Effects of supplementation of different levels of coarse fenugreek seeds in the diet of White Leghorn hens on egg production and quality

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Abstract

The study aimed to evaluate the effects of supplementing coarsely ground fenugreek seed (CGFS) on dry matter intake, body weight gain, hen day egg production, egg weight, egg mass, feed conversion efficiency, and egg quality of White Leghorn (WL) chickens at Haramaya University poultry farm. The experiment was conducted for 12 weeks with five supplementation levels, 0 % (T1), 0.5 % (T2), 1 % (T3), 1.5 % (T4), and 2 % (T5), of coarsely ground fenugreek seed. A total of 180 layers with the age of 42 weeks were randomly distributed to five treatments each replicated three times with twelve layers and two cockerels per replicate in a completely randomized design (CRD) and kept on a deep litter system. Dry matter intake and egg production of T1 were significantly ($p < 0.001$) higher than other inclusion levels. Feed conversion efficiencies of birds fed ration T3, T4, and T5 were significantly ($p < 0.01$) higher than T2 and T1. The yolk color score was significantly ($p < 0.05$) higher in T5, T4 and T3 indicating that fenugreek increased the intensity of yellow color. Therefore, supplementation of fenugreek seed leads to lower feed intake of layers and as a result the egg production performance of chickens is decreased.

Keywords: Egg production; Egg quality; Fenugreek seed.

Introduction

The industrialization of poultry husbandry and the improvement of feed nutritional efficiency have accelerated the introduction of feed additives which became widely used in animal feed for many decades (Nisha, 2008). The current total number of chickens in Ethiopia is estimated at about 57 million, of which

78.85% are native, 9.11% exotic and 12.03% crossbred chickens (CSA, 2021). Since the banning of antibiotic growth promoters in animal production, there has been the use of some alternatives including enzymes, organic acids, probiotics, prebiotics, herbs, immune stimulants, and specific management practices. The use of herbs in animal production may relate to their wide spectrum of physiological and nutritional effects depending on the herb. These effects may include `growth-promoting, antimicrobial, and hormonal-like effects. Feed costs are the leading obstacles to modern small-scale chicken production in Ethiopia (Yitbarek, 2017). Therefore, it is necessary to look locally available nonconventional feeds with the potential to improve chicken performance (Tamasgen, 2015).

Fenugreek (*Trigonella foenum – graecum* L) is among the available non-conventional herbal plants and is used as a supplementary feed additive in chicken production in Ethiopia. Fenugreek (*T. foenum graecum*) is an annual herb belonging to the family Leguminosae (Venkata *et al.,* 2017). Gaikwad et al. (2019) reported the highest consumption rate of feed with the highest level of fenugreek seed in broiler birds. Yasin et al. (2020) also indicated that supplementation of fenugreek seed powder in broiler diets improved feed consumption, which can be due to the improvement of palatability of the feed containing fenugreek seed powder. In harmony of these above findings Qureshi et al. (2015) noted that the cumulative feed consumption was significantly improved in fenugreek seeds supplemented groups compared with the control group. Ethiopian fenugreek seed has a high proportion (26.4±0.04 %) of protein (Suleiman, 1995). Kasaye and Jha (2015) found that fenugreek flour has 7.9 % crude fat and 11.34 % crude fiber value. Thus we aimed to evaluate the effect of coarsely ground fenugreek (*T. foenum graecum*) seed supplementation on egg production and egg quality of White Leghorn layer hens.

Materials and methods

Experimental site

The experiment was conducted at Haramaya University poultry farm. The study area is located 515 km east of Addis Ababa. The annual mean rainfall of the area amounts to 790 mm and the average minimum and maximum temperatures 8 and 24 ^{o}C, respectively (Mishra *et al.,* 2004).

Ingredients and experimental rations

The feed ingredients used in the formulation of the different experimental rations of the study were maize grain, coarsely ground fenugreek (5 mm sieve size), wheat short, noug seed cake, soybean meal, layer premix, salt, di-calcium phosphate, and limestone. Fenugreek seed (Chala variety) was purchased from the local market. The seed was thinly spread on a plastic sheet and sun-dried for 24 h, then foreign matters were cleaned by hand picking, after which it was coarsely ground at the feed mill of Haramaya University. Samples of fenugreek seed, maize, soybean meal, groundnut cake, noug seed cake, wheat short, and bone and meat meal were taken for chemical analysis (Table 1). Samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), ash, calcium, and phosphorous following the proximate method of analysis (AOAC, 2000). Calcium and phosphorous content of coarsely ground fenugreek seed were analyzed by flame atomic absorption spectrometry. Based on the chemical analysis results five treatment diets containing coarsely ground fenugreek at levels of 0 % (T1), 0.5 % (T2), 1 % (T3), 1.5 % (T4), and 2 % (T5) were formulated (Table 2). The four treatment rations used in this study were formulated to be isocaloric and equiprotein with 2800-2900 kcal ME/kg DM and 16-17 % CP to meet the nutrient requirement of layers (NRC, 1994).

Table 1. Chemical composition of feed ingredients used to formulate experimental ration (DM%, others as %DM).

Chemical components	Ingredients						
	Maize	CGFS	Wheat short	NSC	SBM	GNC	BMM
DM	91	90.9	90.7	93	94	92.1	94.0
CP	8.1	31.8	15.1	31	38	41.0	50.2
EE	5.5	6.6	4.3	5.1	8.4	7.9	18.5
ASH	4.2	4.7	4.8	7.8	5.4	9	21.4
CF	4.9	11.8	6.9	17.9	7.3	12.8	2.4
NFE	68.3	36	59.6	31.2	34.9	21.4	1.5
P	0.02	0.29	0.85	0.2	0.3	0.18	5.1
Ca	0.32	0.17	0.2	0.3	0.7	0.84	10.3
ME kcal/kgDM	3644.2	3071.62	3377	2322.4	3540.13	2878.2	3871.4

CGFS: coarsely ground fenugreek seed; NSC: noug seed cake; SBM: soya bean meal; WS: wheat short; GNC: groundnut cake; BMM: bone and meat meal

Table 2. Proportion of ingredients used in formulating the experimental rations.

Ingredients %	Treatments				
	T1	T2	T3	T4	T5
Maize grain	48	48	48	48	48
Fenugreek seed	0	0.5	1	1.5	2
Wheat short	7	7	7	7	7
Noug seed cake	18	18	18	18	18
Soya bean meal	11	11	11	11	11
Groundnut cake	6	6	6	6	6
Bone and meat meal	2	2	2	2	2
Layer premix	0.5	0.5	0.5	0.5	0.5
Lysine	0.02	0.02	0.02	0.02	0.02
Methionine	0.01	0.01	0.01	0.01	0.01
Dicalcium phosphate	1	1	1	1	1
Salt	0.5	0.5	0.5	0.5	0.5
Limestone	6	6	6	6	6
Total	100	100	100	100	100
Chemical composition					
Dry matter (%)	91.86	91.83	91.52	91.31	91.48
Ether extract (%DM)	5.89	5.61	5.60	5.56	5.57
Ash (%DM)	11.88	10.53	9.98	10.28	9.46
Crude fiber (%DM)	7.35	7.42	7.5	7.54	7.56
Phosphorous (%DM)	0.49	0.42	0.43	0.44	0.43
Calcium (%DM)	3.14	3.13	2.95	2.94	2.94
CP (%DM)	16.37	16.98	16.92	16.81	16.89
ME (Kcal/kg DM)	2731.41	2738.56	2728.28	2718.82	2770.63

Experimental birds and management

A deep litter-type poultry experiment house of Haramaya University poultry farm was used for the experiment. The fifteen pens of the experiment house were properly cleaned and disinfected ten days before the placement of the experimental chickens. The watering and feeding equipment were thoroughly cleaned in advance before the birds were placed in the experimental pens. One hundred eighty 42 weeks old White Leghorn layers were randomly allocated to five dietary treatments each having three replicates containing 12 layers per replicate and 36 layers per treatment in a CRD design. Birds were acclimatized to experimental diets for one week before the start of data collection.

Measurement and observations

Feed intake

Feed intake was determined as a difference between the quantity of feed offered and left over which was collected in the morning of the following day (Lee *et al.,* 2016).

Mean daily feed intake = (Total feed offered- Total leftover)/(Duration of experiment × No.of birds)

Egg production

Eggs were collected four times per day, i.e. at 8:30 AM, 11:30 AM, 2:00 PM, and 4:30 PM. The sum of the four collections was recorded as daily egg production. The rate of lay for each replicate was expressed as an average percentage of hen-housed and hen-day egg production, and the replicate means were used to analyze treatment means (Hunton, 1995).

Hen-housed egg production %= (The sum of daily egg counts)/(Number of the hens originally housed×No.of birds) ×100

Hen-day egg production %= (Number of eggs collected per day)/(Number of hens present that day) ×100

Egg quality parameters

For external and internal quality, nine eggs from each experimental group (three eggs per replicate) were randomly picked and weighed every two weeks throughout the experimental period. The weighed eggs were broken to measure shell thickness, shell weight, yolk diameter, yolk index, yolk color, yolk weight, yolk height, albumen weight, and albumen height.

Egg weight and egg mass

Every afternoon, at 5:30 PM collected eggs for each replicate were weighed and the average egg weight was computed by dividing the total weight by the egg number. The daily egg mass was computed by multiplying the average egg weight with the percent hen-day egg production for each replicate, EM = P*W, where EM = Average egg mass, P = hen-day egg production, and W = average egg weight.

Eggshell weight and thickness

The sample eggs were broken and the shell was separated. The weight of the shell was measured by using electronic digital sensitive balance with accuracy of 0.01 g. The shell was further broken into smaller pieces and the shell membrane was manually removed and the thickness was measured using a micrometer gauge. The shell thickness was taken from the three sites; sharp, blunt, and at the equator. Then the average values of these three sites were taken for each egg.

Albumen quality

Albumen quality was evaluated by calculating Haugh unit (HU), using egg weight (g) and albumen height (mm) data. The albumin height of each sample egg was measured with a tripod micrometer (baxlo haugh digital micrometer). Haugh unit was determined according to the formula suggested by Haugh (1937) as follows: $HU = 100 \log (H + 7.57 - 1.7W^{0.37})$, where HU = Haugh unit, H = Albumen height (mm), and W= egg weight (g).

Albumen weight was calculated as the difference between the weight of the whole egg, and the sum of the weight of the yolk and eggshell. The proportion of the albumen to egg weight was calculated by using the following formula:

$$\text{Albumen percentage} = \text{(Albumen weight (g))/(Weight of whole egg (g))} \times 100$$

Yolk quality

The quality of the yolk was determined by taking the weight, diameter, height, and color. Yolk weight was determined by using electronic digital sensitive balance with accuracy of 0.01 g. Yolk diameter was measured by manual analog caliper measuring tools. The yolk height of the broken egg was measured after removing it from the albumen, using a tripod micrometer, and recorded to the nearest 0.1 mm. To measure yolk color, first yolk membrane was removed, the yolk was mixed and the sample was taken on pieces of white paper and compared with Roche color fan strips, which have 1-15 strips, ranging from pale to orange-yellow.

Yolk quality was expressed also in terms of the yolk index. It was determined as the ratio between yolk height and diameter according to the formula: YI = YH/YD, where YI = yolk index, YH = yolk height (mm), and YD = yolk diameter (mm). The percentage of yolk to egg weight was determined by the following formula:
Percentage of yolk = (Yolk weight (g))/(Weight of whole egg (g)) ×100

Statistical analysis

Data on feed intake, egg production and egg quality were subjected to statistical analysis using SAS version 9.1. (2008) with one-way ANOVA. When the analysis of variance reveals significant differences between treatment means, the least significance difference (LSD) method was used to show the treatment means that were significantly different from each other (Gomez and Gomez, 1984). The following model was used for the analysis,

Yij = µ +Ti +eij, Where: Yij = the j observation taken under i treatment, µ = over all mean, Ti = i treatment effect, eij = error term

Logistic regression analysis was used for data recorded on yolk color,

$\text{Ln} \{ \pi/(1-\pi)\} = \beta_0 + \beta_1 * (X)$

Test H_0: No treatment effect (i.e., $\beta_1 = 0$) vs. H_A: significant treatment effect ($\beta_1 \neq 0$)

Where: β = slope, X = treatment and π = probability.

Results

The results on egg production, feed intake, egg weight, egg mass and feed conversion efficiency are presented in Table 3. Hen day egg production, egg mass and feed conversion efficiency of layers fed the control diet were significantly higher ($p < 0.05$) than those fed the coarsely ground fenugreek seed (CGFS)-supplemented diet. Dry matter intake of birds fed T2, T3, T4, and T5 was significantly ($p < 0.001$) lower than birds fed the control diet.

Table 3. Effect of CGFS on dry matter intake and performance of layers.

Parameter	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
DMI (g/h/d)	102.09[a]	97.45[b]	92.15[c]	91.62[c]	91.88[c]	0.589	***
Total eggs produced	604[a]	566[b]	559[b]	558[b]	556[b]	6.446	**
Total egg per hen	50.35[a]	47.2[b]	46.66[b]	46.54[b]	46.34[b]	0.537	**
HDEP %	55.95[a]	52.44[b]	51.72[b]	51.85[b]	51.50[b]	0.597	**
Egg weight (g)	51.55[c]	52.41[bc]	53.34[ab]	53.45[a]	53.34[ab]	0.308	**
Egg mass (g/hen/day)	28.84[a]	27.59[b]	27.48[b]	27.71[b]	27.47[b]	0.308	*
FCE	0.28[b]	0.28[b]	0.29[a]	0.30[a]	0.29[a]	0.003	**
PER	1.72[b]	1.67[c]	1.76[ab]	1.80[ab]	1.77[a]	0.017	**
EER	10.34[b]	10.34[b]	10.93[a]	11.12[a]	10.79[a]	0.109	**

[a,b,c]: means within a row with different superscripts are significantly different; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; ns: not significant; DMI: dry matter intake; IBW: initial body weight; FBW: final body weight; BWG: body weight gain; HDEP: hen day egg production; FCE: feed conversion efficiency; PER: protein efficiency ratio; EER: energy efficiency ratio.

Result of yolk color logistic regression analysis and yolk color points of egg samples are given in Table 4 and 5, respectively. Logistic regression analysis for yolk color showed a significant difference (pr > chisq <0.0001 at α <0.05) with a Wald chi Sq value of 23.72 among the treatments. Roche color fan reading recorded during the experiment ranges from 1 (pale yellow) to 8, with 61.85% of the eggs having 4 and 5 values on the yolk color point.

Table 4. Effect of supplementing CGFS on logistic regression of yolk color of layers.

		Wald	
Parameter	**DF**	**Chi-square**	**Prob.>chisq**
Yolk color	4	23.7161	<0.0001

Table 5. Effect of supplementing CGFS on yolk color points of egg samples of layers.

Treatments	Roche color fun number								
	1	2	3	4	5	6	7	8	Total
T1		5	15	17	13	3	1		54
T2		6	13	16	13	3	2	1	54
T3		2	7	22	17	4	2		54
T4	1	1	5	21	19	6	1		54
T5		1	6	12	17	12	4	2	54
Total	1	15	46	88	79	28	10	3	270

T1: 0% CGFS (control), ration with no CGFS; T2: ration with 0.5% CGFS; T3: ration with 1% CGFS; T4: ration with 1.5% CGFS; T5: ration with 2% CGFS; CGFS: coarsely ground fenugreek seeds.

The effect of supplemental CGFS on albumen weight, yolk weight, shell weight, yolk height, yolk diameter, yolk index, albumen height, Haugh unit and eggshell thickness of laying hens has been shown in Table 6. The data indicate these parameters were not significantly affected by supplementation of CGFS to the diets ($p > 0.05$).

Table 6. Effect of supplementing CGFS on Egg quality parameters of layers.

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Yolk color	3.83[c]	4.08[bc]	4.37[b]	4.44[b]	4.98[a]	0.123	***
Albumen weight	29.91	30.71	30.86	31.40	32.11	0.503	Ns
Albumen %	57.29	57.10	57.46	57.67	59.27	0.569	Ns
Yolk weight	15.72	15.87	16.04	15.83	16.31	0.213	Ns
Yolk %	28.81	29.36	29.40	29.09	29.40	0.388	Ns
Shell weight	6.04	5.98	5.99	6.13	6.27	0.122	Ns
Shell %	11.23	11.26	11.27	11.03	11.09	0.154	Ns
Albumen height	8.23	8.31	8.23	7.87	8.31	0.302	Ns
Yolk height	15.27	15.59	15.47	15.59	15.38	0.075	Ns
Yolk diameter	3.66	3.70	3.74	3.72	3.69	0.024	Ns
Yolk index	0.42	0.42	0.41	0.42	0.42	0.004	Ns
Shell thickness	0.32	0.32	0.31	0.31	0.32	0.004	Ns
Haugh unit	93.01	93.17	92.57	90.61	92.59	1.506	Ns

[a,b,c]: means within a row with different superscripts are significantly different; **: $p < 0.01$, ***: $p < 0.001$; Ns: not significant; T1: no CGFS; T2: 0.5% CGFS; T3: 1% CGFS, 1.5% CGFS, 2% CGFS; CGFS: coarsely ground fenugreek seed.

Discussion

Dry matter intake (DMI) of birds fed T2, T3, T4, and T5 was significantly decreased than birds fed the control diet. In contrast, El-Kaiaty *et al.* (2002) reported that inclusion of 0.50 % fenugreek in the diet of laying hens had no significant effect on feed consumption compared to the control group. The experiment detected a significant difference ($p < 0.05$) in egg weight among laying hens fed the different diets. Birds fed on T3, T4, and T5 laid significantly heavier eggs than birds consumed T2 and the control diet. The increase in egg weight for fenugreek seed treated groups might be due to the linoleic acid content of fenugreek seed. Egg weight was increased when linoleic acid content of the diet increased from 0.79% to 1.03% (Grobas *et al*., 1999). Similarly, fenugreek seed powder supplementation at the level of 0.9 %, 2.7 % and 3.6 % was proven to bring considerable improvement in egg weight (Tesissa *et al.,* 2023). The egg mass of layers fed the control diet was significantly higher than that of layers fed the CGFS-supplemented diet. The improvement in egg mass in layers fed the control diet is attributed to the higher hen day egg production. On the contrary, Samani *et al.* (2020) reported inclusion of fenugreek power at 1 % and 2 % levels didn't have significant effect on egg mass of Leghorn laying hens. The improvement in egg mass in layers fed the control diet is attributed to the higher hen day egg production. Birds fed on control diet had significantly ($p < 0.01$) lower feed conversion efficiency than T3, T4 and T5. Similarly, feed conversion efficiency of Leghorn layers increased at 2 % supplementation of fenugreek powder (Samani *et al.,* 2020). Additionally, Paneru *et al.* (2022) reported that supplementation of fenugreek seed powder to broiler chicken diets significantly ($p < 0.001$) increased feed conversion efficiency.

Supplementation of layers' diet with CGFS had no significant effect on egg quality except egg yolk color. Egg yolk color is one of the important egg quality characteristics and can affect egg marketing. A significant increase in egg yolk color may be associated with the presence of carotenoids such as beta-carotene in fenugreek powder, which can be deposited in egg yolk (Pant *et al.,* 2018). This result is in line with Samani *et al.* (2020) who reported 1 % inclusion of fenugreek powder significantly increased yolk color. In harmony with Omri et al. (2017) the present study showed that shell weights were not affected by diet with fenugreek. In line with this result Tesissa *et al.* (2023) reported supplementation of fenugreek seed powder with the level of 0.9 %, 2.7 % and 3.6 % in the ration of Lohmann Brown layers did not have significant effect on eggshell thickness. However, contrary to our finding, Park *et al.* (2018) reported that supplementation of fenugreek seed on Hy line-brown laying hens significantly ($p < 0.05$) increased eggshell thickness compared with the control group.

Results of the present study were not in agreement with the findings of El-Kaiaty *et al*. (2002) who reported that fenugreek had a significant effect on yolk and albumen weights. On the other hand, Wahab *et al.* (2019) reported that supplementation of fenugreek seed at the level of 0.5 %, 0.75 % and 1 % on the diets of Rhode Island Red spent layers did not present any significant influence on albumin height and Haugh unit. In another study, contrary to our observation, albumen weight was observed to be greater in the control group than the 1 % fenugreek supplementation group (Criste et al., 2015). Moustafa (2006) has also detected a numerical increase in yolk index and shell thickness, and a significant decrease in Haugh units when white laying hens were fed diets supplemented with 0.15 % fenugreek. .

Conclusions

Supplementation of fenugreek seed in the diet of laying hens results in a noticeable reduction in their feed intake. This decrease in the amount of feed consumed has a direct negative impact on the egg production performance of the chickens. Consequently, the incorporation of fenugreek seed into the treatment rations led to a significant decline in the overall productivity of the hens in terms of egg output. As a result of this decreased productivity, the economic returns from using rations that include fenugreek seed are lower compared to those obtained from using the control ration, which does not contain fenugreek seed. This reduction in net return is attributable to the diminished egg production, which is a critical factor in the profitability of poultry farming.

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Author contribution statement

Methodology, investigation, conceptualisation, writing review and editing, Mengie Ahmed, Negassi Amha and Mengistu Urge; Software and Formal analysis, Nurlign Mohammed; Data curation, Mengie Ahmed and Nurlign Mohammed; Visualization and supervision, Negassi Amha and Mengistu Urge.

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Conflict of interest

The authors declared no conflict of interest.

Ethics

This article is original and has never been published before. The author has also confirmed to all authors involved in this study to read and agree to the contents of this article and that there are no ethical issues involved.

References

AOAC, 2000. Association of Official Analytical Chemists. Official Methods of Analysis. Vol. II, 17th Edition, AOAC, Washington DC.

Criste, R.D., Panaite, T., Bercaru, A., Varzaru, I., Ropota, M. and Cornescu, G.M., 2013. Study on the use of fenugreek in laying hens diets on egg quality. In: 19th European Symposium on Poultry Nutrition, Potsdam, Germany.

El-Kaiaty, A.M., Soliman, A.Z. and Hassan, M.S.H., 2002. The physiological and immunological effects of some natural feed additives in layer hen diets. *Egypt Poult. Sci.*, 22, 175-183.

Gaikwad, B.S., Patil, R.A., Padghan, P.V. and Shinde, S.S., 2019. Effect of fenugreek (Trigonella foenum-gracum L.) seed powder as natural feed additive on growth performance of broilers. Int. J. Curr. Microbiol. App. Sci., 8(10), 1137-1146.

Gomez, K.A. and Gomez, A.A., 1984. Statistical Procedures for Agricultural Research. 2nd edition. John Willey and Sons, New York.

Grobas, S., Mateos, G.G. and Mendez, J., 1999. Influence of dietary linoleic acid on production and weight of eggs and egg components in young brown hens. *J. Appl. Poult. Res.*, 8(2), 177-184.

Hassan, H.A. and Ragab, M.S., 2007. Effects of using black seeds on egg production, egg quality and immune response in laying diets varying in their protein content. *Fayoum J. Agric. Res. Dev.*, 21(2), 206-224.

Haugh, R.R., 1937. The Haugh unit for measuring egg quality. United States Egg Poultry Magazine. 43: 552- 555.

Hunton, P., 1995. Egg production, Processing and Marketing. World Poultry Science, Elsevier, Tokyo, pp.457-480.

Kasaye, A.T. and Jha, Y.K., 2015. Evaluation of composite blends of fermented fenugreek and wheat flour to assess its suitability for bread and biscuit. *Int. J. Nutr. Food Sci.*, 4(1), 29-35.

Lee, S.A., Kong, C., Adeola, O. and Kim, B.G., 2016. Different coefficients and exponents for metabolic body weight in a model to estimate individual feed intake for growing-finishing pigs. *Asian-Australas. J. Anim. Sci.*, 29(12), 1756-1760.

Mishira, B.B., Kidan, H.G., Kibret, K., Assen, M. and Eshetu, B., 2004. Soil and land resources inventory at Alemaya Universiry research farm with reference to land evaluation for sustainable agricultural management and production. Synthesis of Working Papers, Soil Sciences. *Alemaya University Bulletin*, 1, 123.

Moustafa, K.E.M.E., 2006. Effect of using commercial and natural growth promoters on the performance of commercial laying hens. *Egypt. Poult. Sci. J.*, 26(3), 941-965.

Nisha, A.R., 2008. Antibiotic residues- a global health hazard. *Vet. World*, 1(12), 375-377.

NRC (National Research Council). 1994. Nutrient Requirement of Poultry 9th Edition. National Academy of Sciences. Washington DC, USA.

Omri, B., Chalghoumi, R. and Abdouli, H., 2017. Study of the effects of dietary supplementation of linseeds, fenugreek seeds and tomato-pepper mix on laying hen's performances, egg yolk lipids and antioxidants profiles and lipid oxidation status. *J. Anim. Sci. Livest. Prod.*, 1(2), 008.

Paneru, D., Tellez-Isaias, G., Romano, N., Lohakare, G., Bottje, W.G. and Lohakare, J., 2022. Effect of graded levels of fenugreek (*Trigonella foenum-graecum* L.) seeds on the growth performance, hematological parameters, and intestinal histomorphology of broiler chickens. *Vet. Sci.*, 9(5), 207.

Pant, N.C., Tewari, M., Dhoundiyal, R., Pandey, C.S., Singh, J.P. and Agrawal, S., 2018. Evaluation of micronutrients in fenugreek (*Trigonella foenum-graecum* L.): a viable alternative for micronutrient supplementation. *Int. J. Curr. Microbiol. Appl. Sci.*, 7, 2446-2464.

Park, J.H., Kim, Y.M. and Kim, I.H., 2018. Egg production, egg quality, blood profiles, cecal microflora, and excreta noxious gas emission in laying hens fed with fenugreek (*Trigonella foenum-graecum* L.) seed extract. *J. Poult. Sci.*, 55(1), 47-53.

Qureshi, S., Banday, M.T., Adil, S., Shakeel, I. and Munshi, Z.H., 2015. Effect of dandelion leaves and fenugreek seeds with or without enzyme addition on performance and blood biochemistry of broiler chicken and evaluation of their in vitro antibacterial activity. *Indian J. Anim. Sci.*, 85(11), 1248-1254.

Samani, S.K., Ghorbani, M.R., Fayazi, J. and Salari, S., 2020. The effect of different levels of Fenugreek (*Trigonella foenum-graecum* L.) powder and extract on performance, egg quality, blood parameters and immune responses of laying hens in second production cycle. *Vet. Res. Forum*, 11(1), 53-57.

Suleiman, A.M, EL.H. 1995. Fenugreek Supplementation Backet Products Quality Aspect MscFood Science and Technology of G U.

Tamasgen, N., 2015. The effect of feeding graded level of dried cafeteria food leftover on egg production and quality of White Leghorn chickens. *J. Nat. Sci. Res.*, 5(7), 93-104.

Tesissa, E., Tamiru, M., Tadese, D.A., Demeke, S., Ababor, S., Asres, A., *et al.*, 2023. Evaluation of fenugreek (*Trigonella foenum graecum*) seed powder and *Moringa oleifera* leaf meal on production performance and egg quality of laying hens. doi: 10.20944/preprints202305.1289.v1

Venkata, K.C.N., Swaroop, A., Bagchi, D. and Bishayee, A., 2017. A small plant with big benefits: Fenugreek (*Trigonella foenum-graecum* Linn.) for disease prevention and health promotion. *Mol. Nutr. Food Res.*, 61(6), 1600950.

Wahab, F., Chand, N., Khan, R.U., Ahmad, N., Pervez, U. and Zia-Ur-Rehman, N.S., 2019. Dietary supplementation of fenugreek (*Trigonella foenum graecum*) on the egg quality characteristics of Rhode Island Red spent layers. *Pak. J. Zool.*, 51, 1793-1797.

Yassin, M., Nurfeta, A. and Banerjee, S., 2020. The effect of supplementing fenugreek (*Trigonella foenum-graecum* L.) seed powder on growth performance, carcass characteristics and meat quality of Cobb 500 broilers reared on conventional ration. *Ethiop. J. Agric. Sci.*, 30(3), 129-142.

Yitbarek, M.B., 2017. Management Practices and Constraints of Small-Scale Commercial Poultry Farms, and Performance Evaluation of Broilers Fed Diets Containing Graded Levels of Dried Blood-Rumen Content Mixture. PhD Dissertation, Addis Ababa University, College of Veterinary Medicine and Agriculture, Bishoftu, Ethiopia.

Żuk-Gołaszewska, K. and Wierzbowska, J., 2017. Fenugreek: productivity, nutritional value and uses. *J. Elem.*, 22(3), 1067-1080.