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EFFECT OF SPLIT FEEDING SYSTEM ON EGG PRODUCTION AND EGG QUALITY OF DANDARAWI LAYERS

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ABSTRACT: This study was conducted to study the effect of split feeding system on egg production and egg quality of Dandarawi layers during their late phase of egg production cycle. A total of 100 Dandarawi Layers (12 months old) were divided into two groups. Each group was divided into 5 replicates (10 hens each). The first group was kept as control and fed one diet throughout the day (regular diet with optimum level of energy, protein and calcium). Whereas, the second group was fed according to split feeding system by having access to two diets throughout the day. The first diet (high energy, high protein and low calcium) offered from 6 am to 6 pm, and the second diet (low energy, low protein and high calcium) offered from 6 pm to 6 am. The diet offered throughout the daily hours was higher by 10% energy, 23% protein and lower by 50% calcium than the diet offered throughout the night hours. Body weight, feed intake, feed conversion ratio, egg production traits, egg quality were recorded, estimated or calculated. The results revealed that the split feeding system did not result in any significant (P>0.05) changes in body weight or body weight change during the experiment period from 12 to 16 months of age. Feed consumption was significantly decreased by 16.1 % and feed conversion ratio was significantly improved by 25 % by following split feeding system. There was a tendency to numerical increase in egg number by 9.47 %, egg laying rate % by 9.5%, and egg mass by 9 % for the split feeding system during the previous period. Split feeding system significantly increased egg length, egg width, albumen weight, albumin height and Haugh units compared with the control group. However, there was no significant influence of split feeding on egg weight, egg specific gravity, shape index, egg yolk quality, albumin%, and eggshell traits. It could be concluded that split feeding of Dandarawi layers at their late phase of egg laying cycle has led to decreasing feed consumption, improving feed conversion ratio, saving in feed cost and increasing egg number and egg mass.

Keywords: Split feeding system, egg production, egg quality, layers

INTRODUCTION

Eggs are nutritionally and commercially valuable food commodity. Egg contains about 16% of high quality protein, which is nutritionally complete, meaning it contains all the essential amino acids that human body cannot synthesized (Idahor, 2017). Biological value of eggs is 100 (Hoffman and Falvo, 2004) which is higher than other meat products, implying the protein is more available to the body. Due to this nutritional significance, egg is a popular food among the consumers all over the world. High demand encourages high production; however, the quality of eggs is also important. Commercially, eggs are usually graded according to their external properties such as size. Generally, larger eggs are expensive because edible percentage in larger eggs is comparatively higher (Jacob *et al*., 2000).

Eggshell quality is an important criterion for egg producers. As the eggs in the production chain are exposed to physical and environmental stress during handling, packaging, and transportation, the incidence of eggshell cracking increases if the quality of eggshell is poor. Micro cracks can also lead to microbial contamination which might incur health hazard among consumers (Hunton, 2005). Besides, a broken egg also means lower grade, loss of nutrient and money.

Quality of eggs can be influenced by the feeding system. In a conventional feeding system, hens daily diets contain the same nutrient concentration. However, when offered free choice hens show different pattern of nutrient consumption. Protein consumption is higher early in the day while calcium consumption is higher later (Chah and Moran Jr, 1985). Mongin and Sauveur (1974) reported that consumption of oyster shells sharply increased from 1600-2000 hr when fed with low calcium diet. The variation in nutrient consumption can be largely explained by the physiological need for specific nutrients depending on the egg formation stage.

Most of the eggshell calcification occurs during dark hours when the hen has stopped eating. Very little (if any) calcium is stored in the oviduct, thus calcium has to be mobilized through the blood (Driggers and Comar, 1949). When the dietary calcium becomes deficient, the hen depends on its bones to provide the necessary calcium (Saunders-Blades *et al.,* 2009). If this continues bone quality declines, and dependency on bone mobilization can also be negatively impact eggshell quality (Farmer *et al*., 1986). This suggests that birds must have access in the morning to a feed rich in protein and amino acids (Galea, 2015).

One of the main concerns is a decrease in eggshell quality as the hen ages (Roberts *et al.,* 2013, Molnár *et al.,* 2016 and Kulshreshtha *et al.,* 2018). Therefore, the conventional practice of providing hens with only a single complete feed during the whole day might not be an ideal approach for optimal utilization of nutrients. Split feeding is an alternative system for feeding layers. It provides different morning and afternoon diets to the hens. This responds to their physiological feeding behavior and nutrient intake according to the different requirements throughout the day. Benefits may be improved nutrient efficiency, cost savings, greater profits and increased egg quality (Mozos *et al.*, 2014). Zarghi *et al.,* (2008) reported that split diets had significant positive effect on feed conversion ratio, cost of feed per egg production, egg mass and egg yield, but it had no effect on feed intake, egg weight, shell thickness, egg components, Haugh units and bone ashbone ash. Also, the calcium intake of the hens can be reduced by split feeding without affecting eggshell quality (Niraula, 2018).

Therefore, the aim of this study was to evaluate the effect of feeding layers during their late phase of laying period according to split feeding system against the conventional feeding system commonly applied for egg layers.

MATERIALS AND METHODS

This study was conducted at the Poultry Research Farm, Faculty of Agriculture, Assiut University from January to April, 2018.

Experimental birds and design:

A total of 100 Dandarawi Layers at their late phase of egg production (12 months old) were divided into two groups (50 birds each) and housed in 10 floor pens (2.2 m × 1 m × 2 m) furnished with a litter of wheat straw. Each pen was supplied with laying nest of 4 holes each. Each group was divided into 5 replicates (10 hens each). The first group was kept as control and fed one diet throughout the day (regular diet with optimum level of energy, protein and calcium). Whereas, the second group was fed according to split feeding system by having access to two diets throughout the day. The first diet (high energy, high protein and low calcium) offered from 6 am to 6 pm, and the second diet (low energy, low protein and high calcium) offered from 6 pm to 6 am (Table 1).The diet offered throughout the daily hours was higher by 10% energy, 23% protein and lower by 50% calcium than the diet offered throughout the night hours.

The experiment was run for four months at the layers' age between 12 to 16 months. Feed and fresh water were available *ad libitum*. Vaccination and medical program were done according to common veterinarian care practice. Birds were exposed to photoperiod regimen 17 hrs light - 7 hrs dark cycles (light from 6 am to 11 pm, and dark from 11pm to 6 am).

Data collection:

Live body weight (g) of each bird was recorded at the beginning and end of the experimental period (12 and 16 months of age). Feed consumption (FC) was calculated per each bird per day (g/bird/day). Feed conversion ratio was calculated as the amount of feed consumed (g) required to produce a unit (g) of egg mass (FCR = g, feed /g, egg).

Eggs were collected at 12 a.m. and recorded daily. The percentage of egg production (%) for each replicate was calculated. Eggs were individually weighed daily on a digital balance to the nearest 0.1 g and the average egg weight was calculated for each replicate. Egg mass (g/hen/d) was calculated for each replicate.

The eggs produced in the last three days of every month throughout the experimental period subjected to egg quality investigation in the same days of production. External egg quality such as egg shape index, eggshell percent, shell thickness, specify gravity, shell weight per unit of surface area and the breaking strength of uncracked eggs were measured.

Eggs were weighed and then broken on a flat glass plate to estimate shell weight, yolk weight, and albumin weight. Also, Haugh units and egg yolk quality were determined.

Statistical analysis:

Data collected were subjected to analysis of variance (ANOVA) by applying the general linear model procedure of SAS software (SAS, 2008). All means were tested for significant differences using Duncan's multiple range procedure (Duncan, 1955). All percentages of traits were transformed to Arcsine form before analysis. Significance was set at the 5% level. The used model for analysis was as follows:

$Y_{ij} = \mu + T_i + e_{ij}$

Where Y_{ij}= an observation, μ= the overall mean, T_i= the treatment effect, and e_{ij}= experimental random error.

RESULTS AND DISCUSSION

Productive performance:

The results of body weight and body weight change of Dandarawi layers as affected by split feeding system are shown in Table 2. The split feeding system did not result in any significant (P>.0.05) changes in body weight or body weight change during the experiment period from 12 to 16 months of age. However, there was a slight reduction in the final body weight of the split fed group comparing with its initial weight.

Feed intake of Dandarawi layers was significantly decreased by the split fed group than by the control group during the experimental period (12 – 16 months of age). Moreover, feed conversion ratio was significantly better for the layers followed split feeding system than that of their control during the same period by about 25% (Table 2).

It could be noticed that split-fed hens consumed less feed during the 4-month experiment period than their control by 16.1% (11.49 kg vs. 13.69 kg ; resp.) and if taking in consideration the feed cost of split feeding diets (av. 5793 LE/ton) vs. that of the control (5821 LE/ton) , it means that split feeding system saved 20 % of the consumed feed cost.

The results for egg production of Dandarawi layers during the experimental period as affected by split feeding system are shown in Table 3. The data revealed that there was tendency to numerical increase in egg number, egg laying rate % and egg mass of the split feeding system. However, eggs produced by split fed group in the four months period increased by 9.47 % than their control (58.71 vs. 53.63 egg/b). Also, egg mass produced by split-fed hens throughout the four months experiment exceeded their control by 9 % (2957 vs. 2710 g / b).

However, it could be detected from the mentioned table that there was no significant influence of split feeding on egg weight.

These results partially agree with those reported by Keshavarz (1998a) who observed that there was no difference in laying performance by supplementing 2.5% Ca in the morning and 4.5% Ca in the afternoon as pulverized limestone compared to a control feeding regimen with 3.5% calcium each time. Also, Keshavarz (1998b) reported that hens fed with 2% calcium in the morning and 3.8% calcium in the afternoon did not show difference in egg mass while the dietary intake of the calcium was significantly reduced than the control group that received 3.8% calcium throughout. No effect on productive performance parameters when layer hens fed diets containing calcium levels in the range used in the present study were reported by different studies (Frost and Roland, 1991; Clunies *et al.*, 1992; Leeson *et al*., 1993). Keshavarz and Nakajima (1993) noted no effect on egg weight when layer hens fed diets containing calcium levels ranged from 2.80 and 4.40%. Also, Zarghi *et al.* (2008) reported that split diets had significant positive effect on feed conversion ratio (p<0.01), but it had no effect on egg weight. Moreover, Lin *et al.*

(2018) found that feeding high calcium (3.6%) in the morning and low calcium (3.2%) in the afternoon significantly improved FCR of the hen. Furthermore, Molnar *et al.* (2018) found that body weight and egg production did not differ significantly due to different feeding systems. On the other hand, Molnár *et al.* (2017) found that egg production ratio and egg mass were higher in the control system compared to the split feeding system.

In addition, the present results are in agreement with those of Lee and Ohh (2002), who reported that split feeding with increased protein and energy level in the morning and a decreased level in the afternoon compared to a control diet (16.5%, 2,800 kcal) resulted in similar feed intake, egg production, and egg weight. However, hens in the split system had a lower protein and energy intake, which translates to lower feed costs. Also, Okitoi *et al.* (2007) showed that supplementing different diets with varying levels of energy and protein either in the morning or afternoon to growing scavenging chickens (14-24 weeks) followed by a high energy, high protein supplementary diet for scavenging layers during the day increased feed intake, nutrient intake, egg production and egg weights. Moreover, manipulation of time of access to some nutrients, affects the growth curve, early egg weight and sexual maturity of pullets and consequently egg production (Olver and Malan, 2000 and Pousga *et al*., 2005). The ability of domestic fowls to regulate their nutrient intake when given a choice between high- and low-protein feeds has been shown by Sahin and Forbes, (1999). It has also been shown that the physiological needs and the utilization of protein, energy and amino acids may actually vary at different times of the day (Scott and Balnave, 1998). Also, Okitoi *et al*. (2009) indicated that birds have specific appetites for nutrients such as energy, protein and amino acids. Moreover, Bouvarel *et al.* (2007) found that chickens seemed to adapt their feed consumption in the afternoon according to the protein content of the feed. Chickens exhibited high responses to protein in the afternoon and the explanation was because of increased metabolism e.g. protein turn-over (Muramatsu, 1990) and lipogenesis (Rosebrough *et al.* 1999).

Egg quality

Results of egg external quality as affected by split feeding are presented in Table 4. Split feeding system significantly increased egg length and egg width compared with the control group. However, there was no significant effect of split feeding system on egg specific gravity, egg weight and shape index during the period 12-16 months of age.

Results of egg yolk quality of Dandarawi layers as affected by split feeding are presented in Table 5. There was no significant influence of split feeding on egg yolk quality such as yolk weight, yolk diameter, yolk height, yolk color, yolk % and yolk index during the period from 12 to 16 month of age.

Split feeding significantly increased albumen height and Haugh units during the period 12-16 months of age compared with the control group. However, there was no significant influence of split feeding system on albumin weight and albumin% during the same period (Table 5).

Eggshell traits:

Results of eggshell quality of Dandarawi layers as affected by split feeding are presented in Tables 6 and 7. Split feeding significantly increased eggshell weight, shell % and eggshell thickness at the fourth month of the experiment. Notwithstanding, there was no significant influence of split feeding on shell %, eggshell thickness, eggshell breaking strength and shell weight per unit surface area (SWUSA) (mg/cm2) for the overall experimental period; however, there were significant improvements in these characters at the fourth month. Therefore, it would be conducted that split feeding system may have accumulated effect on eggshell traits that may be more pronounced at the very end of the laying cycle.

Different results were reported by Keshavarz (1998a) who did not find any difference (P>0.05) in eggshell quality by supplementing 2.5% Ca in the morning and 4.5% Ca in the afternoon as pulverized limestone compared to a control feeding regimen with 3.5% calcium each time. However, the author reported that high calcium in the morning and low calcium in the evening reduced the eggshell quality. Also, Keshavarz (1998b) reported that hens fed with 2% calcium in the morning and 3.8% calcium in the afternoon did not show difference (P>0.05) in shell quality traits, such as shell weight and shell percent. Also, our results are in partial agreement with those of Zarghi et al., (2008) who reported that split diets had no effect on shell thickness, Haugh units, and egg components. Moreover, Mozos et al. (2012) reported that hens received low protein and high calcium 8 and 10 hours post-oviposition consumed relatively less calcium, protein, and energy without negatively affecting eggshell quality, in comparison to the control group that received the same diet throughout the day. Similarly, in another study on brown hens aged 57-65 weeks, decreasing calcium concentration in the morning and increasing calcium in the evening feed by 45% and 15% did not reduce eggshell quality (Mozos et al., 2014).

Eventually , relying on the results of this study, it could be concluded that split feeding of Dandarawi layers for 4 months at their late phase of egg laying cycle has led to decreasing feed consumption by 16 % , improving feed conversion ratio by 25 % , saving in feed cost by 20 % , increasing egg number by 9.47 % , increasing egg mass by 9 % . It also has resulted in some improvements in eggshell quality at the very late phase of laying cycle (15-16 month of age).

Table (1): Formula and chemical composition of the experimental diets

Ingredients (%)	**Diets**		
	Control	**Morning**	**Night**
Yellow corn	64.0	67.0	60.5
Wheat bran	3.7	0.0	10.7
Soybean meal (44% CP)	22.0	26.3	16.8
Limestone	8.6	4.9	10.5
NaCl	0.3	0.3	0.3
Dicalcium phosphate	0.7	0.8	0.5
Vit. + min. premix[1]	0.2	0.2	0.2
Anticoccidial	0.1	0.1	0.1
L-Lysine	0.2	0.2	0.2
DL-Methionine	0.2	0.2	0.2
Calculated composition			
ME, Kcal/kg	2695	2838	2564
CP, %	16.05	17.7	14.4
Lysine, %	0.85	0.94	0.80
Methionine, %	0.50	0.52	0.47
Calcium, %	3.50	2.13	4.18
P_{total}, %	0.49	0.51	0.47
Determined composition			
Crude fat, %	2.90	3.19	2.73
Crude fiber, %	3.98	2.50	4.53
Cost (LE/Ton)[2]	5821	6088	5498

[1]Vit+Min mix. Each kg of vitamin mineral premix: contains: vitamin A, 12000000; vitamin D3, 3000000IU; vitamin E, 700 mg; vitamin K3, 500 mg; vitamin B1, 500 mg; vitamin B2, 200 mg; vitamin B6, 600 mg; vitamin B12, 3 mg; folic acid, 300mg; choline chloride, 1000 mg; Niacin, 3000 mg; Biotin, 6 mg; panathonic acid, 670 mg; manganese sulphate, 3000 mg; iron sulphate, 10000 mg; zinc sulphate, 1800 mg; copper sulphate, 3000 mg; iodine, 1.868 mg; cobalt sulphate, 300 mg; selenium, 108 mcg.

2. Average cost of split feeding diets equal 5793 LE/Ton

Table (2): Effect of split feeding of Dandarawi layers on body weight and feed intake during the period from 12 to 16 month of age

Traits	G1 (Control)	G2 (split fed)
Body weight and body weight change		
Initial BW	1701±33.13	1792±31.93
Final BW	1721±41.26	1732±27.87
BWC	8.77±23.94	-51.41±21.69
Feed intake and feed conversion ratio		
Feed Intake (g/b/d)	114.10±1.72[a]	95.72±0.92[b]
Feed Conversion Ratio (g feed/ g egg)	5.20±0.42[a]	3.90±0.15[b]

[a,b,] Means in the same row followed by different superscripts are significantly different at ($p \leq 0.05$)

Table (3): Effect of split feeding of Dandarawi layers on egg production during the period from 12 to 16 month of age

Traits	G1 (Control)	G2 (split fed)
Egg number (egg/b)	53.63±4.90	58.71±1.70
Egg laying rate %	45.06±4.12	49.34±1.43
Egg weight (g)	50.19±0.25	49.93±0.15
Egg mass (g/bird/day)	22.58±1.98	24.64±0.75

Table (4): Effect of split feeding of Dandarawi layers on egg external quality during the period from 12 to 16 month of age

Traits	G1 (Control)	G2 (split fed)
Egg specific gravity	1.080±0.0005	1.078±0.0006
Egg weight (g)	50.34±0.26	50.15±0.34
Egg length (mm)	51.77±0.19[b]	52.77±0.17[a]
Egg width (mm)	40.56±0.15[b]	41.19±0.08[a]
shape index	78.41±0.24	78.24±0.27

[a,b,] Means in the same row followed by different superscripts are significantly different at ($p \leq 0.05$)

Table (5): Effect of split feeding of Dandarawi layers on egg internal quality during the period from 12 to 16 month of age

Traits	G1 (Control)	G2 (split fed)
Egg yolk quality		
Yolk weight (g)	16.89±0.11	16.48±0.18
Egg yolk diameter(mm)	40.71±0.13	40.88±0.12
Yolk height(mm)	20.12±0.13	20.27±0.09
Egg yolk color	6.39±0.08	6.50±0.07
Yolk %	33.59±0.18	34.33±1.54
Yolk index	49.53±0.37	49.71±0.27
Egg albumin quality		
Albumen weight (g)	28.58±0.20	29.17±0.27
Albumen height (mm)	5.77±0.06^{b}	6.28±0.07^{a}
Albumen %	56.73±0.20	60.00±2.25
Haugh unit	77.93±0.52^{b}	81.47±0.51^{a}

^{a,b,} Means in the same row followed by different superscripts are significantly different at ($p \leq 0.05$)

Table (6): Effect of split feeding of Dandarawi layers on eggshell quality during the experimental periods

Group	Traits			
	Eggshell weight (g)	**Shell %**	**Eggshell thickness (mm)**	**Eggshell breaking strength (kg/cm^2)**
Fourth month (15-16 month of age)				
G1 (control)	4.50±0.11^{b}	8.87±0.21^{b}	33.15±0.74^{b}	3.50±0.17
G2 (split fed)	5.01±0.07^{a}	9.74±0.12^{a}	37.53±0.49^{a}	3.88±0.12
Overall (12-16 months of age)				
G1 (control)	4.85±0.05^{a}	9.66±0.09	35.83±0.32	3.84±0.08
G2 (split fed)	4.71±0.05^{b}	9.62±0.26	35.53±0.32	3.61±0.07

^{a,b,} Means in the same column followed by different superscripts are significantly different at ($p \leq 0.05$).

Table (7): Effect of split feeding of Dandarawi layers on eggshell weight per unit surfaces area at the end of the experiment

Traits	G1 (control)	G2 (split fed)
Egg surface area (cm^2)	63.13±0.23	63.12±0.25
Shell weight per unit surface area (mg/cm^2)	76.96±0. 749	75.25±0. 710

^{a,b,} Means in the same row followed by different superscripts are significantly different at ($p \leq 0.05$)

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Split feeding system, egg production, egg quality, layers

الملخص العربي

تـأثير نظام التغذية المنفصلة على إنتاج وجودة البيض للدجاج الدندراوى

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أجريت هذه الدراسة لتقييم تأثير نظام التغذية المنفصلة على إنتاج وجودة البيض في المراحل المتأخرة لدورة انتاج البيض في الدجاج الداندراوي. تم تقسيم عدد مئة دجاجة من الداندراوي البياض (عمر12 شهراً) إلى مجموعتين. وتم تقسيم كل مجموعة إلى 5 مكررات (10 دجاجات لكل مكررة). تم الاحتفاظ بالمجموعة الأولى كمجموعة كونترول وتمت تغذيتها علي نظام غذائي واحد على مدار اليوم (النظام الغذائي المنتظم مع المستوى الأمثل من الطاقة والبروتين والكالسيوم). في حين أن المجموعة الثانية تمت تغذيتها وفقا لنظام التغذية المنفصلة من خلال الحصول على عليقتين على مدار اليوم: العليقة الأولى (ذات مستوى عالي من الطاقة والبروتين ومستوى منخفض من الكالسيوم) وتقدم للطيور من الساعة 6 صباحًا حتى الساعة 6 مساءً، والعليقة الثانية (ذات مستوى منخفض من الطاقة والبروتين ومستوى عالي من الكالسيوم) وتقدم للطيور من الساعة 6 مساءً حتى 6 صباحًا. وكانت العليقة النهارية اعلى بنسبة 10% طاقة، 12% بروتين وأقل بنسبة 50% كالسيوم عن العليقة المسائية. وتم تسجيل وحساب وتقدير وزن الجسم، التغيير في وزن الجسم، استهلاك العلف، معامل التحويل الغذائي، صفات إنتاج البيض، صفات جودة البيض. وأظهرت النتائج أنه لم ينتج عن نظام التغذية المنفصلة أي تغييرات معنوية في وزن الجسم أو تغيير وزن الجسم خلال فترة التجربة من 12 إلى 16 شهرًا من العمر. وانخفض استهلاك العلف انخفاضا معنويا بنسبة 16.1 %، وتحسن معامل التحويل الغذائي تحسنا معنويا بنسبة 25 % باتباع نظام التغذية المنفصلة. أدى نظام التغذية المنقسمة إلى زيادة عددية في عدد البيض بنسبة 9,47% ومعدل انتاج البيض٪ بنسبة 9,5% وكتلة البيض بنسبة 9% مقارنة بمجموعة الكونترول خلال الفترة من 12 إلى 16 شهرًا من العمر. كما أدى نظام التغذية المنفصلة إلى زيادة طول البيض وعرض البيض ووزن البياض، وارتفاع البياض ووحدات Haugh خلال الفترة من 12-16 شهرا من العمر مقارنة بمجموعة الكونترول. بينما لم يكن هناك تأثير معنوي لنظام التغذية المنفصلة على الكثافة النوعية للبيض، دليل شكل البيض، وجودة صفار البيض، ونسبة الألبومين. وكان هناك تأثير إيجابي معنوي للتغذية المنفصلة خلال الشهر الرابع للتجربة على كل من وزن، ونسبة وسمك قشرة البيض.

وبناء على النتائج يمكن استنتاج أن التغذية المنفصلة للدجاج الدندراوي في المرحلة المتأخرة من دورة انتاج البيض أدت إلى تقليل استهلاك العلف، وتحسين معامل التحويل الغذائي، وتوفير تكلفة التغذية وزيادة عدد البيض وكتلة البيض والى تحسن بعض صفات القشرة في الشهر الأخير للتجربة.