME) Figure 1. The results indicate that a 20% SBM inclusion is sufficient to support egg production in mid-lay Bovans Brown layers (34-46 weeks), with higher levels providing no additional production benefit. This result is in agreement with Li et al. (2013), diets containing 16.0% balanced CP produced optimal egg performance for Lohmann Brown laying hens aged from 26 to 38 weeks.

The effect of different soybean meal inclusion levels on production performance is presented in Table 4. According to the results of the current study, an increase in nutrient density had no significant effect on the rate of egg production, egg mass, egg weight, feed intake, and feed conversion ratio of laying hens. The comparable egg production performance of all treatment rations might be related to the amount of nutrient density, in which all diets have an adequate amount of ME and variation in CP was supplemented by the most limiting amino acids (lysine and methionine). These results align with those of Panda et al. (2012) and Kim & Kang, (2022), who reported that an increase in nutrient density did not affect laying performance and egg quality.

However, increasing the SBM inclusion level significantly ($P < 0.05$) affected body weight; the highest BWC (400g) was recorded for a 25% SBM inclusion level, and the lowest BWC (167g) was recorded for the control diet. The significant increase in BWC of the groups fed increasing levels of SBM could be due to the increase in nutrient intake, which might have increased fat deposition. Ding et al. (2016) and Kim and Kang (2022) also support the hypothesis that an excess in nutrient intake results primarily in increases in body weight gain rather than in further increases in egg mass production.

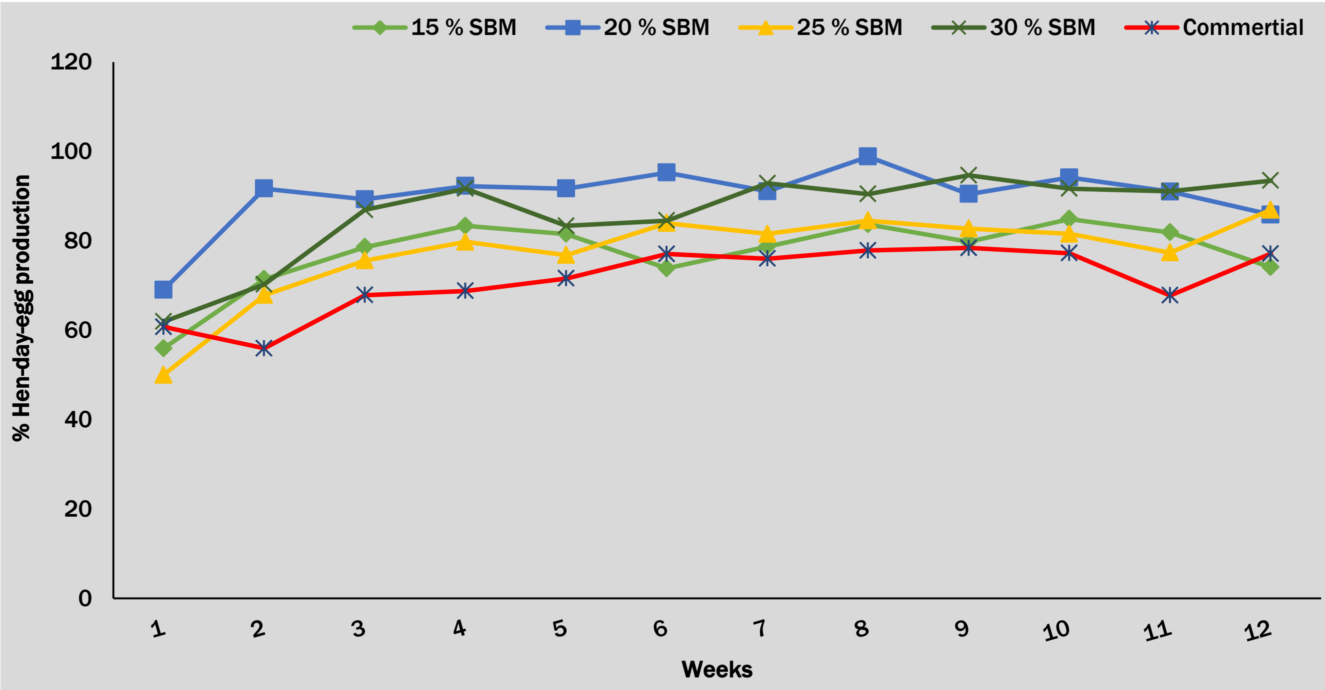

Figure 1 - Effect of SBM inclusion levels on % of hen day egg production in 12 weeks.

Table 4 - Effect of different levels of SBM inclusion on production performance of layer hens

Parameters	T1	T2	T3	T4	T5	SEM	P value
% HDEP	71.887	77.373	89.712	77.500	86.276	2.243	0.0693
Egg mass (g/hen/day)	43.440	45.865	54.280	47.342	53.607	1.482	0.0704
Egg weight (g)	60.447	60.447	60.482	61.082	62.120	0.404	0.3561
Final BW (kg)	1.635	1.601	1.743	1.827	1.759	0.031	0.0884
Initial BW (kg)	1.467	1.363	1.429	1.427	1.394	0.019	0.5804
BWC (kg)	0.167^{c}	0.238^{bc}	0.314^{abc}	0.400^{a}	0.365^{ab}	0.028	0.0351
FI (g/hen/day)	108.507	110.291	112.031	114.218	115.743	1.784	0.8246
CPI (g/hen/day)	16.283^{b}	16.261^{b}	17.959^{ab}	19.903^{a}	20.326^{a}	0.527	0.0110
MEI (kcal/hen/day)	383.09	352.06	349.57	348.54	377.95	6.755	0.4059
FCR	2.541	2.419	2.061	2.419	2.163	0.069	0.1960

Means within the same rows with different $^{a-c}$ superscripts are significantly different ($P < 0.05$). Whereas values with no superscripts do not differ significantly ($P > 0.05$). T1: Commercial layer diet, T2: 15%SBM, T3: 20%SBM, T4:25%SBM and T5:30%SBM inclusion level. HDEP: hen day egg production. BWC: Body Weight change. FI: Feed Intake. CPI; crude protein intake. MEI: metabolizable energy intake. FCR: Feed Conversion Ratio

Egg quality

The results of the egg quality parameters are presented in Table 5. There were no significant (P > 0.05) differences between all the treatment groups in all egg quality parameters, except for yolk color. Similarly, Junqueira et al. (2006) did not find any effect on egg quality parameters of laying hens by comparing 3 metabolizable energy levels (2,850; 2,950, and 3,050 kcal of ME/kg) and 3 protein levels (16, 18, and 20% CP) and Pérez-Bonilla et al. (2012) also reported, that increasing the levels of CP in the diet from 16.5 to 18.5% does not affect the performance or egg quality of brown egg-laying hens. Significantly higher (P < 0.0001) value for egg yolk coloration was recorded from the groups placed on the control diet, which might be due to the addition of pigmenting additives in commercial diets.

Partial Budget Analysis

The economic returns from the perspective of partial budget analysis from egg sales and feed costs are presented in Table 6. Feed cost rose with increasing dietary SBM inclusion. The control diet had a significantly lower cost than all SBM-based diets (P < 0.05). Despite having a higher feed cost than the control diet, the diet with 20% SBM inclusion resulted a significantly (P < 0.05) higher net return compared to all other dietary treatments. Therefore, a 20% SBM inclusion is the most profitable and balanced option for mid-lay Bovans Brown layer hens. It generates higher egg production while maintaining a relatively lower feed cost than higher inclusion levels, which increase expense without a proportional return.

Blood Hematology and some serum chemistry

The effect of different SBM inclusion levels on hematology and serum cholesterol is presented in 7. There was no significant difference between the dietary treatments in WBC values ranging between 37.76- 40.97×10³/µL. However, the results found in this research were higher than the normal 12- 30 × 10³ µl range (Bounous and Stedman, 2000). This elevation likely reflects the hens' exposure to tropical heat stress and may represent a compensatory response to counteract pathogen invasion, which is exacerbated by heat-induced compromised immunity (Hassan et al., 2023). All RBC values were within the normal range. The recommended normal range was for RBC: 2.5- 3.5 x106 µl, PCV: 22-35 %, HGB: 7- 13 g/dl, MCV: 90- 140 fL, MCH: 33-47 pg/cell and MCHC: 26- 35 g/dl (Bounous and Stedman, 2000). Cholesterol levels ranged from 94 to 131 mg/dL, with no significant differences among treatments. The HDL and LDL values ranged from 13.5-29.5 (mg/dL) and 33.5-49.50 (mg/dL), respectively. Similarly, there was no statistically significant difference between the dietary treatments. Similar to our result, Hassan et al. (2023) reported that the standard laying hen strain had lower plasma HDL, but higher plasma LDL.

Table 5 - Effect of different levels of SBM inclusion on egg quality parameters of layer hens

Parameters	T1	T2	T3	T4	T5	SEM	P value
Egg index	78.564	79.531	78.331	79.082	79.357	0.275	0.3062
Sample egg weight (g)	60.163	58.865	59.917	62.808	62.083	0.557	0.1446
Albumen height (mm)	9.196	9.104	8.446	8.9458	8.868	0.098	0.1656
Yolk height (mm)	18.587	17.811	18.402	18.725	18.552	0.185	0.6757
Yolk weight (g)	14.868	14.725	15.417	15.963	15.589	0.191	0.2759
Eggshell weight (g)	7.8438	8.1750	7.687	7.846	7.8500	0.077	0.5107
Eggshell thickness (mm)	0.359	0.359	0.357	0.355	0.365	0.003	0.8841
Albumen weight (g)	38.475	35.906	36.754	39.067	38.565	0.498	0.1522
Yolk index	0.455	0.452	0.462	0.462	0.465	0.004	0.9388
Haugh unit (%)	95.519	95.377	91.804	93.703	93.477	0.517	0.1472
Yolk color	9.333^{a}	1.00^{b}	1.00^{b}	1.00^{b}	1.00^{b}	0.893	<0.0001

Means within the same rows with no superscripts do not differ significantly (P > 0.05). T1 is a commercial diet, whereas the other diets contain T2 (15%), T3 (20%), T4 (25%), and T5 (30%) SBM inclusion levels.

Table 6 - Effect of dietary inclusion of SBM in the diet on economics during the experimental period

Parameters	T1	T2	T3	T4	T5	SEM	P value
Total egg (number/hen)	64.42	69.64	80.87	69.75	77.65	2.028	0.0587
Total feed consumed (kg/hen)	9.766	9.926	10.083	10.279	10.417	0.161	0.8246
Total feed cost per head (ETB)	419.93^{b}	510.07^{a}	523.86^{a}	535.938^{a}	550.38^{a}	14.257	0.0158
Total return (ETB)	773.06	835.67	970.48	837	931.84	24.334	0.0587
Net return (ETB)	353.14^{ab}	325.61^{ab}	446.63^{a}	301.06^{b}	381.45^{ab}	19.166	0.1604

T1 is a commercial diet, whereas the other diets containing T2 (15%), T3 (20%), T4 (25%), and T5 (30%) SBM inclusion levels. Means within the same rows with $^{a-b}$ superscripts are significantly different (P < 0.05). Whereas values with no superscripts do not differ significantly (P > 0.05). ETB - Ethiopian Birr.

Table 7 - The effect of different SBM inclusion on blood hematology, cholesterol, LDL, and HDL

Parameters	T1	T2	T3	T4	T5	SEM	P value
WBC ×10^3/μL	40.480	37.760	40.265	38.375	40.975	0.778	0.6163
HT ×10^3/μL	11.985	9.778	13.964	9.360	8.419	0.853	0.2613
LYM,×10^3/μL	25.337	25.151	22.893	25.953	29.015	1.142	0.7447
MON×10^3/μL	1.8927	2.1148	1.2074	2.0642	2.3827	0.166	0.1531
EO ×10^3/μL	1.266	0.697	2.201	0.978	1.158	0.343	0.7903
BAS ×10^3/μL	0.00	0.0187	0.00	0.0198	0.00	0.005	0.6833
RBC×10^6/μL	2.46	2.485	2.57	2.51	2.45	0.026	0.7753
HGB, g/dL	9.050	9.000	8.850	9.350	10.550	0.327	0.5790
HCT, %	31.500	31.550	32.250	32.100	31.800	0.312	0.9569
MCV, fL	128.010	126.992	125.558	127.855	129.791	0.708	0.5139
MCH, pg	36.696	36.215	34.457	37.219	43.096	1.347	0.4013
MCHC, g/dL	28.593	28.524	27.443	29.104	33.209	0.929	0.4370
PLT ×10^3/μL	2.5	8.0	5.5	2.0	3.5	1.086	0.5061
HDL (mg/dL)	29.50	22.00	22.50	14.00	13.50	3.783	0.5908
LDL (mg/dL)	49.00	34.50	33.50	47.50	49.50	4.986	0.7409
COL (mg/dL)	119.50	94.00	131.00	123.00	118.00	4.817	0.1580

Means within the same rows with no superscripts not differ significantly (P > 0.05). T1 is a commercial diet, whereas the other diets containing T2 (15%), T3 (20%), T4 (25%), and T5 (30%) SBM inclusion levels. WBC = white blood cell count; HT = heterophil; LYM = lymphocytes; MON = monocytes; EO = eosinophils; BAS = basophil; RBC = red blood cell count; HBG = hemoglobin; HCT = hematocrit; MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC = mean corpuscular hemoglobin concentration; PLT = platelets; HDL = high-density lipoprotein; LDL = low-density lipoprotein; COL = cholesterol.

CONCLUSION

This study demonstrated significant variation in the proximate composition of soybean meals (SBM) sourced from different processing plants in the Amhara Region of Ethiopia. These findings highlight the importance of routinely assessing the quality of processed SBM to ensure consistency and reliability in poultry feed formulation. Among the inclusion levels tested, a 20% SBM inclusion was found to be optimal for Bovans Brown layers during mid-production, providing the highest egg production, comparable egg quality, and improved economic returns. Overall, this research provides valuable guidance for formulating nutritionally and economically efficient layer diets while emphasizing the need for ongoing quality control and further study of local SBM sources.

DECLARATIONS

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Data availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Ethics approval

The animals were handled and cared for following welfare standards and experimental protocols approved by the College of Agriculture and Environmental Sciences Animal and Research Ethics Committee of Bahir Dar University (Ref. No. 007-2025).

Authors' contribution

The authors declare that no funds, grants, or other support were received. All authors contributed to the study conception and design. Y. Yimer conducted material preparation, data collection, and analysis, and drafted the initial manuscript. F. Tegegne and S. Demeke collaborated on the critical review and editing. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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