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Research Article

Effects of replacement noug seed cake (*Guizotia abyssinica*) with treated tagasaste (*Chamaecytisus palmensis*) leaf meal on egg quality traits of layer hens

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Abstract

Egg quality treats are significantly impacted by nutritional factors either deficient or excessive quantities in the layer diets. In this study one hundred eight, 32 weeks age of Bovans Brown chickens were used as an experimental animals. Four iso-nitrogenous and iso-caloric based ration diets were formulated. The level of ration replacing NSC by TTLM was at 0%(T1), 5%(T2), 10%(T3) and 15%(T4) from the total ration. Complete Randomized Design (CRD) was used with four treatments, three replicate (9chicken/replicate) and the experiment lasted for 12 weeks. Egg quality parameters were determined at the interval 28 days by randomly taking 5 freshly-laid eggs from each replication and determine egg size, eggshell, albumen and yolk quality by using different measurement parameters. The results showed that egg shape index, yolk weight (g) and yolk ratio (%) were similar (P>0.05) among treatment groups. Eggshell thickness and yolk color score were significantly varied (p<0.05) with different levels of TTLM substitution. In the present study shell thickness, shell weight and shell ratio were higher in the treatment groups (5, 10 and 15% TTLM) than the control (0%) diets. The study showed that shell thickness ranged from 0.32-0.38 mm at T1 and T3 TTLM, respectively. Haugh unit (84.04±1.79) and albumen height (7.01±0.23) were highest (P<0.05) at T_3 than the other treatments. Based on results most of the external and internal egg quality parameters were significantly changed when the level of TTLM increased up to15% than the control diet and it implies a great opportunity in utilizing TTLM.

Introduction

Chicken production is becoming the major market-oriented business of the livestock industry in urban and pri-urban areas of Ethiopia [1]. Chicken productions have been created both rural and urban youth and women employment opportunities and generate income. Because, it is easy to rear and benefits women and children compared to other livestock species [2]. Egg production is one of the major production components of chicken and it is made up of three distinct parts could shell, yolk and albumen, which have 10, 30 and 60% of weight egg. The quality of eggs is paramount to egg producers as they achieve to meet consumers' preferences, realize their internal financial objectives and ensure the sustainability of egg production [3]. Inconsistent yolk color or poor eggshell quality will have serious financial consequences. According to Julie [4] reported that shell quality, albumen quality, as well as egg yolk characteristics, are important to consumers in the high supermarket standards.

The egg shape is also important because of the effect on the setting position of the egg. It may influence hatchability by determining the position of the air cell during incubation. Egg production performances and egg quality traits are significantly impacted by nutritional factors either deficient

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or excessive quantities in the layer diets. It may lead to poor laying performance, a poor eggshell and in low attractive yolk color [5]. The eggshell is the biological packaging that allows the handling and distribution of the egg to the marketplace in essentially the form in which it is laid [4]. Whereas, Świątkiewicz, et al. [5] stated eggshell quality is one of the most important indicators in chicken farms that influencing the economic profitability of egg production, sustainability, and hatchability.

The most common method to determine albumen quality is the Haugh Unit (HU). Egg having Haugh units' value greater than 72 is the best [6]. Many factors are reported to affect Haugh units such as storage time, nutrition (dietary protein and amino acid content e.g. lysine, methionine, and protein source), additives (ascorbic acid, vitamin E), heredity, age of birds, temperature, loss of carbon dioxide from the egg and disease [7]. Most of the consumers prefer a nice, golden yolk color, there for egg producers must ensure that they consistently meet these expectations by monitoring the intensity of the yolk color and adjusting the formulation of the rations fed to laying chickens [3]. Therefore, to respond to the poor qualities of egg, search cheap, available, and safe non-conventional alternative feed sources which have good vitamins, minerals, protein and energy nutrients for chickens are needed. The possibility of cheap vitamin, minerals and protein sources option is some tropical legume forage and plant leaf meal [8]. Because, Ethiopia has many different kinds of tropical legume foliage trees, which are suitable for chickens feeding [9]. One of such legume is tagasaste (*Chamaecytisus palmensis*).

As a reason, the study was conducted on the treated tagasaste leaf meal to replacing noug cake *(Niger or Guizotia abyssinca)* for the Bovans Brown (BB) layer chicken ration diet. Tagasaste is a small tree or shrub grown up to 6 meters tall with dark green trifoliate leaves and it is drought tolerant, starts cutting when plants grow more than 1 meter tall and can be cut regularly and harvest up to 4500 kg DM/ha/year. In addition to these, it is a good protein source of feed for ruminant animals and it is used to improve soil fertility, soil & water conservation, firewood, biological fence purposes and flowers are good sources for honey bee forage. Moreover, it has from 18-33% of crude protein and rich in essentials amino acid, pigments, vitamins, and minerals [10].

Tagasaste leaf meal has tannins, phenolic and alkaloids anti-nutritional factors and high fiber content, but it's can be reduced through the use of chemical or physical methods for the efficient utilization of nutrients [11,12]. Thus, tagasaste leaves have been treated for better use in the chicken's diet. To remove or lower these anti-nutritional factors and crude fiber content can use the combination process such as adding molasses, silage making, adding wood ash, drying and grounding [13,14]. These methods are enabled to easily applicable and accessible by small-scale chicken producers in the study area.

Moreover to perform, this experiment one hundred eight, 32 weeks age of Bovans Brown chickens were used under cage production system. Before rationing of experimental feed, each ingredient was done proximate analyzed, then four iso-nitrogenous and iso-caloric based ration diets were formulated which ration contain Treated Tagasaste Leaf Meal (TTLM) at 0 (T1), 5 (T2), 10 (T3) and 15% (T4). The experiment was arranged in a Complete Random Design (CRD) with four treatments, three replicates (nine chicken/ replicate) and the experiment lasted for 12 weeks. The egg quality parameters in this experiment were determined at the interval of 28 days (4 weeks) by randomly taking 5 freshly-laid egg representative samples from each replication (15 eggs per treatment). Then, we had taken different measurement parameters to determine the egg size, eggshell, albumen and yolk quality.

The results obtained from this experiment were egg shape index, yolk weight (g) and yolk ratio (%) similar ($P>0.05$) among four experimental feed groups. The eggshell thickness and yolk color score were significantly varied ($p<0.05$) with different levels of TTLM replacement. Haugh unit (84.04±1.79) and albumen height (7.01±0.23) were highest ($P<0.05$) at T_3 than the other treatments. In this experiment, most of the external and internal egg quality parameters positively significantly changed when the level of TTLM increased up to15% than the control diet of Bovans Brown layer chicken. It implies a great opportunity in utilizing TTLM for improving egg quality.

Materials and methods

Description of the study area

The study was conducted on Debre-Tabor town private small scale intensive chicken farm. Which is located at 38.03°E longitude, 11.87°N latitude, at an altitude ranges from 2447 to 2838 meters above sea level and 100 km southeast of Gondar and 50 km east of Lake Tana. The mean annual temperature is 15°C and the average annual rainfall is 1497 mm.

Preparation of experimental ingredients and ration formulation of treatments

Feed ingredients used to formulate the experimental rations of the study were Yellow Corn Grain (YCG), Wheat Bran (WB), Noug Seed Cake (NSC), Soybean Meal (SBM), Meat & Bone Meal (MBM), vitamin premix, limestone, salt, lysine and Treated Tagasaste Leaf Meal (TTLM). The concentrates were purchased from the local market and tagasaste leaves were collected that are grown around Debre-Tabor town. That is planting on along the bund and backyards, from a six-year-old age plant and more than a year of re-growth during the short rainy season (Personal communication). As shown in Figure 1, before ration formulation the leaf collection and treatments were conducted. To reduce the Anti-Nutritional Factors (ANF) and Crude Fiber (CF) level of the leaf, by taken 4% molasses from the total collected leaves proportion and mix this molasses with a 1:1 ratio warm water to evenly distribute with leaf and mix it. Then it was ensiled by a plastic bag for twenty-one days to ferment [13,14]. After 21 days, open out the silages and added 2% eucalyptus wood ash and mixed it. Finally, the silage was sundried for one and half days and during the process of drying, leaves were turned regularly to prevent uneven drying and possible decay of the leaves. Then hand mortal milled to pass through 5 mm sieve to produce Treated Tagasaste Leaf Meal (TTLM). The other feed ingredients, except wheat bran, vitamin premix, lysine and limestone also milled in

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size of 5 mm and stored until required for the formulation of experimental rations.

Representative feed samples from TTLM, NSC, SBM, WB and YCG were taken and analyzed dry matter, crude fiber, total ash, ether extract, and Kjeldahl nitrogen procedure at Debre Birhan Agricultural research center. The CP content was determined by multiplying the nitrogen content by 6.25 [15]. The Metabolizable Energy (ME) content of the feed ingredients was also determined indirectly by Wiseman [16] formula as true ME (Kcal/kg DM) = 3951 + 54.4 EE – 88.7 CF – 40.8 Ash. The nitrogen-free extractive was also calculated from the total DM subtracted the sum of ash, crude protein, ether extract and crude fiber. The calcium and phosphorus content of TTLM, NSC, SBM, WB and YCG were determined by the atomic absorption spectrophotometer at Amhara Design and Supervision Works Enterprise, Bahir-Dar.

After laboratory analysis result of the nutrient composition of each ingredient, the experimental rations were formulated on an iso-caloric and iso-nitrogenous basis in such a way to consist 2750-2900 kcal ME/kg DM and 16-18% CP to meet the nutrient requirements of the BB layers [17]. The ration formulation of the experimental diets was indicated in Table 1. Then proximate analysis was done again on experimental diets. Moreover, experimental diets were supplemented with vitamin premixes (0.4%) and lysine (0.3%) to address the recommended nutrient requirements of chicken.

Experimental design and management of experimental chickens

The experiment was conducted using a Complete Randomized Design (CRD) with four treatments. One hundred eight layers with no defects, uniform size and similar age (32 weeks). Chickens were obtained own small-scale intensive chicken farm for used this study and randomly distributed into four treatments and each treatment was comprised of 27 layers in three replication (9 layers per replication) Table 2.

The experimental period was lasted for 12 weeks. The layers were kept on the cage house system partitioned into pens under a half-open cage house. Cage was made up of locally available materials that could be easily accessed by small scales intensive chicken producers such as bamboo, eucalyptus wood and mesh wire. The width, length and height of each cage were 50, 200 and 50 cm, respectively, per each replicate. Chickens of each replicate group were placed in the caged pen with one feeder and one water troughs. The feeder was made up of iron sheet 15,140 and 15 cm width, length and height respectively and drinkers were made up of highland plastic and had a capacity of holding two letters of water. Light access of the chicken was 12Hr natural light and 4 Hr. artificial light and total of 16Hr per day to increase feed intake and laying performance.

Experimental pens, watering and feeding troughs and internal houses were cleaned, disinfected, and sprayed against external parasites before introducing chickens. Chickens were vaccinated against Newcastle and Gumboro (infectious bursal) disease and medications were provided using broad-spectrum antibiotics. Other health precautions and sanitary measures were also taken throughout the experimental period. The layers were adapted to experimental diets for seven days before the commencement of the actual data collection. Feed was measured and provided to the animals every day. The daily feed (130 g/chicken per day *as-fed* basis or nearly 120g DM/chicken per day) were offered to experimental chickens three times a day at 07:00 12:00 and 17:00. Moreover, clean water was also provided in *ad-libitum*.

Figure 1: Indicated the process of harvesting and silage making of leaves.

Table 1: Ingredients proportion in the ration formulation layer diets.

Ingredients	Treatments			
	T_1	T_2	T_3	T_4
Treated leaf meal	0	5	10	15
Yellow corn grain	51	52	51	51
Wheat bran	14	12	12	11
Noug seed Cake	15	10	5	0
Soybean meal	10	11	11	12
Bone &meat meal	1	1	2	2
Lime stone	8	8	8	8
Vitamin premix	0.4	0.4	0.4	0.4
Lysine	0.3	0.3	0.3	0.3
Salt	0.3	0.3	0.3	0.3
Total	100	100	100	100

Table 2: Experimental layout of feeding trial on three levels of cage position.

Cage position	Number of chickens per replication and per treatments				Total chicken / Block
Lower	T_1R_1=9	T_3R_1=9	T_2R_1=9	T_4R_1=9	36
Mid	T_3R_2=9	T_4R_2=9	T_1R_2=9	T_2R_2=9	36
Top	T_4R_3=9	T_2 R_3=9	T_3 R_3=9	T_1 R_3=9	36
Total chicken	T_1=27	T_2=27	T_3=27	T_4=27	108

Egg quality measurements

Egg quality parameters were determined the interval of 28 days (4 weeks) during the experimental period by taking 5 freshly-laid egg representative samples from each replication (15 eggs per treatment). Eggs were randomly chosen from

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each replication and a total of 60 eggs were taken every 28 days until the end of the experiment (180 eggs the entire period of experiments) at Andassa Livestock Research Center. Both external and internal egg quality measured were taken and an average was computed for each quality parameters.

External egg qualities were measured like sample egg weight, egg length, egg width, shell weight, and shell thickness. The individual egg was weighed on egg multi-tester (EMT-5200). The egg length and breadth of eggs were measured with the help of digital calipers and the shape index was calculated as the ratio of breadth to length times 100. After breaking the eggs, then separated yolk & albumen and the shell & its membrane were measured together as shell weight by using an electrical sensitive balance. The eggshell thickness was measured without shell membrane at three locations of the egg (air cell, equator, and sharp end) by digital calipers and an average of the three sites took were record as eggshell thickness. Also, the eggshell ratio and egg shape index of each egg were calculated using the following formulas.

$$\text{Shell}(\%) = \frac{\text{Shell weight}}{\text{Egg weight}} * 100$$

$$\text{Shape index}(\%) = \frac{\text{Width of egg}}{\text{Length of egg}} * 100$$

The internal egg quality such as albumen height (mm), yolk color and Haugh unit (HU) were measured using egg multi tester (EMT-5200). Haugh unit in egg multi tester results was similar to the HU=100log ($H-1.7W^{0.37}+7.6$) formula results. Where H is the height of the albumen (mm) and W is the weight of the egg (g). Albumen weight was calculated as egg weight- (Yolk weight + shell weight). After breaking the egg on flat glass and separating eggshell and albumen then yolk weight was measured using electrical sensitive balance and yolk height measured with stem caliper. To estimate the yolk ratio, albumen ratio and yolk albumen ratio the following formulas were used.

$$\text{Yolk}(\%) = \frac{\text{Yolk weight}}{\text{Egg weight}} * 100$$

$$\text{Albumen}(\%) = \frac{\text{Albumen weight}}{\text{Egg weight}} * 100$$

$$\text{Yolk albumen ratio} = \frac{\text{Yolk weight}}{\text{Albumen weight}} * 10$$

Measurements of chicken production performance

The amount of feed offered and refused from chickens per replication were weighed and recorded every morning during the experimental period. The amount of feed consumed per chicken was determined as the difference between the feed offered and refused. Chicken's weight was measured at the start and end of the experiment by using a digital balance early in the morning of the day before feed and water were offered. Bodyweight change was determined as the difference between final and initial body weights. The feed conversion ratio was determined per replicate by dividing daily grams of feed intake in DM by daily grams of eggs laid. Eggs laid by chickens in a pen were collected once a day at 17:00 hr. and recorded the total number of eggs per replication. Collected eggs were weighed using the sensitive balance and the average egg weight was computed by dividing the total egg weight by the total number of eggs per replication. Hen-day and hen-housed egg production as a percentage were calculated by the following formulas.

$$\%HDEP = \frac{\textit{Number of eggs collected per day}}{\textit{Number of chicken presentthat that day}} * 100$$

%HDEP= percent of hen day egg production

$$\%HHEP = \frac{\text{Number of eggs collected in the period}}{\text{Number of hens originally housed x no. of days}} \times 100$$

%HHEP= percent of hen housed egg production

Statistical analysis

The data were analyzed using the general linear model procedures of the Statistical Analysis System (SAS) version 9.1 [18] with the model containing treatments. Differences between treatments were separated using Fisher's LSD tests, the means were considered significant at $P < 0.05$. To analyzing the standard error of the means (SEM) descriptive statistics was used. The following statistical model was used for the study.

$Yi = \mu + Ti + ei$

Where;

Yi = response variable (i.e. egg quality) taken under each treatment i.

μ = overall means

Ti = the effect due to the i^{th} treated tagasaste leaf meal level and

ei = random error

Results and discussion

Chemical Composition

The chemical compositions of the feed ingredients and treatments are presented in Table 3. The results of the current study indicated TTLM has relatively rich in protein (22.56%) that is comparative with the value (22% and 22.51%) reported by Dereje [19] and Rajan, et al. [20], respectively but lower than the value of CP% (24; 24.7 and 24.61) reported by Ajebu, et al. [11], Ek [12] and Ajila, et al. [21], respectively. The cause of lowering CP content in this study might be due to the old age of the plant (six-year) and more than a year of re-growth.

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The calculated ME content of TTLM noted in the current study (2370.94 kcal/kg) is higher than the values of (2174.95 and1998.09 Kcal/kg DM) reported by Heuzé, et al. [14] and Ajila, et al. [21], respectively, without treated. To the reverse CF content of TTLM in the current study (17%) is lower than the values (20%) reported by Ajebu, et al. [11]. The higher level of ME and lower level of CF of TTLM in the present study might be due to the addition of molasses which increased the energy value. Silage making was also a factor to decrease the CF content of TTLM in the present study.

The TTLM used in this study contains 0.446 % of calcium and 0.171% of phosphorus, which is lower than (2.2%) calcium content reported by Ajebu, et al. [11]. Generally, various factors including the plant growing environment, age, harvesting stage, storage condition and processing methods could be possible responsible for the differences in the chemical composition of tagasaste leaf meal observed in different studies. Since, the rations of treatment were formulated after identified the individual nutritional composition of each ingredient and nearly iso-nitrogenous and iso-caloric bases, the CP and ME range value (16.18-16.47% CP and 2869.77-2874.55 Kcal/kg DM) of the present study are within the recommended values (16-18% CP and 2750-2900 kcal ME/kg DM) for BB layers ration Ismail, et al. [17]. The P: Ca ratio of the present treatment feed (1:6.46, 1:6.98, 1:7.14 and 1:7.6) are comparable with the reported by Julie [6], who stated the quantity of calcium and phosphorus in the layer diet was extremely important and the optimal ratio around 1:6.3 (phosphorus: calcium).

Egg quality

Egg size: The values of the egg shape index obtained in this study did not show significant (P> 0.05) differences among the treatment groups and the values range 73.66-75.43 were obtained. Which, the lowest one was observed in the control group (0%) and the highest was chickens fed at 15% TTLM. Similar to the current study, , egg shape index from layers fed that different level (0-15%)of MOLM varies between 74.3-75.2% [22], but lower than the range between 75.80-80.92% [23]. Based on concerning eggs shape index (SI), eggs are classified as sharp eggs (SI <72), normal (standard) eggs (SI=72–76) and round eggs (SI >76) [24]. According to this classification, the shape index of the present study lined in normal (standard) eggs Table 4.

Eggshell quality

Eggshell quality problems are associated with inadequate

Table 3: Laboratory and calculation results of the nutrient compositions.

Ingredients	Nutrients compositions of ingredients and treatments									
	DM	Ash	CP	EE	CF	ME	NFE	Ca	P	P: Ca
YCG	91	4.9	10.6	5.91	3.86	3728.49	65.73	0.138	0.35	1:0.4
WB	92	4.35	17.58	4.21	9.4	3154.88	56.44	0.084	0.66	1:0.1
NSC	94	12.77	32.28	7.47	17.65	2270.55	23.83	0.729	1.12	1:0.7
SBM	93	6.45	45.31	8.4	5.8	3632.89	27.04	0.488	0.76	1:0.6
TTLM	94	7.45	22.56	4.9	17.4	2370.94	41.65	0.446	0.17	1:2.6
Treatments										
T1	91.15	13.06	16.47	5.23	9.39	2869.77	47.00	3.36	0.52	1:6.5
T2	91.15	12.96	16.21	5.16	9.38	2870.93	47.44	3.35	0.48	1:7.0
T3	91.2	12.9	16.18	5.10	9.33	2874.55	47.69	3.43	0.48	1:7.1
T4	91.21	12.84	16.47	5.29	9.48	2874.03	47.13	3.43	0.45	1:7.6

DM: Dry Matter; YCG: Yellow Corn Grain; NSC; Noug Seed Cake; SBM: Soybean Meal; TTLM: Treated Tagasaste Leaf Meal; CP: Crude Protein; ME: Metabolize Energy; NFE: Nitrogen-Free Extract; EE: Ether Extract; CF: Crude Fiber

Table 4: Egg quality parameters at a different level of treated tagasaste leaf meal.

Parameters	Treatment				Sig	CV (%)
	T_1	T_2	T_3	T_4		
Egg length (mm)	59.48±0.51^a	58.38±0.91^{ab}	56.60±0.2^c	57.89±1.66^{bc}	**	1.46
Egg width (mm)	43.81±0.4^a	43.84±0.23^a	42.93±0.6^b	43.65±0.35^a	**	0.66
Egg shape index	73.66±0.8	75.11±1.48	75.42±2.0	75.43±1.58	NS	1.76
Sample Egg weight (g)	62.2±1.8^a	61.77±0.52^a	60.20±1.9^{ab}	60.48±2.8^{ab}	*	2.49
Shell thickness (mm)	0.32±0.014^b	0.34±0.02^{ab}	0.38± 0.05^a	0.386±0.01^a	*	7.12
Shell weight (g)	6.47±0.21^b	7.04±0.30^{ab}	7.34±0.21^a	6.92±0.81^{ab}	*	4.48
Eggshell ratio (%)	10.41±0.10^b	11.41±0.47^b	12.61±0.65^a	11.26±0.94^b	**	4.71
Albumen height (mm)	5.60±0.21^b	5.47±0.36^b	7.01±0.23^a	6.01±0.53^b	**	5.13
Albumen weight (g)	38.42±1.9^a	38.41±1.09^a	34.78±1.5^b	36.84±1.4^{ab}	*	3.50
Albumen ratio	61.79 ± 1.28^a	62.18±1.25^a	59.75±0.6^b	61.80±1.19^a	*	1.54
Haugh unit	72.42±2.10^b	71.98±3.14^b	84.04±1.79^a	76.95±4.26^b	**	3.38
Yolk height (mm)	17.79±0.64^a	17.99±0.83^a	16.9±0.4^{ab}	16.41±1.02^b	**	3.29
Yolk weight (g)	17.27± 0.31	16.98±1.38	16.58±1.50	16.46±0.76	NS	5.65
Yolk color score	4.40±0.87^c	5.40b±0.34^b	6.09±0.42^{ab}	7.04±0.40^a	**	8.41
Yolk ratio	27.80± 1.30	26.41±1.25	27.63±0.23	27.22±0.66	NS	3.06
Yolk /Alb ratio	45.02±3.04	42.50±2.84	46.24±0.63	44.27±2.00	NS	4.54

^{a,b,c}with different letters in the same row are significantly different at the indicated level; value within row; *= significant (P < 0.05); **= highly significant (P< 0.01) on the different level of TTLM, respectively; NS=Non-Significant

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levels of calcium and vitamin D. It is determined by the shell weight, percentage, thickness and strength [4]. Egg shell thickness in the current study was significantly (P<0.05) higher at T_3 and T_4. The shell weight and shell ratio also significantly higher (p<0.05) at $T_{3,}$ than the control diets (T_1). Shell thickness current study ranged from 0.32-0.38 mm at T_1 and T_3 TTLM, respectively and these results are agreed with previous similar works that can be categorized as the best result of breaking strength and hatchability, the eggshell thickness should be between 0.33-0.35 mm [4]. But, higher than the value (0.29-0.30 mm) who reported by Niraj, et al. [25], with the increased level of ground *Prosopis juliflora* leaf meal from (0-30%) on BB chickens ration. The reduction of calcium in diet causes a decrease in the amount of calcium deposited on the eggshell and therefore poor in eggshell quality [4].

The eggshell weight account in the current result (10.41-12.61%) was in line with Julie [4] who reported the shell accounts for only 9-14% of the total egg proportion. The values of shell strength, shell thickness and shell weight in the present study showed an increasing tendency with the increasing level substitution of TTLM. On the contrary Muhammad, et al. [26] was reported eggshell weight and shell ratio decreased slightly when the level of mulberry leaf meal (0-9%) increase. This implies that TTLM is considered a good supply of the adequate amount of minerals and vitamins required for proper growth and development for shell formation. So, it could be used in layers ration by replacing noug seed cake without compromising the eggshell quality characteristics.

Albumen quality

The albumen height and Haugh unit are important parameters in evaluating albumen quality and egg freshness and the most common method to determine albumen quality is the Haugh unit [3]. In the current experiment, the albumen height and Haugh unit (HU) were higher for T_3 compared with all the other treatment groups. This result suggested the replacement of treated TLM at 10% has a beneficial effect on the albumen height and Haugh unit. This study was in agreement with the finding of Wei, et al. [22] who noted higher albumen height and Haugh unit that for Hy-Line Grey layers fed 10% of *Moringa oleifera* leaf meal.

The range of Haung units for medium (B), good (A) and best (AA) scores were 31–60, 61–72 and >72, respectively [6]. Therefore, based on the result of the current study the average values (0,10 and 15% TTLM substitution) were score grade AA and collected at 5% TTLM treatment were scored grade A. The highest albumen quality in T_3 might be due to the balanced amino acid and vitamins (lysine, methionine and vitamin A, ascorbic acid, vitamin E) found in the higher amount of TTLM than NSC Figure 2.

Yolk quality

The results for yolk colour in the present study showed a significant difference among the various graded levels of TTLM. The present study reported that the intensity of yolk colour was a linearly (P < 0.05) improved trend as the level of TTLM substitution increased. The reason for the higher yolk colour score with an increasing level of TTLM might be due to the higher carotenoid contents of the TTLM. Thus, TTLM can be a potential ingredient for egg yolk coloration, because many consumers prefer egg with more yellow yolk colour. In general, the variation of yolk colour is influenced by the content and profile of pigmenting carotenoids present in the feed of chickens. This phenomenon was also reported by Julie [4]; yolk color is derived from the deposition of xanthophylls (a group of carotenoid pigments). The yolk weight a little bit decreased when the level TTLM of substitution increase. This was in agreement with the results of Muhammad, et al. [26] who reported increasing levels of mulberry leaf meal from (0-9%) in Hi-Sex Brown layer ration, the yolk weight was slightly decreased without significant differences (P>0.05) Figure 3.

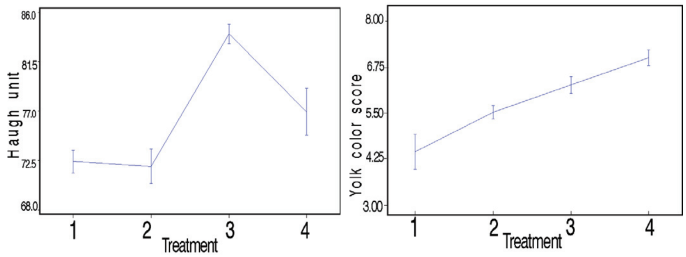

Figure 2: Effects TTLM on albumen quality left and yolk quality on the right one.

Figure 3: Measuring sample egg weight (g), albumen height (mm), yolk color score and Haugh unit (HU) by Egg multi tester (EMT-5200).

Egg production and feed conversion performance

The results regarding egg laying and feed conversion performance are indicated in Table 5. The dry matter intake, body weight change, average egg production/hen, HDEP, HHEP and feed conversion efficiency were not significant differences (P>0.05) among the layers fed a ration containing different (0-15%) levels of TTLM. However, chickens subjected at T_3 TTLM indicate a little bit higher egg production, HDEP and HHEP. There was a little bit reduced egg production when the chickens offered T_2 TTLM than the control diet due to miss behaviour development of cannibalism during experimental period.

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Table 5: Production performance at a different level of treated tagasaste leaf meal.

Parameters	Treatments				Sig	CV
	T_1	T_2	T_3	T_4		
DMI(g/ hen /d)	104.05± 4.9	102.97±3.5	104.14±4.4	102.08±5.3	NS	3.85
IBW (g/ hen)	1593.33±6.7	1613.21±22	1605.37±12.9	1612.62±2.9	NS	0.71
FBW (g/ hen)	1674.8±8.67	1691.5±23.74	1686.2±14.78	1698.7±2.2	NS	0.78
BWC (g/ hen)	81.43±4.06	78.36±7.86	80.81±10.6	86.16±4.32	NS	8.5
Average egg/hen	62.07±5.1	60.59±4.0	63.07±4.4	61.48±6.4	NS	5.50
HDEP (%)	73.98± 5.9	72.66±5.1	75.20±5.4	73.19 ±0.8	NS	5.58
HHEP (%)	73.98±5.9	72.13±4.8	75.20±5.4	73.19±0.8	NS	5.48
Egg weight (g)	60.43±0.7	60.44±1.0	59.51± 1.1	59.15±0.6	NS	1.27
FCR(g F/g E)	2.33± 0.1	2.35±0.2	2.34±0.1	2.34±0.1	NS	4.32

DMI: Dry Matter Intake; IBW: Initial Body Weight; FBW: Final Body Weight BWG: Bodyweight Change; FCR: Feed Conversion Ratio; HDEP: Hen–Day Egg Production; HHEP: Hen-Housed Egg Production; Sig: Significant (P <0.05); H: hen; NS: Not Significant (P >0.05); CV: Coefficient of Variation

Conclusion

The results of the current study revealed that most of both external and internal egg quality parameters were improved, when the layer chickens were feeding TTLM up to 15% compared to the control ration without negative impacts of egg production and feed conversion performances. Especially eggshell and yolk color were significantly improved when the level of replacing of TTLM were increased up to 15% than the control diet (0%). This implies that there is a great opportunity in utilizing TTLM as a replacing of noug seed cake in layer ration to improve egg internal and external quality where tagasaste (tree lucerne) growing areas of Ethiopia.

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