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Original Research

Egg Quality of Bovan Brown Pullets Fed Different Dietary Mixtures at Wallaga University

Temesgen Barsisa[1], Diriba Diba[2], Hasan Yusuf [2] & Gemeda Duguma[3]*

[1]Horro Guduru Livestock Research and Genetic Conservation Center, Wallaga University, P O. Box 395, Nekemte, Ethiopia

[2]Faculty of Agriculture, Wallaga University, P.O. Box 395, Nekemte, Ethiopia

[3]School of Veterinary Medicine, Wallaga University, P. O. Box 395, Nekemte, Ethiopia

Abstract

The present study was conducted at Wallaga University, Nekemte campus, to examine the egg quality of Bovan brown chicken fed different treatment diets formulated from locally available feed ingredients. The study was conducted for about 26 weeks using 90 chicks (42 days old) raised at the campus who were randomly categorized into three treatments based on their body weight and each treatment had three 10 chicks. The experimental design employed was a completely randomized design (CRD). The three treatments are T_1 = Quality Protein Maize (QPM) which is used as a source of essential amino acid + common salt + limestone powder; T_2 = Normal maize + soybean grain which is used as the source of protein + common salt + limestone powder and T_3 = Normal maize + common salt + limestone powder + Sesbania sesban (S. sesban) green leaf which was used as the source of protein. In the current study, the experimental diets had no significant influences (p>0.05) on eggshell weight, egg width, and egg shape index, except on egg shell thickness and egg length. The average egg weight for T_1, T_2, and T_3 were 48.12g, 49.56g, and 47.41g, respectively. Egg-shape index values obtained were 70, 73, and 75 for T_1, T_2, and T_3, respectively; and egg-shape index values of T2 and T3 of the current study had a normal shape. The average egg length obtained for T_1, and T_3 of the present study was 47.4, 46.3, and 41.7mm, respectively. The present study result indicated that albumen width was significantly (P<0.05) affected by treatment diets. However, other albumen traits were not influenced by the treatment diets. The experimental diets used in the present study had no significant effect (p>0.05) on yolk width, yolk height, yolk weight, and yolk index, except yolk color, Yolk index values ranging from 0.20 to 0.23 are reported in the current study, which is below the accepted yolk index values of 0.3 to 0.50 for fresh eggs. Generally, sensory preferences of egg quality and yolk color were improved by feeding quality protein maize (T_1) compared to the other two treatment diets (T_2 and T_3). Thus, feeding quality protein maize (QPM) is suggested as a better feeding option for layers in the study areas with optimization of the treatment diets used to improve the sensory and physical egg quality attributes.

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*Corresponding Author:
Gemeda Duguma

E-mail:
gdjaallataa@yahoo.com

INTRODUCTION

There are about 23 billion poultry all over the world which could be about three per person (FAOSTAT, 2016). Poultry are kept and raised in a wide range of production systems and provide mainly meat, eggs, and manure for crop fertilization. From poultry products eggs production reached 73 million tonnes and poultry meat production is close to 100 million tons per year (GLEAM, 2016) in the globe. In East Africa, over 80% of human populations live in rural areas and over 75% of these households keep indigenous chickens and the remaining keep exotic and hybrids. In Ethiopian conditions, poultry means solely chicken, and the total chicken population at the country level is estimated at 57 million (CSA, 2020). In Ethiopia, chicken production plays a significant role in income generation, and supply of human food (eggs and meat) in rural and urban areas. According to CSA (2020), about 78.85%, 12.02%, and 9.11% of the total chicken population of the country were reported to be indigenous, hybrid, and exotic, respectively. However, the productivity of the indigenous breeds is low and by far incomparable with their huge population. For instance, from the total eggs produced per annum from each of the breeds reported by CSA (2020), about 33.52%, 57.10%, and 9.38% of eggs were produced from indigenous, hybrid, and exotic breeds, respectively. The indigenous chicken breeds which surpassed the hybrid genotypes by about 66.83% were reported to produce about 23.57% fewer eggs than the hybrid chicken genotypes.

For a profitable and sustainable poultry enterprise, productivity and product quality are important attributes as they influence the profitability and marketability of the products, respectively. Lishan (2017) relates the product quality of poultry to the quality of eggs and meat produced. Egg quality is a general term that relates to various standards that are imposed on the eggs. The standards can be divided into exterior egg quality (egg shell) and interior egg quality (interior of the egg). Among the many quality characteristics, external factors including cleanliness, freshness, egg weight, and shell weight are important in consumer's acceptability of shell eggs (Dudusola, 2010).

In Ethiopia, consumers' preferences give superior acceptance and/or select eggs that are laid from local chicken rather than eggs laid by hybrid and exotic hens. This is because people assumed that the eggs obtained from the local chicken were more delicious than those laid by the exotic breeds. The preference for eggs from indigenous breeds compared to hybrid genotypes and exotic breeds has sparked a question in the researcher's mind: "Is the preference for eggs from indigenous breeds due to variation in diets or to breed differences?' Currently, there has not been any detailed information conducted on the Bovan brown chicken breed supplemented with quality protein maize (QPM), soybean, normal maize, Sesbania (Sesban) green leaf, salt, and limestone about the egg quality of local and/or exotic chickens. So, the objectives of the current study were to evaluate the effect of feeding different rations formulated from different locally produced ingredients on the quality of Bovan brown chicken eggs evaluated via physical (laboratory) and sensory methods.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out at Wallaga University, Nekemte campus, which is located about 328km from Addis Ababa to the western direction from December to April 2019, for five months. The campus is situated at 1000`N latitude and 37030` E longitude. The elevation of the site is about 2088 m.a.s.l. The minimum and maximum temperature of the area is reported to be 80C and 300C, respectively. The coldest and hottest months are December and April, respectively. The area receives a mean annual rainfall (RF) of 1,998 mm. The minimum and maximum relative humidity (RH) in the experimental house was between 31% and 110% which appeared in December and January, respectively. The average annual rainfall was taken from Nekemte Meteorological Service (NMS, 2019), while the minimum and maximum temperature and relative humidity were recorded using mobile data software.

Management of Experimental Chicken

A total of 90 Bovan brown chicks 42 days old age were purchased from Nekemte Poultry and Hatchery Center together with a starter ration. The chickens were vaccinated against Newcastle disease, using the HB1 vaccine when they were seven days old, and thereafter vaccinated with the infectious bursal disease (Gumburo) vaccine on their 14th and 28th days. Birds were also vaccinated with LaSota on their 42nd and 90th days. In addition, the animals were vaccinated with the fowl typhoid on their 58th and 111th days based on the advice of the animal health professionals of the University. The chickens were provided different rations during the entire experimental period, but exposed to the same management and hygienic environment. Feed and water were availed ad libitum. A total lighting length of 16 hours that covers the whole night time and a few of the dark day periods was practiced.

Experimental Feeds and Feeding Management

Quality protein maize (QPM), normal maize grain, and soybean grains were used to formulate different diets by the daily allowance of chicks, pullets, and layers. The second filial generation (QPM) of quality protein maize (QPM) was purchased from maize-producing farmers in the Bako Tibe district, who obtained seed from the first filial generation (QPM) of quality protein maize (QPM) from the National Maize Research Project of Bako Agricultural Research Centre (BARC). Normal maize and soybean grains were purchased from the local market. In the current study, soybean grain was used instead of soybean meal, which is a food processing byproduct that is not available or less accessible to most farmers. The dietary feeds and treatments were measured and provided ad libitum to all groups of birds twice a day at 8:00 a.m. and 4:00 p.m., regularly adjusted at 20% leftover. Sesbania Sesban (S. sesban) green leaf was hanging on and provided separately to one of the different chicken treatment groups. Sesbania sesban foliage is protein-rich forage commonly used as supplementary feeds. Its crude protein content is generally above 22% and its DM is about 30%. Sesbania sesban foliage (stem + leaves) also has a moderate to low cell wall content (less than 30% NDF) in most cases. Therefore, this green plant was provided as a source of protein for chicken. Limestone powder and common salt were fed to all groups as the source of minerals.

Feed Sample for Laboratory Analysis

The formulated ration was mixed by hand at two-week intervals. Handfuls of samples were taken from the different feeds provided to the experimental animals, and the ones left over were taken, weighed every morning, collected in different bags, and kept until the end of the experimental period (five months). At the end of the feeding trial, the samples collected in the bag were thoroughly mixed and sub-sampled for chemical analysis to determine the nutrient composition of the feeds. Feed offered and leftovers were weighed regularly, and the intake of birds was computed. Analysis of the chemical composition of the rations was done at Bishoftu National Veterinary Institute) in order to determine dry matter (% DM), mineral matter (% MM), crude fibre (% CF), crude fat (% EE), metabolizable energy (ME kcal/kg), and Ca. The crude protein (% CP) was estimated by multiplying the N content by the factor 6.25. Dry matter, ash, CF, and EE of the feed samples were determined as per the procedure of the AOAC, (1995). Metabolizable energy was calculated following Wiseman (1987), as indicated below: $ME\ (MJ) = (3951+54.4\times EE-88.7\times CF-40.8\times Ash) \times 0.92\times 0.004184$.

Experimental Design and Treatment

A total of 90 Bovan brown chicks, 42 days old, were used in the current study, which was divided into three treatment groups. Each treatment group was comprised of 30 chicks, which were further subdivided into three (3) replications, and each replication had chicks. The birds were maintained in a deep litter house using dry wood shaved, which was initially disinfected with the HI-7 disinfectant, and stayed for about two weeks before the chicks were introduced. The littering material was approximately 5cm from the ground. The experimental design used was a completely randomised design (CRD). The grouping factor was the difference between feed ingredients (ration). There were three different feed treatments:

T1 = Quality protein maize (QPM) which is used as a source of essential amino acid + common salt + limestone powder

T2 = Normal maize + soybean grain which is used as source of protein + common salt + limestone powder

T3 = Normal maize + common salt + limestone powder + Sesbania sesban (S. sesban) green leaf which was used as a source of protein. The feeding experiment was formulated in three phases depending on the amount of calcium (Ca) required for growers (from 6 to 9 weeks), pullet (from 10 to 16 weeks), and layers (after 17 weeks). According to the National Research Council (1994) poultry feed requirement recommendation, the calcium (Ca) requirements for growers, pullets, and layers are 1.26%, 3.25%, and 5.02%, respectively. NaCl and limestone were based on Keshavarz (1987) and Wideman et al. (1985) poultry nutrient requirement recommendations. Proportions of ingredients used in ration formulation, ration formulated for growers, pullets and layers are indicated in Tables 1, 2, 3, and 4, respectively.

Table 1

Proportion of feed ingredients (%) used in formulating the experimental rations

Ingredients %	Treatments								
	T1			T2			T3		
	Growing	Pullet	Layer	Growing	Pullet	Layer	Growing	Pullet	Layer
Normal Maize (%)	-	-	-	73.49	71.5	69.73	98.49	96.5	94.73
QPM (%)	98.49	96.5	94.73	-	-	-	-	-	-
Soybean (%)	-	-	-	25	25	25	-	-	-
Limestone (%)	1.26	3.25	5.02	1.26	3.25	5.02	1.26	3.25	5.02
Salt (%)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
S. sesban.	-	-	-	-	-	-	Freely access feeding		

Table 2

Formulated grower ration of Bovan brown chicken for different treatments rations

Feed ingredients	T_1			T_2			T_3		
	Proportion mixed	CP %	Calculated CP	Proportion mixed	CP %	Calculated CP	Proportion mixed	CP %	Calculated CP
NM	-	-	-	73.49	8.7	6.39	98.49	8.7	8.57
QPM	98.49	12.5	12.31	-	-	-	-	-	-
Soybean	-	-	-	25	37.69	9.42	-	-	
Limestone	1.26	-	-	1.26	-	-	1.26	-	
Salt	0.25	-	-	0.25	-	-	0.25	-	
S. Sesban	-	-	-	-	-	-	-	-	
Total	100		12.31	100		15.81	Freely access		8.57

NM=Normal maize; QPM=Quality protein maize; S. Sesban = Sasbania sesban

Table 3

Formulated pullet ration of Bovan brown chicken for different treatments ration

Feed ingredients	T_1			T_2			T_3		
	Proportion mixed (%)	CP %	Calculated CP	Proportion mixed (%)	CP %	Calculated CP	Proportion mixed	CP %	Calculated CP
NM	-	-	-	71.5	8.7	6.22	96.5	8.7	
QPM	96.5	12.5	12.06	-	-	-	-	-	-
Soybean	-	-	-	25	37.96	9.42	-	-	
Limestone	3.25	-	-	3.25	-	-	3.25	-	
Salt	0.25	-	-	0.25	-	-	0.25	-	
S. Sesban	-	-	-	-	-	-	-	-	
Total	100		12.06	100		15.64	Freely access		8.39

Table 4

Formulated layers ration of Bovan brown chicken for different treatments rations

Feed ingredients	T1			T2			T3		
	Proportion mixed (%)	CP %	Calculated CP	Proportion mixed (%)	CP %	Calculated CP	Proportion mixed	CP %	Calculated CP
NM	-	-	-	69.73	8.7	6.1	94.73	8.7	8.24
QPM	94.73	12.5	11.84	-	-	-	-	-	-
Soybean	-	-	-	25	37.69	9.42	-	-	
Limestone	5.02	-	-	5.02	-	-	5.02	-	
Salt	0.25	-	-	0.25	-	-	0.25	-	
S. Sesban	-	-	-	-	-	-	-	-	
Total	100		11.84	100		15.52	Freely access		8.24

Egg Quality Determination

Egg quality evaluation was determined by sensory and laboratory methods. The laboratory egg quality evaluation was done at Jimma College of Agriculture and Veterinary Medicine at Jimma University. A total of 90 egg samples (thirty eggs from each treatment) were randomly picked from each treatment group for the quality analysis. The quality evaluation was done three days after the eggs were laid. The sensory evaluation was performed by 50 panelists of individuals selected from Wallaga University staff and students. A total of 75 egg samples (twenty-five eggs from each treatment) were used for the sensory evaluation.

Sensory evaluation of the egg sample

Sensory evaluation of the egg quality determination was done by freshly laid eggs collected within 24 hours of laying and at the 25th week of chicken age. Collected eggs from each treatment were cooked in three different bowls for about ten minutes; the shell was separated from the egg and then cut by breadknife into two equal parts. Before the sensory evaluation, orientation was given to the ‘panelists’ on how to evaluate the sampled eggs from the different treatment diets in accordance with the normal egg appearance (shape, color), flavor, aroma and tenderness. That was generally to encourage them to express their preference on the 1 to 9 hedonic scale (9 = like extremely, 8 = like moderately, 7 = like, 6 = like slightly, 5 = neither like nor dislike, 4 =dislike slightly, 3 = dislike, 2 = dislike moderately, 1 = dislike extremely). ‘Panelists’ used water to rinse (refresh) their sense organs after tasting a sample before the next taste. Then the proportion and mean values were calculated for each treatment.

Physical evaluation of egg samples for determination of egg quality

Egg samples from each of the three treatment groups were coded at the time of collection. Egg weight was measured on a sensitive balance, and then the weight of each egg was recorded.

Egg Length and Width (cm)

This was determined using a pair of calipers and read on a ruler calibrated in centimeters.

Egg Shape Index (%)

The egg shape index was calculated as the ratio of egg width to the egg length following Olawumi and Ogunlade (2008).

$$Egg\ shape\ index\ (\%) = \frac{Egg\ width}{Egg\ length} * 100$$

Egg shell thickness

The egg shell thickness was measured in a micrometer gauge at the narrow end, broad end and medium end of the egg and then their average was recorded as an egg shell thickness (Ajuwon et al., 2002). Finally, each treatment eggs shell thickness value was computed as the average of the total number of eggs from each treatment.

Albumen Quality

One of the primary egg quality traits most frequently measured is albumen quality. Albumen quality has a major influence on overall interior egg quality, and it provides more protein than the yolk. This measurement is a very efficient method of determining the quality and freshness of eggs. Albumen quality was measured in millimeters (the higher the reading the better the quality). Albumen gets thin as the egg is aged because the protein in the egg changes in character over time. Thinning of the albumen is a sign of quality loss.

Albumen index

The albumen index was calculated as the proportion of albumen height to albumen width.

$$Albumen\ index = \frac{Albumen\ height}{Albumen\ width} * 100$$

Albumin height (mm)

Albumen height was measured using a tripod micrometer calibrated (adjusted) in millimeter.

Albumen width (mm)

Albumen width was taken as the maximum cross-sectional width of the albumen using a pair of calipers read on a ruler calibrated in millimeter. Albumen weight was calculated by subtracting the yolk and shell weights from the egg weight. Its' weight was measured using a sensitive balance. Both albumen index and yolk index were determined according to (Olawumi & Ogunlade, 2008). The most important factor in determining albumen quality is the Haugh Unit (HU). The Haugh Unit score was calculated using the egg weight (g) and albumen height (mm). The Haugh unit value for this study was calculated for individual eggs using the Haugh equation by Monira et al. (2003).

$$\mathrm{HU} = 100_{log}(AH - 1.7EW^{0.37} + 7.6)$$

Where: HU = Haugh Unit, AH = Albumen height (mm), EW = Egg weight (g)

Yolk Height (mm)

The weighed egg was broken and then placed on a flat surface. Then the yolk height was measured using a tripod micrometer calibrated in millimeter. Yolk width was taken as the maximum cross-sectional width of the yolk using a pair of calipers and read on a ruler calibrated in millimeter.

Yolk index

The yolk index was calculated as the proportion of yolk height to width, while yolk color was put on a flat clean table and computed by the yolk color fan measurement, which has 1–15 strips from pale to orange-yellow color.

$$Yolk\ index = \frac{Yolk\ eight}{Yolk\ width} * 100$$

In general, during the study period, data were collected and calculated for body weight change, egg yield, feed intake and feed conversion efficiency, and external and internal egg qualities.

Data Presentation and Analysis

The analysis of variances for all parameters was performed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 2008) and mean differences as applicable were separated using the Tukey Honestly Significant Difference (HSD) test at α = 0.05. The statistical model fitted for the study was:

$$Yij = \mu + ti + eij$$

Where Yij = response variable (i.e. egg quality parameters) and taken under treatment i, μ = overall means, ti = the ith treatment effect (feeds), eij = the error term.

Result and Discussion

Chemical Compositions of Ingredients Used in the Ration

The nutrient compositions of the different dietary ingredients are presented in Table 5. Soybean (95.6%) and S. sesban (95.30%) had almost similar higher values of DM, while QPM got middle (89.56%) but normal maize (NM) had the lowest figure (86.90). Soybean was the highest with regard to CP value (37.69%) followed by S. sesban (25.3%) and QPM (12.50), but NM was the least (8.75%). The 45% average CP average soybean meal reported by Panagiota et al. (2014) was higher than the 37.69% obtained in the current study. The likely explanation for the lower CP% obtained in the present study was due to the fact that we used whole grain. The metabolizable energy content steadily increased from S. sesban to QPM as listed in Table 5. Both the EE and CF compositions were highest for soybean grain while NM had the least EE. Ca was highest in QPM while NM had the least. The total ash composition was highest for S. sesban grain, followed by soybean, while that of NM was the lowest. The variations in nutrient compositions of all the above feed ingredients were mainly due to variations in species (Ahemed et al. 2014) (e.g., NM and soybean grain) and varieties (e.g., QPM and NM).

Table 5

Chemical composition of ingredients used in the ration (% on DM basis)

Ingredients	QPM	NM	soybean	*S. sesban*	LS	Salt
DM (%)	89.56	86.90	95.6	95.30	99	95
CP (%)	12.50	8.70	37.69	25.30	0.00	0.00
ME (Kcal/Kg)	375.9kcal/100g	3340	3223	2342.25	0.00	0.00
EE (%)	5.63	3.60	22	-	0.00	0.00
CF (%)	1.30	2.10	4.60	-	0.00	0.00
Ca (%)	2.35	0.04	0.21	0.75	0.00	0.00
Ash (%)	1.86	1.81	4.29	6.3	0.00	0.00

DM=dry matter, CP=crude protein, ME=metabolizable energy, EE=ether extract, CF=crude fiber, QPM=quality protein maize, NM=normal maize.

Chemical Compositions of the Experimental Ration

The nutrient composition of the mixed dietary ration fed to Bovan brown layers is given in Table 6. The DM percentage and ash content of the ration had consistently decreased from T_1 toT_3. T_2 had the highest CP value (21.97%) mainly due to the existence of soybean grain in this treatment. The first treatment (T_1) has got 12.49% CP while T_3 had least value (8.41%). In the third treatment (T_3), although S. sesban contained about 25.3% CP in the ingredient as protein, the total CP of the ration became the lowest. This may be due to the lowest CP content of NM in T_3, which might have pulled down the mean values of CP. The EE and Ca values increased from T_1 to T_3, while CF% did not show a consistent trend. The highest ME value was recorded in T_2 (3756.54 Kcal/kg) which might be due to the high energy content of NM and the CF was highest in T_1 (4.77%) and followed by T_3 (2.05%) and T_2 (1.48%).

Table 6

Chemical composition of different formulated chickens' ration

Chemical composition%	Treatments		
	T1	T2	T3
DM (%)	88.20	86.72	86.00
Ash (%)	1.52	1.24	1.16
CP (%)	12.49	21.97	8.41
EE (%)	6.43	5.09	3.48
CF (%)	4.77	1.48	2.05
Ca (%)	2.4	0.10	0.04
ME (Kcal/Kg)	2609.1	3756.5	3231.45

DM=dry matter, CP=crude protein, EE = ether extract, CF = crude fiber, ME=metabolizable energy. NM = normal maize, QPM = quality protein maize, SB = Soybean grain crushed.

Effect of Experimental Diets on Egg Quality

In the current study, the experimental diets had significant influences ($p<0.05$) on egg shell thickness and egg length (Table. 7). However, the experimental diets had no significant influence ($p>0.05$) on egg shell weight, egg width, and egg shape index. The average egg weights for T_1, T_2, and T_3 were 48.12g, 49.56g and 47.41g, respectively. Tadesse et al. (2015) reported higher average egg weights of 64.78g and 58.9g for Isa Brown (IB) layers under intensive and extensive management systems, respectively. The authors also reported average egg weights of 63.46g and 59.32g and 47.79g and 47.53g for Bovan Brown (BB) and Potchefstroom Koekoek (PK) layers under intensive and village production systems, respectively. The likely difference between the average egg weights ranging from 47.41g to 49.56g recorded in the current study is lower than the average egg weights ranging from 58.9g to 64.78g reported for the IB and BB layers by Tadesse et al. (2015) may be due to agro-ecology, management, and genotype differences. Tadesse et al. (2015) carried out a comparative study of egg quality traits in the dry arid agroecology of the east Shewa zone under intensive and extensive (village) production systems. The difference observed may be due to the body weight differences of birds. According to Akanni et al. (2008), the higher the body weight of the hen at the first egg, the higher the weight of the first egg, indicating a direct correlation between body weight and egg weight in the chickens. Positive relationships were also reported between body weight and egg weight in many breeds of poultry (Ojo et al., 2019). Even though the size of the egg determines hatchability, bigger eggs tend to have poorer hatchability and poorer shell quality due to the increased number of cracks. The standard average egg weight that leads to good hatchability and quality egg shell is within the range of 49 to 56g, which is slightly higher than the average egg weight obtained in the current study. This could be due to the chickens' age. Older birds tend to lay bigger eggs and have a higher egg output, which impacts on shell strength or thickness (Butcher & Miles, 2003). The mean egg weight ranging from 48.12g to 49.56g reported by Tadesse et al. (2015) for PK layers was, however, within the range reported in the current study.

During the current study, egg shape index values obtained were 70, 73 and 75 for T_1, T_2 and T_3, respectively. Duman et al. (2016) reported that the shapes of eggs most often encountered are sharp, normal, and round eggs, and their shape indices are reported as < 72, 72 to 76 and >76, respectively. Therefore, the egg-shape index values of T_2 and T_3 of the current study had a normal shape; while T_1 had a sharp shape. The average egg length obtained for T_1, T_2 and T_3 of the present study were 47.4, 46.3 and 41.7mm, respectively. The average egg lengths reported in the current study are lower than the 56.4±0.16mm egg length reported by Nebiyu (2016) for the Bovan brown layer. The likely reason for the observed difference may be the age of the hens and management. Egg length has been reported to be significantly affected by egg weight (Monira et al., 2003), which is again influenced by the age and weight of hens. In the current study, a negative correlation was indicated between egg weight and egg length. However, Apuno et al. (2011) reported positive and significant correlations ($p<0.05$) between egg weight, egg length, and egg width. The difference might be attributed to the software and model of analysis fitted.

Egg shell quality

The egg shell thickness values ranging from 0.26mm to 0.35mm were obtained in the current study. These values are lower than the 0.39mm average value reported for Bovan brown hens managed under the cage system and slightly lower than the 0.35mm reported for the same chicken breed under the free-range system reported by Yenice et al. (2016). For the best result of egg hatchability, shell thickness should be between 0.33 to 0.35mm and even a few eggs with a shell thickness of less than 0.27mm could be hatched (Khan et al., 2004). Thus, the mean egg shell thickness reported in the current study falls within the acceptable range for good egg hatchability. Particularly, the 0.33 and 0.35mm mean egg shell thickness obtained from birds managed in T_1 and T_2, respectively, perfectly much the best hatchability standard, while the value of egg shell thickness (0.27mm) obtained from birds of T_1 is below the standards indicated above. According to Tadesse et al. (2015), the difference in eggshell thickness is due to breed difference, while the present egg shell thickness differences may be due to feed variation. The chickens consumed T_2 diet had shown the best results in most of the physical characteristics of eggs evaluated, indicating that the protein values of the QPM (F_2 generation) in T_1 and that of S. sesban green leaf in T_3 could not compete with the soybean grain inT_3.

Good shell thickness is an important bio-economic trait in commercial egg production as it may help to reduce the percentage of cracked eggs (Fayeye et al., 2005). The quality of eggs depends on the physical makeup and chemical composition of their constituent parts (Chukwuka et al., 2010). Ketelaere et al. (2002) reported that egg weight has increased significantly while shell thickness has decreased. This shows that components of the eggs that make the whole eggs can play an important role in egg quality measurements.

Table 7

Physical (external) characteristics of eggs from Bovan brown layers fed different feeds formulated from locally available ingredients

Parameter	T_1	T_2	T_3	SEM	P-value
Egg weight (g)	48.12	49.56	47.41	0.67	0.19
Egg Length (cm)	4.74a	4.63ba	4.17b	0.09	0.03
Egg width (cm)	3.35	3.39	3.16	0.26	0.82
Egg Sell Index (%)	70.00	73.00	75.00	0.05	0.77
Egg Shell thickness (mm)	0.33ba	0.35a	0.26b	0.01	0.03
Egg Shell weight (g)	5.29	5.66	5.53	0.19	0.46

Different superscripts within a row indicate significant differences at (p<0.05); SEM = standard error of the mean.

Internal egg quality of Bovan brown layers as affected by formulated diets

Effect of the diets on albumen quality

The evaluation results of the albumen quality of Bovan brown pullets fed locally formulated diets are indicated in Table 8. The present study result indicated that albumen width was significantly (P<0.05) affected by treatment diets. However, other albumen traits were not influenced by the treatment diets. Albumen width was higher in T_2 than in $T_1$and T_3. Albumen height and HU are the two most important indicators of albumen quality. In the present study, the values of the albumen height range from 6.91 to 7.72mm and the values are higher than the 6.21mm to 6.68mm albumen height reported by Garba et al. (2010).

However, the 7.1±0.08mm mean albumen height reported by Nebiyu (2016) for Bovan brown chickens managed in an urban production system in Addis Ababa city falls within the mean range (6.91 to 7.72mm) reported in the current study. Albumen height was higher for those birds managed in T_1 followed by those managed in T_2; and those birds managed in T_3 recorded the least albumen height.

Albumen weight was not significantly (p<0.05) influenced by the treatment diets, which may be due to egg weight. According to Harms and Hussein (1993), albumen weight was more closely associated with weight than yolk weight. Tadesse et al. (2015) reported albumen weights ranging from 25.14 to 35.98g for three chicken breeds. In the current study, albumen weights ranging from 30.37g to 31.73g were reported, and the values are within the range reported by Tadesse et al. (2015).

Table 8

The effect of treatment diets on albumen quality

Parameter	T1	T2	T3	SEM	P-value
Albumen height(mm)	7.72	6.91	6.78	0.62	0.56
Albumen weight (g).	31.55	31.73	30.37	0.62	0.35
Albumen width (mm).	4.96^{b}	5.67^{a}	5.15^{b}	0.07	0.005
Albumen index	1.57	1.27	1.34	0.13	0.38
Haugh unit	89.58	84.75	83.84	4.07	0.60

Different superscripts within a row indicate significant differences at (p<0.05); SEM = standard error of mean

Experimental diets had no significant effect (p > 0.05) on yolk width, yolk height, yolk weight, or yolk index, except yolk colour, which was significantly influenced by the experimental diets (Table 9). Yolk width values ranging from 33.80 to 37.00mm were obtained in the current study. Birds fed on diet had the highest yolk width (37.00 mm), followed by those fed on, and those fed on were the least. A similar trend was recorded for yolk weight with regard to treatments. Alkan et al. (2015) also reported that yolk weight had a significant positive correlation with yolk width. The yolk width values reported in the current study are in agreement with the 36.80±0.18mm reported by Abera et al. (2012).

In the current study, yolk colour was significantly affected (p<0.05) by treatment diets. Chicken fed (consumed) on quality protein maize had a better yolk colour (yellow) than those fed on, and this is consistent with Altamirano (2005), who reported that yellow maize supplementation had improved yolk colour as opposed to other feed ingredients. Even though the colour of the yolk does not affect the nutritional content of the egg (FAO, 2003), it has market value under Ethiopia's conditions. Okeudo et al. (2003) also indicated that yolk colour is one of the main criteria by which consumers' judge the quality of eggs. However, Jacob et al. (2000) argued that consumers' preferences for yolk colour are highly subjective and vary widely from country to country. The average yolk colour points for eggs from birds fed on and on the Roche scale were 9.80, 2.06, and 3.16, respectively. Garba et al. (2010) also reported that egg yolk colour depends on the type of diets. The values obtained for yolk colour in the current study are lower than the values ranging from 10.36 to 11.85 reported by Yenice et al. (2016) for the Bovan brown breed raised under different management systems.

The yolk height values recorded in the present study ranged from 16.20 to 16.45mm, which are higher than the yolk height values ranging from 14.60mm to 15.60mm reported by Madubuike and Obidimma (2009). It was also higher than the values ranging from 14.24 to 14.94mm reported by Alkan et al. (2015). However, the yolk height values obtained in the current study are within the range of 16.21 mm to 17.60 mm reported by Garba et al. (2010).

Yolk index values ranging from 0.20 to 0.23 are reported in the current study (Table 9). The yolk index values reported in the current study are below the accepted yolk index values of 0.3 to 0.50 for fresh eggs (Ihekoronye and Ngoddy, 1985). It has been shown that a high yolk index value is one of the indicators of internal egg quality (Dudusola, 2010). Therefore, it seems that based on the standard yolk index values, the eggs laid by Bovan brown chickens under the present experiment did not meet the required standard. Alkan et al. (2015) reported a positive and highly significant (r = 0.755) correlation between yolk index and yolk height. Furthermore, the authors indicated that yolk index was positively correlated with albumen height. This indicates that improvements in albumen height, yolk height, and yolk width will result in a better yolk index.

Table 9

Internal characteristics of egg yolk quality of Bovan brown hens

Parameter	T1	T2	T3	SEM	P-value
Yolk width (mm).	33.80	37.00	34.50	0.10	0.21
Yolk height (mm).	16.45	16.20	16.23	0.16	0.57
Yolk weight (g).	11.27	12.16	11.50	0.37	0.32
Yolk index	0.20	0.23	0.21	0.007	0.38
Yolk color	9.80^{a}	2.06^{b}	3.16^{b}	0.37	0.0002

Different superscripts within a row indicate significant differences at ($p<0.05$); SEM = standard error of mean

Sensory evaluation of eggs from Bovan brown chicken

The sensory evaluation of eggs was done with 'panelists' in the current study. The sensory evaluation results are indicated in Table 10. The results indicated that egg appearance (shape, color), flavor (taste), and aroma (smell) were significantly ($p<0.05$) influenced by treatment diets, except tenderness which was non-significant ($p>0.05$). The decision made by 'panelists' showed that hens fed on T_1(QPM) had a higher value of egg appearance, flavor (taste) and aroma (smell) than eggs from hens fed on T_2 and T_3. However, there was no significant difference between T_2 and T_3 with regard to the traits considered in the current study. The perception that eggs laid by exotic birds are inferior in quality compared to local breeds due to their yolk color (i.e., yolk color is not yellow) was disproved in that improving the diet of birds could change the yolk color. Other researchers also confirmed that yolk color is a function of feed, not breeds (Demeke, 2004, Altamirano, 2005). According to Jacob et al. (2000), yolk color, a key factor with regard to egg quality. Consumer preferences for yolk color are highly subjective and vary widely from country to country.

Table 10

Results of sensory evaluation of eggs from Bovan brown chickens fed different treatment diets

Parameter	T1	T2	T3	SEM	P-value
EA (Shape, color)	8.08[a]	6.67[b]	6.57[b]	0.16	0.005
Aroma (Smell)	8.06[a]	6.55[b]	6.63[b]	0.27	0.03
Flavor (Taste)	7.40[a]	6.79[b]	6.76[b]	0.14	0.02
Tenderness	7.40	6.82	6.75	0.25	0.06

Different superscripts within a row indicate significant differences at ($p<0.05$); SEM = standard error of the mean

CONCLUSIONS

The study was conducted at Wallaga University, Nekemte campus to evaluate the effect of different locally available feeds on Bovan's brown chicken eggs' quality traits. A total of 90 Bovan brown chickens with uniform body weight were used in the current study. The study was conducted for up to 26 weeks. Sensory and physical egg quality traits were determined once during an early laying period. Results of the present study showed that different dietary rations significantly ($p<0.05$) affected egg appearance (shape, color), flavor (taste), aroma (smell), egg length, egg shell thickness, albumen width, and yolk color of eggs of Bovan brown chicken. However, most of the egg quality traits were not significantly influenced ($p>0.05$) by the treatment diets used. Generally, sensory preferences of egg quality and yolk color were improved by feeding quality protein maize (T_1) compared to the other two treatment diets (T_2 and T_3). Thus, feeding quality protein maize is suggested as a better feeding option for layers in the study areas.

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