Hassan, H. A. and Ragab, M. S. (2007). The productive performance and egg quality of laying hens under the effect of dietary fenugreek seeds (ungerminated and germinated) and different dietary protein levels. ***Annals of Agric. Sci., Moshtoher, 45: 1395-1406*.**

The productive performance and egg quality of laying hens under the effect of dietary fenugreek seeds (ungerminated and germinated) and different dietary protein levels

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Abstract: This experiment was conducted to study the effects of fenugreek (germinated and ungerminated) and dietary protein on the productive performance ,egg quality and economical efficiency of laying hens. A total number of 180 Hy- Line W- 36 laying hens 49 weeks old were distributed randomly into fifteen equal groups each group contain 12 hens, one hen / replicate. The experiment was designed as factorial arrangement, three levels of crude protein (CP: 14.75,13.25,and 11.75%) x five levels of fenugreek (0.0, 1.0% ungerminated, 2.0% ungerminated, 1.0% germinated, 2.0% germinated) The results obtained could be summarized as follows:

The group fed diet contains 14.75 %CP+ 1% germinated fenugreek seeds had the highest values of egg production (EP%) and egg mass (EM), best values of feed conversion (FC) and caloric conversion ratio (CCR) and the group fed diet contains 13.25 %CP+ 1% ungerminated fenugreek seeds had the best value of crude protein conversion (CPC). However, the lowest values of EP% and EM were for the group fed 11.75%+ 2% ungerminated fenugreek seeds, and the worst values of FC, CPC and CCR were for the group fed 11.75%+ 1% germinated fenugreek seeds. The highest value of yolk % was found with the group fed 14.75 % + 2% ungerminated fenugreek. However, the group fed 13.25 %CP+ 0.0 fenugreek had the highest value of yolk color, but the highest values of

Yolk index (YI) % and Haugh unit (HU) were for the group fed 11.75 % CP +2.0% germinated fenugreek.

The group which fed diet contains 14.75% CP level had significantly higher EP%, EM, egg weight (EW), feed intake (FI) and, it had better FC and CCR than the other groups. The 13.25 % CP level had the highest values of yolk color and the 11.75% CP level had the highest YI or HU

No significant differences were found in EP%, EM, EW, FI, FC, CPC , CCR and LBWC amonge the goups which fed diets contain the fenugreek (ungerminated or germinated) compared with the control. All levels of fenugreek caused high significant increase in the YI values compared to the control. Also, the group of 2% ungerminated fenugreek had the highest value of HU. Using germinated fenugreek seeds at 1% level in the diet of layers that contains the CP% requirements improved the economical efficiency and relative economical efficiency of laying hens compared with the others

It could be concluded that adding 1.0 % germinated fenugreek seeds as natural feed additive in diets of laying hens which contain the recommended CP level by strain catalog (14.75%) improved economically egg production without adverse effect on egg quality.

Key words: (Layers, , productive performance, egg quality fenugreek (ungerminated and germinated) dietary protein)

INTRODUCTION

Fenugreek (*Trigonella foenum graecum*) is an annual herb belonging to the family Leguminosea (**Alarcon-Aguilara *et al.*, 1998)**, widely grown in Mediterranean region, Indian,

and China. It has a high proportion of protein (approximately 20%-30%), the fatty acids ranged from 5-10% which are predominantly linoleic, linolenic, oleic and palmitic acids. It had 45-65 % total carbohydrates with 15 % of galactomannan (a soluble fiber). Also, it contains flavonoids, saponins and more calcium, phosphorous, iron, zinc and manganese (**Schryver, 2002**). It contains amino acid (4-hydroxyisoleucine) which has been shown to stimulate insulin secretion and improve glucose tolerance in normal and diabetic animals as the result of direct ß- cell stimulation (**Broca *et al.*, 1999 and 2000 ; Sauvaire *et al.*, 1998 and Schryver, 2002)**. Saponins components are considered as an appetizer and helps in digestion. Fenugreek contains phytoestrogens which are of great interest because of their estrogenic (**Mazur *et al.*, 1998**). Also, it have been recognized as a potential source of diosgenin, a basic compound in the hemisynthesis of steroidal sapogenins such as cortison and sex hormones (**Brenac and Sauvaire, 1996 a and b**)

Germinated fenugreek seeds had significantly higher content of total protein (29%) and lysine compared to ungerminated seeds. Germination decreased fiber and starch thereby raising the level of sugars. In vitro starch and protein digestibility and availability of Ca, Fe and Zn were also increased appreciably due to reduction in antinutrient contents (phytic acid and polyphenols) after 48 h germination (**Shalini and Sudesh, 2003)**.

Using alternatives to antibiotic growth promotants in commercial chickens have become important mainly because of apprehensions about the possible development of resistant bacteria. At the same time, continuous use of antibiotic growth promotants in breeders may have one important ramification

that could affect the poultry industry, (**Shashidhara and Devegowda, 2003**).

Dietary protein content has a much consideration due to its high cost and its great effect on the production parameters of laying hens. Lowering the CP of the laying hens diets not only reduce nitrogen consumption but also means that less unutilized nitrogen is excreted. The response by the laying hens to dietary protein levels has been controversial for many years. **Fernandez, *et al*. (1973)** reported that increasing dietary protein level lead to an increase in egg production %. Also, average egg weight of layers increased as dietary protein level increased (**Summers, 1993**). Moreover, **Calderon and Jensen (1990)** observed an improvement in FC due to high dietary protein level. However, **Angelovicova (1994**) found that a low-protein diet containing 14.1 % CP reduced average daily FI and improved FC. **Glick, *et al*. (1983**) showed that diet deficient in protein (33% of requirement) could reduce numbers of lymphocytes in the thymus of chickens. However, the responses were varied by strain, dietary protein (**Cheema *et al*., 2003)** environment, stress, production state and health status. The present experiment aimed to effects of fenugreek seeds (ungerminated and germinated) and dietary protein on the productive performance and egg quality of laying hens.

MATERIALS AND METHODS

The experimental work of the present study was carried out at the Poultry Research Station, Poultry Department, Faculty of Agriculture, Fayoum University from April to July 2003. to study effects of fenugreek (germinated and ungerminated) and dietary protein on the productive performance ,egg quality and economical efficiency of laying hens. A total number of

180 Hy- Line W- 36 laying hens, 49 weeks old were distributed randomly into fifteen equal groups each group containing 12 hens, one hen / replicate. The experiment was designed as factorial arrangement, three levels of crude protein (CP: 14.75, 13.25, and 11.75%) x five levels of fenugreek (0.0, 1.0% ungerminated, 2.0% ungerminated, 1.0% germinated, 2.0% germinated).The basal diets were formulated to satisfy nutrient requirements of laying hens according to the strain catalog recommendations (14.75 CP % and 2770 ME K cal / Kg). The composition and chemical analysis of the experimental diets are shown in Table (1). The fenugreek was purchased from the local market and germinated to 48 h and was spread on clean floor for sun drying. Artificial light was used beside the normal day light to provide 16-hour day photoperiod. Feed and water were provided *ad libitum*. Individual body weights were recorded at the beginning and the end (61 weeks of age) of the experiment to calculate live body weight changes (LBWG). Egg number (EN) and egg weight (EW) were recorded daily to calculate egg production % (EP% = EN*100/84 day) and egg mass (EM= EN* EW). Feed intake (FI) was recorded weekly and used to calculate feed conversion (FC= FI/ EM), crude protein conversion (CPC= FI* CP%/ EM) and caloric conversion ratio (CCR= FI* ME K cal / EM).

Egg quality measurements were determined monthly on eggs of the last three days. Twelve eggs / group were collected monthly throughout the experimental period to determine egg shape index % (SI, **Carter, 1968**), shell thickness (ST) including shell membranes was measured using a micrometer at three locations on the egg (air cell, equator and sharp end), the percentage of shell , albumen and yolk were calculated. Yolk color (YC) was determined by matching the yolk with

one of the 15 bands of the "1961- Roche improved yolk color fan. Yolk index (YI) % was calculated according to **Well, (1968**), Haugh unit score (HU) was applied from a special chart using egg weight and albumen height which was measured by using a micrometer according to **Haugh (1937).**

Economical efficiency of egg production was calculated from the input-output analysis which was calculated according to the price of the experimental diets and eggs produced. These values were calculated as the net revenue per unit of total cost.

Analysis of variance was computed using the general linear model (GLM) procedure of statistical analysis system according to **SPSS (1999**). Significant differences among means were evaluated using Duncan's multiple range test (**Duncan, 1955**).

RESULTS AND DISCUSSION

Productive performance of laying hens

Results presented in Table (2) showed that except for EW, FI, and LBWG there were significant treatment interaction effects on each of EP%, EM, , FC, CPC and CCR. The group fed diet contains 14.75 %CP+ 1% germinated fenugreek seeds had the highest values of EP% and EM, best values of FC and CCR and the group fed diet contains 13.25 %CP+ 1% ungerminated fenugreek seeds had the best value of CPC compared to the other droups. **Shalini and Sudesh (2003)** found that, In vitro starch and protein digestibility and availability of Ca, Fe and Zn were increased appreciably due to reduction in antinutrient contents (phytic acid and polyphenols) after 48 h germination of fenugreek. whereas, the lowest values of EP% and EM were of the group fed 11.75%+

2% ungerminated fenugreek seeds, and the poorest values of FC, CPC and CCR were of the group fed 11.75%+ 1% germinated fenugreek seeds and this may be due to decreasing the level of CP%.

Regardless of the fenugreek levels, CP% levels significantly ($P<0.01$and $P<0.05$) affected EP%, EM, EW, FI, FC, CPC and CCR values. The group fed diet contains 14.75% CP level had significantly higher EP%, EM, EW, FI values and better FC, and CCR than the other groups . However, it not differ in CPC with the group of 13.25% CP. Morever, no significant effects were found due to dietary protein level on the LBWC of laying hens. however, decreasing the level of protein improved CCR. Similar trends were found by **Bunchasak *et al*. (2005)** that high CP of 16 and 18 % tend to have better EP% and EM than the lower level of 14 % CP. However, **Hammershoj and Kjaer (1999)** reported that different levels of dietary protein did not affect EP%. On the other hand, **Harms and Russell (1995)** concluded that the 10.95% CP satisfied the requirements needed for egg production , egg mass and egg content.

Regardless the level of CP, no significant differences were found in EP%, EM, EW, FI, FC, CPC , CCR and LBWG amonge the goups which fed diets contain the fenugreek (ungerminated or germinated) compared with the control except the group fed 2 % ungerminated fenugreek seeds which had the lowest EP% and worst CPC. Similarly, **El –Kaiaty *et al.*,2002;Tollba *et al.*,2005 and Abaza, 2007** found that adding fenugreek in the diet from 0.5 up to 2% had no effects on egg production, egg weight and egg mass. **El –Kaiaty *et al.*(2002)** and **Moustafa (2006**) reported that fenugreek supplementation at the level of 0.5% had no significant effect

on feed consumption compared to the control group, however, **Abaza (2007)** indicated that the same level (0.5%) caused significant decrease in feed consumption and improved the feed conversion of laying hens. Also, **EL-Mallah *et al.*(2005)** noted that increasing the level of fenugreek seeds to 2% in diet of turkey chicks caused significant increase in digestibility of NFE% and this may be due to saponin content in fenugreek seeds that stimulate insulin activity.

Egg quality

Results presented in Table (3) showed that there were significant treatment interaction (CP % + tow types of fenugreek) effects on yolk %, yolk color, YI, and HU. The highest value of yolk % was found for the fed group 14.75 % CP + 2% ungerminated fenugreek and the lowest value was found for the group fed 13.25 % + 2% ungerminated fenugreek. However, the group fed 13.25 %CP+ 0.0 ungerminated fenugreek had the highest value of yolk color and the group fed 14.75 %CP + 1.0% ungerminated fenugreek had the lowest value. But the highest values of YI and HU were recorded witl the group fed 11.75 % CP +2.0% germinated fenugreek .

Regardless of the fenugreek levels effect , the CP% significant effect on yolk color, YI, and HU values . The 13.25 % CP had the highest value of yolk color and the 11.75% CP had the highest YI and HU as shown in Table (3). However, **Hammershoj and Kjaer (1999**) reported that increasing dietary protein decreased albumen quality traits and egg shell %.

Regardless of the CP%, using fenugreek in diets of laying hens had significant effects on yolk color, YI, and HU. No significant difference was found in yolk color between the groups fed diets contain 1% germinated fenugreek and those fed the control diet, while the other groups recorded lower values compared with the control. All levels of fenugreek caused high significant increase in YI values compared to the control. Also, the group of 2% ungerminated fenugreek had the highest value of HU. However, **Abaza (2007)** found that hens fed diet supplemented with 0.5% fenugreek had numerically highest values of shell thickness and albumen %.

Economical efficiency

Using 1% germinated fenugreek seeds in diets of laying hens the CP % requirements improved the economical efficiency and relative economical efficiency of laying hens compared with the other treatments as shown in Table (4). Also, **Moustafa (2006)** and **Abaza (2007)** observed that economic evaluation for egg production was improved by the addition of 0.5% fenugreek seeds to layers diets

It could be concluded that adding 1.0 % germinated fenugreek seeds as natural feed additive in diets of laying hens which contain the recommended level of CP (14.75%) by strain catalog improved economically egg production without adverse effects on egg quality follwed by the diet contains the recommended levels CP (14.75%) without feed additive .

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الأداء الإنتاجي وجودة البيضة للدجاج البياض تحت تأثير بذور الحلبة

(الغير مستنبتة و المستنبتة) و المستويات المختلفة لبروتين العليقة

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أجريت هذه التجربة لدراسة الأداء الإنتاجي وجودة البيضة للدجاج البياض تحت تأثير بذور الحلبة (الغير مستنبتة و المستنبتة) و المستويات المختلفة لبروتين العليقة وصممت

التجربة كتوزيع عاملي، ثلاث مستويات من البروتين الخام (١٤,٧٥، ١٣,٢٥، ١١,٧٥%) x خمس مستويات من الحلبة (صفر ، ١% بذور حلبة غير مستنبتة ، ٢% بذور حلبة غير مستنبتة ، ١% بذور حلبة مستنبتة ، ٢% بذور حلبة مستنبتة).تم توزيع عدد ١٨٠ دجاجة بياضة عمر ٤٩ أسبوع من سلالة الهاي لين دبليو ٣٦ ً إلى ١٥مجموعة متساوية كل مجموعة احتوت على ١٢ دجاجة.

ويمكن تلخيص النتائج كما يلي

١. كانت المجموعة المغذاة على المستوى ١٤,٧٥ % بروتين + ١% بذور حلبة مستنبتة هي الأعلى في نسبة إنتاج البيض ، كتلة البيض والأفضل في معدل التحويل الغذائي ومعدل تحويل الطاقة بينما كانت المجموعة المغذاة على المستوى ١٣,٢٥ % بروتين + ١% بذور حلبة غير مستنبتة هي الأعلى في معدل تحويل البروتين .وكانت القيمة الأقل في نسبة إنتاج البيض كتلة البيض للمجموعة المغذاة على ١١,٧٥% بروتين + ٢% بذور حلبة غير مستنبتة وكانت القيم الأسوأ لمعدل التحويل الغذائي و ومعدل تحويل الطاقة ومعدل تحويل البروتين للمجموعة المغذاة على١١,٧٥ % بروتين + ١% بذور حلبة مستنبتة وكانت القيمة الأعلى لنسبة الصفار للمجموعة المغذاة على المستوى ١٤,٧٥ % بروتين + ٢% بذور حلبة غير مستنبتة في حين أن المجموعة المغذاة على ١٣,٢٥% بروتين + صفر % بذور حلبة كانت الأعلى في لون الصفار وكانت القيمة الأعلى لدليل الصفار ووحدة (هو) للمجموعة المغذاة على ١١,٧٥%بروتين + ٢% حلبة مستنبتة

٢. كانت المجموعة المغذاة على ١٤,٧٥ % بروتين كانت الأعلى معنويا في نسبة إنتاج البيض ، كتلة البيض، وزن البيض والغذاء المأكول وكانت هي الأفضل (معنويا جدا) في معدل التحويل الغذائي ومعدل تحويل الطاقة ، وكانت مجموعة المستوى ١٣,٢٥ % بروتين هى الأعلى في لون الصفار ومجموعة المستوى ١١,٧٥ % بروتين كانت الأعلى في دليل الصفار ووحدة (هو).

٣. لم يكن هناك اختلافات معنوية بين المجاميع المغذاة على علائق احتوت على حلبة مستنبتة أو غير مستنبتة والكنترول في كل من نسبة إنتاج البيض ، كتلة البيض، وزن البيض ، معدل التحويل الغذائي و ومعدل تحويل الطاقة.و معدل تحويل البروتين . سببت كل مستويات الحلبة زيادة في دليل الصفار بينما كانت مجموعة ٢% حلبة غير مستنبتة هي الأعلى في وجدة (هو).

٤. استخدام الحلبة المستنبتة بمستوى ١% في علائق الدجاج البياض والتي تحتوى على النسبة الموصى بها من البروتين الخام حسنت الإنتاج وأيضا أعطت كفاءة اقتصادية أعلى بدون تأثير سئ على جودة البض.

٥. يمكن التوصية باستخدام الحلبة المستنبتة بمستوى ١% في علائق الدجاج البياض والتي تحتوى على النسبة الموصى بها من البروتين الخام وأيضا وذلك للحصول على أفضل إنتاج واعلى كفاءة اقتصادية.

Table (1): Composition and chemical analyses of the experimental diets.

Ingredients	0.0% Fenugreek			1.0% Fenugreek			2.0% Fenugreek		
	14.75% CP	13.25% CP	11.75 % CP	14.75% CP	13.25% CP	11.75 % CP	14.75% CP	13.25% CP	11.75 % CP
Yellow corn, ground	69.30	71.42	73.47	68.40	70.52	72.50	67.50	69.6	71.60
Soybean meal (44%CP)	20.00	15.34	10.44	19.46	14.80	9.85	18.93	14.25	9.31
Wheat bran	0.00	2.36	5.06	0.44	2.80	5.72	0.87	3.27	6.16
Fenugreek	0.00	0.00	0.00	1.00	1.00	1.00	2.00	2.00	2.00
Calcium carbonate	8.00	8.10	8.10	8.00	8.10	8.00	8.00	8.10	8.00
Di calcium phosphate	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vit. and Min. premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL- methionine	0.10	0.12	0.15	0.10	0.12	0.15	0.10	0.12	0.15
Lysine	0.00	0.06	0.18	0.00	0.06	0.18	0.00	0.06	0.18
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis**									
CP %	14.69	13.19	11.63	14.70	13.20	11.65	14.72	13.21	11.66
EE%	2.79	2.91	3.03	2.82	2.94	3.06	2.86	2.97	3.09
CF%	2.92	2.90	2.90	2.98	2.96	2.98	3.04	3.02	3.03
Ca%	3.43	3.46	3.45	3.43	3.46	3.41	3.43	3.46	3.41
Available P %	0.47	0.47	0.45	0.47	0.46	0.45	0.46	0.46	0.45
Methionine%	0.35	0.34	0.35	0.34	0.34	0.34	0.34	0.33	0.34
Methionine+Cystine%	0.61	0.57	0.55	0.60	0.56	0.54	0.59	0.55	0.53
Lysine%	0.72	0.67	0.68	0.65	0.66	0.67	0.69	0.64	0.65
ME, K cal /Kg	2767	2765	2760	2767	2765	2759	2767	2765	2759
Cost (L.E./ton)***	816.3	793.0	779.4	819.2	796.0	781.9	822.3	798.7	784.8
Relative cost****	100.00	97.15	95.48	100.35	97.15	95.78	100.03	97.84	96.14

***Each 3.0 Kg of the Vit. and Min. premix manufactured by Agri-Vet Company, Egypt contains : Vit. A, 10000000 IU ; Vit. D_3 2000000 IU ; Vit. E, 10 g ; Vit. K_3, 1 g ; Vit. B1, 1 g ; Vit. B2, 5 g; Vit. B6, 1.5 g ;Vit. B12, 10 mg ; choline chloride, 250 g ; biotin, 50 mg ; folic acid, 1 g ; nicotinic acid , 30 g ; Ca pantothenate, 10 g ;Zn, 50 g ; Cu, 4 g ; Fe, 30 g ; Co, 100 mg ;Se, 100 mg; I, 300 mg ; Mn, 60 g, and completed to 3.0 Kg by calcium carbonate.**

**** According to NRC, 1994.**

***** According to market prices of 2003.**

****** Assuming that the control equals 100.**

Table (2): Productive performance of laying hens under the effect of dietary fenugreek seeds (ungerminated and germinated) and different dietary protein levels (Mean ± SE).

Items	Egg production (EP%)	Total egg mass (EM, g)	Average egg weight (EW,g)	Daily feed intake (FI, g)	Feed conversion (FC)	Crude protein conversation (CPC)	Caloric conversation ratio (CCR)	Live body weight gain (LBWG, g)
Treatments								
14.75% CP+0.0 F	**70.83±1.43^{A}**	**3118±95.00^{AB}**	**52.59±1.03**	**94.12±1.61**	**2.58±0.07^{FG}**	**0.380±0.01^{BCDE}**	**7.15±0.20^{FG}**	**136.69± 20.37**
13.25% CP+0.0 F	**65.48±2.08^{AB}**	**2932±110.28^{ABC}**	**53.25±0.82**	**93.35±2.36**	**2.74±0.08 ^{EFG}**	**0.363±0.01 ^{CDE}**	**7.59±0.24^{EFG}**	**80.96 ± 24.94**
11.75% CP+0.0 F	**54.17±2.35^{DEFG}**	**2380±95.44^{EF}**	**52.47±0.85**	**88.39±2.07**	**3.28±0. 13^{BCD}**	**0.385±0.02 ^{BCDE}**	**9.08±0.36^{BCD}**	**107.43±42.51**
14.75% CP+1.0% F	**70.34±1.98 ^{A}**	**3228±87.76 ^{A}**	**54.82±1.18**	**96.08±1.09**	**2.53±0.08^{G}**	**0.373±0.01 ^{BCDE}**	**7.01±0.21^{G}**	**114.88±18.03**
13.25% CP+1.0% F	**68.35±194 ^{AB}**	**3058±70.92^{AB}**	**53.49±1.13**	**93.98±1.75**	**2.64±0.08^{FG}**	**0.350±0.01 ^{E}**	**7.31±0.25^{FG}**	**97.29 ±26.56**
11.75% CP+1.0% F	**49.5±2.93^{EFG}**	**2161±118.65^{F}**	**52.20±0.74**	**93.25±2.25**	**3.61±0.15^{ABC}**	**0.425±0.02^{ABC}**	**10.02±0.42^{ABC}**	**120.84±27.81**
14.75% CP+2.0% F	**61.71±3.56^{BCD}**	**2864±149.25^{BCD}**	**55.54±0.88**	**93.25±2.04**	**2.91±0.18^{DEFG}**	**0.429±0.02 ^{AB}**	**8.05±0.50^{DEFG}**	**105.38± 31.30**
13.25% CP+2.0% F	**57.04±2.69^{CDE}**	**2569±129.00^{DE}**	**53.72±1.21**	**89.77±2.03**	**3.17±0.19 ^{CDE}**	**0.420±0.02 ^{ABCD}**	**8.77±0.55^{CDE}**	**118.61 ± 32.85**
11.75% CP+2.0% F	**47.62±2.24^{G}**	**2124±88.33^{F}**	**53.29±0.95**	**88.67±2.54**	**3.72±0. 17^{AB}**	**0.437±0.02 ^{AB}**	**10.31±0.47^{AB}**	**124.43±23.47**
14.75% CP+1.0% FG	**71.21±2.27 ^{A}**	**3241±87.43^{A}**	**54.31±0.74**	**92.91±1.55**	**2.44±0.06^{G}**	**0.360±0.01 ^{DE}**	**6.76±0.20^{G}**	**128.60±30.89**
13.25% CP+1.0% FG	**56.71±2.72 ^{CDEF}**	**2585±140.19^{DE}**	**54.18±0.87**	**90.91±2.63**	**3.16±0.17^{CDE}**	**0.418±0.02 ^{ABCD}**	**8.75±0.47^{CDE}**	**134.26 ±32.41**
11.75% CP+1.0% FG	**49.89±2.71^{EFG}**	**2159±105.40 ^{F}**	**51.81±1.10**	**93.12±1.67**	**3.86±0.22^{A}**	**0.453±0.02 ^{A}**	**10.69±0.62^{A}**	**67.01±17.49**
14.75% CP+2.0% FG	**64.07±2.86^{ABC}**	**2930±120.59 ^{ABC}**	**54.68±1.22**	**93.55±1.63**	**2.81±0. 15^{DAFG}**	**0.415±0.02 ^{ABCD}**	**7.79±0.41^{DEFG}**	**97.41±25.62**
13.25% CP+2.0% FG	**61.71±2.00^{BCD}**	**2671±83.31^{CDE}**	**51.62±0.77**	**90.95±1.91**	**3.03±0.16^{DEF}**	**0.402±0.02 ^{ABCDE}**	**8.41±0.46^{DEF}**	**67.86±15.98**
11.75% CP+2.0% FG	**49.24±2.32^{FG}**	**2195±94.66 ^{F}**	**53.25±0.90**	**87.28±3.07**	**3.54±0.22^{ABC}**	**0.417±0.02 ^{ABCD}**	**9.82±0.61^{ABC}**	**76.03 ±20.43**
Over all mean	**59.98±0.87**	**2686±39.42**	**53.29±0.26**	**92.00±0.54**	**3.13±0.05**	**0.401±0.01**	**8.48±0. 14**	**105.18±7.01**
Level of CP								
14.75	**67.63±1.21^{A}**	**3076±49.21 ^{A}**	**54.38±0.46^{a}**	**94.01±0.71 ^{a}**	**2.65±0.06 ^{C}**	**0.391±0.01 ^{b}**	**7.35±0.16^{C}**	**116.59± 11.30**
13.25	**61.95±1.16^{B}**	**2766±53.62 ^{B}**	**53.24±0.44^{ab}**	**91.81±0.95 ^{ab}**	**2.94±0.07 ^{B}**	**0.390±0.01 ^{b}**	**8.16±0.19^{B}**	**99.80 ± 12.17**
11.75	**50.15±1.13^{C}**	**2206±45.54 ^{C}**	**52.59±0. 39^{b}**	**90.17±1.04 ^{b}**	**3.60±0. 08 ^{A}**	**0.423±0.01 ^{a}**	**9.97±0.23^{A}**	**99.15±12.36**
Fenugreek level								
0.0	**63.49±1.80^{a}**	**2810±72.33**	**52.77±0.56**	**91.95±1.22**	**2.86±0. 10**	**0.376±0.01 ^{B}**	**7.94±0.20**	**108.36±17.67**
1.0% ungerminated	**62.73±1.87^{a}**	**2816±95.17**	**53.50±0.56**	**94.44±1.01**	**2.93±0. 10**	**0.382±0.01 ^{B}**	**8.11±0.29**	**111.00±14.00**
2.0% ungerminated	**55.68±1.82^{b}**	**2530±87.67**	**54.21±0.57**	**90.62±1.27**	**3.25±0. 12**	**0.428±0.01 ^{A}**	**9.01±0.33**	**116.14±16.60**
1.0 % germinated	**59.27±1.95^{ab}**	**2662±101.00**	**53.43±0.59**	**92.31±1.14**	**3.15±0. 14**	**0.410±0.01 ^{AB}**	**8.72±0.38**	**109.96±16.33**
2.0 % germinated	**58.44±1.96^{ab}**	**2601±76.5**	**53.14±0.59**	**90.60±0.54**	**3.13±0. 11**	**0.411±0.01 ^{AB}**	**8.66±0.31**	**80.43±11.83**

a..c and A.. C values in the same column within the same item followed by different superscripts are significantly different at P <0.05 for a to c ; P <0.01 for A to C.

F, Fenugreek (ungerminated) FG, Fenugreek (germinated)

Table (3): External and internal egg quality of laying hens under the effect of dietary fenugreek seeds (ungerminated and germinated) and different dietary protein levels (Mean ± SE).

Items	Shape index (SI)	Shell thickness (mm)	Shell %	Albumen%	Yolk %	Yolk color (YC)	yolk index (YI)	Hough unit (HU)
Treatments								
14.75% CP+0.0 F	**77.07±0.46**	**0.357±0.01**	**10.17±0.18**	**61.02±1.23**	**28.71±0.48^{BC}**	**9.52 ± 0.20^{ABC}**	**51.49±1.24^{DE}**	**81.66±209 ^{ABC}**
13.25% CP+0.0 F	**77.04±0.88**	**0.355±0.01**	**10.31±0.18**	**60.52±0.45**	**29.08±0.41^{ABC}**	**10.04±0.20 ^{A}**	**50.49±1.22^{E}**	**77.39±1.55 ^{CDE}**
11.75% CP+0.0 F	**76.66±0.45**	**0.352±0.01**	**10.22±0.21**	**61.78±0.58**	**28.03±0.48 ^{C}**	**9.48 ± 0.19^{ABC}**	**53.76±1.19^{BCDE}**	**79.26±2.24 ^{ABCD}**
14.75% CP+1.0% F	**77.28±0.32**	**0.359±0.01**	**10.13±0.15**	**61.00±0.52**	**28.87±0.48 ^{ABC}**	**8.78 ± 0.19^{E}**	**54.60±1.05^{BCD}**	**76.43±1.61 ^{CDEF}**
13.25% CP+1.0% F	**74.92±0.53**	**0.350±0.01**	**10.00±0.25**	**61.95±1.27**	**29.13±0.40 ^{ABC}**	**9.52±0.12 ^{ABC}**	**53.43±0.99^{CDE}**	**75.08±2.01 ^{DEF}**
11.75% CP+1.0% F	**76.23±0.56**	**0.356±0.01**	**10.21±0.19**	**59.95±0.59**	**29.83±0.56 ^{AB}**	**9.11 ± 0.26^{CDE}**	**55.81±0.86^{ABC}**	**81.25±1.45 ^{ABC}**
14.75% CP+2.0% F	**76.96±0.47**	**0.358±0.01**	**10.14±0.16**	**59.40±0.42**	**30.46±0.32 ^{A}**	**8.96 ± 0.20 ^{CDE}**	**52.30±1.05^{DE}**	**75.06±2.22 ^{DEF}**
13.25% CP+2.0% F	**77.28±0.44**	**0.364±0.01**	**10.09±0.17**	**61.99±0.44**	**27.93±0.40 ^{C}**	**9.33±0.19 ^{CDE}**	**55.86±0.94^{ABC}**	**79.76±1.98 ^{ABCD}**
11.75% CP+2.0% F	**75.40±0.55**	**0.348±0.01**	**9.81±0.16**	**60.39±0.64**	**29.80±0.54 ^{AB}**	**9.37 ± 0.20 ^{ABCD}**	**57.04±0.90^{AB}**	**84.25±1.44 ^{AB}**
14.75% CP+1.0% FG	**76.01±0.49**	**0.356±0.01**	**10.06±0.18**	**60.20±0.57**	**28.82±0.52 ^{ABC}**	**9.37 ± 0.28 ^{ABCD}**	**50.80±1.02^{E}**	**72.90±2. 42 ^{EF}**
13.25% CP+1.0% FG	**76.00±0.40**	**0.347±0.01**	**9.93±0.23**	**59.74±0.62**	**29.87±0.47 ^{AB}**	**9.63±0.27^{AB}**	**54.299±1.29^{BCD}**	**70.48±2.18 ^{F}**
11.75% CP+1.0% FG	**75.32±0.63**	**0.353±0.01**	**10.27±0.17**	**60.74±0.45**	**29.99±0.42 ^{AB}**	**9.41 ± 0.19 ^{ABCD}**	**56.02±1.07 ^{ABC}**	**81.99±2.16 ^{ABC}**
14.75% CP+2.0% FG	**75.17±0.48**	**0.350±0.01**	**10.06±0.16**	**60.73±0.86**	**29.21±0.77 ^{ABC}**	**8.93 ± 0.25^{DE}**	**53.64±1.29 ^{BCDE}**	**71.91±1.89 ^{EF}**
13.25% CP+2.0% FG	**76.60±0.51**	**0.342±0.01**	**10.52±0.29**	**61.73±0.52**	**28.75±0.65 ^{BC}**	**9.37±0.15 ^{ABCD}**	**54.45±1.02^{BCD}**	**79.04±1.55 ^{BCD}**
11.75% CP+2.0% FG	**77.83±0.38**	**0.350±0.01**	**10.54±0.25**	**61.48±0.18**	**27.98±0.43 ^{C}**	**8.93 ± 0.16 ^{DE}**	**58.09±1.07^{A}**	**85.24±1.62 ^{A}**
Over all mean	**76.39±0.14**	**0.353±0.00**	**10.17±0.05**	**60.88±0.35**	**29.10±0.13**	**9.32 ± 0.06**	**54.16±0.29**	**78.11±0.53**
Level of CP								
14.75	**76.49±0.29**	**0.356±0.003**	**10.11±0.07**	**60.88±0.37**	**29.22±0.25**	**9.11 ± 0.10 ^{B}**	**52.57±0.12 ^{B}**	**75.55±0.95 ^{C}**
13.25	**76.38±0.26**	**0.352±0.003**	**10.19±0.10**	**61.08±0.35**	**28.95±0.25**	**9.57±0.08 ^{A}**	**53.71±0.17 ^{B}**	**76.36±0.87 ^{B}**
11.75	**76.29±0.24**	**0.352±0.003**	**10.20±0.12**	**60.66±0.26**	**29.13±0.25**	**9.26±0.09 ^{B}**	**56.18±0.48^{A}**	**82.40±0.79 ^{A}**
Fenugreek level								
0.0	**76.91±0.36**	**0.355±0.03**	**10.26±0.11**	**61.49±0.48**	**28.60±0.24**	**9.68 ± 0.12 ^{A}**	**51.09±1.02^{B}**	**79.41±1.15 ^{a}**
1.0% ungerminated	**76.16±0.29**	**0.355±0.03**	**10.11±0.11**	**60.97±0.50**	**29.28±0.28**	**9.14±0.12 ^{BC}**	**54.63±1.02^{A}**	**77.62±0.96 ^{ab}**
2.0 %ungerminated	**76.55±0.29**	**0.356±0.03**	**10.01±0.09**	**60.59±0.31**	**29.39±0.27**	**9.22 ± 0.11^{BC}**	**53.77±1.02^{A}**	**79.69±1.17 ^{a}**
1.0% germinated	**75.78±0.29**	**0.352±0.03**	**10.09±0.11**	**60.35±0.32**	**29.56±0.28**	**9.47 ± 0.14^{AB}**	**55.06±1.02^{A}**	**75.12±1.40 ^{b}**
2.0 % germinated	**76.53±0.14**	**0.347±0.03**	**10.37±0.14**	**60.98±0.42**	**28.45±0.36**	**9.07 ± 0.11^{C}**	**55.93±1.02^{A}**	**78.73±1.14 ^{a}**

a..c and A.. C values in the same column within the same item followed by different superscripts are significantly different at P <0.05 for a to c ; P <0.01 for A to C

F, Fenugreek (ungerminated) FG, Fenugreek (germinated)

Table (4): Economical efficiency of laying hens under the effect of dietary fenugreek seeds (ungerminated and germinated) and different dietary protein levels

Items		14.75%CP +0.0% F	13.25 %CP +0.0% F	11.75%CP +0.0% F	14.75%CP +1.0% F	13.25 %CP +1.0% F	11.75%CP +1.0% F	14.75%CP +2.0% F	13.25 %CP +2.0% F	11.75%CP +2.0% F
Price/ K feed(LE)	a	0.816	0.793	0.779	0.819	0.796	0.782	0.822	0.799	0.785
Total feed intake hen(Kg)	b	7.905	7.841	7.425	8.071	7.895	7.832	7.833	7.541	7.448
Total feed cost /hen (LE)	a x b = c	6.454	6.218	5.787	6.612	6.284	6.124	6.441	6.023	5.847
Total number of eggs /hen	d	59.50	55.00	45.50	59.08	57.418	41.58	51.83	47.92	40.00
Price /egg (LE)	e	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total price of eggs / hen (LE)	d x e= f	14.875	13.750	11.375	14.77	14.35	10.40	12.96	11.98	10.00
Net revenue / hen (LE)	f – c = g	8.425	7.532	5.590	8.158	8.066	4.271	6.517	5.957	4.153
Economical efficiency (EEf)	g / c = h	1.305	1.211	0.967	1.234	1.284	0.697	1.012	0.989	0.710
Relative EEf	r	100	92.75	74.01	94.6	98.4	0.534	0.775	0.758	54.43
Items		14.75%CP +1.0% FG	13.25 %CP +1.0% FG	11.75%CP +1.0% FG	14.75%CP +2.0% FG	13.25 %CP +2.0% FG	11.75%CP +2.0% FG			
Price/ K feed(LE)	a	0.819	796	0.782	0.822	.799	0.785			
Total feed intake hen(Kg)	b	7.804	7.636	7.822	7.857	7.639	7.331			
Total feed cost /hen (LE)	a x b = c	6.391	6.078	6.117	6.458	6.104	5.755			
Total number of eggs /hen	d	59.82	47.64	41.91	53.82	51.83	41.36			
Price /egg (LE)	e	0.25	0.25	0.25	0.25	0.25	0.25			
Total price of eggs / hen (LE)	d x e= f	14.955	11.91	10.48	13.46	12.96	10.34			
Net revenue / hen (LE)	f – c = g	8.562	5.832	4.363	7.00	6.856	4.585			
Economical efficiency (EEf)	g / c = h	1.340	0.96	0.713	1.08	1.123	.797			
Relative EEf	r	102.6	73.6	54.66	83.08	86.07	61.05			

a…… (based on average price of diets during the experimental time).

e…….....(according to the local market price at the experimental time).

g /c ….....……...(net revenue per unit feed cost).

r…….……(assuming that economical efficiency of control group equals 100).

F, Fenugreek (ungerminated) FG, Fenugreek (germinated)