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IMPACT OF VITAMIN A SUPPLEMENTATION BEFORE AND DURING EARLY EGG PRODUCTION ON LAYING HEN PERFORMANCE

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ABSTRACT: The effects of dietary vitamin A (Vit. A) supplementation before and during early egg production on productive performance, egg quality, and economical efficiency of Lohmann brown laying hens were studied. In this experiment, a total number of 375 hens 16 wks of age were fed a basal diet supplemented with 10,000 (control); 20,000, 30,000; 40,000 or 50,000 IU Vit. A/kg diet. Each dietary treatment was randomly divided to 5 replicates with 15 birds each. Water and feed in mash form were offered ad-libitum, under a total of 16 hrslight/day regimen during the experimental period. Birds were reared in clean batteries under similar conditions up to 30wks of age.

The results indicated that egg production, egg mass and feed conversion ratio (FCR) significantly improved ($p<0.05$) with vitamin A supplementation. Groups received 30,000; 40,000 or 50,000 IU Vit. A/kg diet showed improvement egg production% at peak production period compared with groups received which 10,000 or 20,000 IU Vit. A/kg. Neither external nor internal egg quality parameters were affected by Vit. A supplementation except yolk index that was significantly decreased with increasing Vit. A level in the diet. Hens received 20000 IU Vit. A/kg diet showed the better relative economical efficiency compared those received the other levels. It could be concluded that, although the supplementation of 50000 IU Vit. A/kg diets before and during the early egg production improved laying hen performance, the hens received 20000 IU Vit. A/kg diet showed the better relative economical efficiency.

Key word: Vitamin A – Performance – Laying hens.

INTRODUCTION

Laying hens nutrition program is classified to starter, grower, developer, pre-layer (optional) and laying periods. After grower period to first egg lay is defined as pre-layer period, from 14 wks to first egg lay, which is considered very important period before the hen starts to lay**.** The hens supplied with higher levels of all nutrients to prepare the hens for laying phase. Few reports investigated the effect of fat soluble vitamins on productive performance during this period and its effect on performance during early egg lay. Laying hen diets should be supplemented with vitamin A for compensation the loss in the vitamin by many reasons including oxidation and those demands due to feed consumption, stress, genotype and quality of feed ingredients (McGinns, 1988; Prabakaran, 2003). Vitamin A is an essential micronutrient throughout the life cycle (Yuan et al., 2014). There are essential functions of vitamin A causes the necessary of addition to commercial layer diets. These functions include supporting the differentiation of epithelial cells, supporting the viability of the reproductive system, and used in the visual cycle (Brody, 1993). Elsherif (2016) concluded that vitamin A supplementation before and during egg production was beneficial to laying hens. Vitamin A has essential roles in vision, bone and muscle growth, reproduction and maintenance of healthy epithelial tissue. Carotene and vitamin A are rapidly destroyed by exposure to air, light and rancidity, especially at high temperature. Since it is difficult to assess the amount of vitamin A present in the feed, diets should be supplemented with this vitamin (Blair, 2008). Trojacanec et al. (2012) concluded that β-carotene and vitamin A supplementation at pre-ovulation could improve follicular growth and development of the corpora lutea in cows. Chen et al. (2016) concluded that dietary vitamin A supplementation improved the laying rate and egg-to-feed ratio, and elevated follicle stimulating hormone receptors, luteinizing hormone receptors, insulin-like growth factor 1 receptors, retinoic acid receptor α, and retinoid X receptor in the ovarian stroma and the walls of yellow follicles of breeders ovaries. Therefore, this study was aimed to investigate the effect of dietary vitamin A supplementation from pre-layer to peak of egg production on productive performance, egg quality and relative economical efficiency.

MATERIALS AND METHODS

This experiment was conducted at the Poultry Farm, Faculty of Agriculture, Cairo University, from November to February 2015 to study the impact of different levels of vitamin A supplementation from 16 to 30 wks old on productive performance and relative economical efficiency of egg production.

Experimental diets and treatments:

Laying hens received five treatments which were treatment 1, fed the control diet, was contained recommended level of vitamin A being 10000 IU/kg diet. Treatments from 2 to 5 were formulated to contain 20000, 30000, 40000 and 50000 IU vitamin A/kg diet, respectively. Vitamin A from ingredients was ignored. The experimental diets were formulated according to nutrition guide of Lohmann brown laying hens to be isocaloric and isonitrogenous for the two diet types for pre-layer and layer periods (Table 1).

Birds and housing:

Three hundred and seventy five Lohmann Brown laying hens 112 days old were randomly divided into 5 groups of 75 hens of 5 replicates with 15 hens each. Hens were housed in 3-deck batteries of clean wire-mesh cages, with dimensions of 40 × 40 cm in an open system house. Feed (in mash form) were offered *ad-lib* and water was offered free all over the experimental period (15 weeks), under total continuous light of 16 hours, daily.

Measurements:

Productive performance:

Hen day egg production (HD) percentage was calculated every four weeks intervals from first egg lay at 19 to 30wks old. Egg Production (HD) was calculated at 5, 20, 65% and peak intervals. Eggs were collected for two days of production and weighed every four weeks during the laying period. Egg mass (g/hen/day) were calculated from HD and egg weight (EW) values. Feed consumption (g/hen/day) was calculated every four weeks. Feed conversion ratio (FCR) were calculated from egg mass and feed consumption records. Hens were weighed at the beginning, at first egg lay and at the end of experiment to calculate body weight change.

Egg quality:

One egg from each replicate was randomly taken to measure the following measurements: Shape index %= egg width/ egg height *100, Shell thickness was determined using a dial pipe gauge. Dry shell with membranes was weighed to the nearest 0.1 g. Haugh units (HU) were calculated based on the height of albumen determined by a micrometer and egg weight according to Eisen et al. (1962). Albumen index (AI) = height/diameter mean x100.Yolk index was calculated according to Funk (1948) where, Yolk index = (yolk height (mm)/yolk diameter (mm) x 100. Yolk Weight (YW) was measured and egg albumen weight were calculated by difference where albumen weight= egg weight – (shell wt + yolk wt). Yolk % = YW/EW*100. Albumen %= AW/EW*100. The yolk height and diameter readings were measured by Vernier Caliber to the nearest mm.

Shell index (SI) was calculated according to Sauveur (1988) using the formula; SI=SW/S×100, where SW is the shell weight (g) and S the surface area (cm^2). S is calculated from the egg weight (EW) from the equation $S = K \times EW^{2/3}$ where K is 4.67, 4.68, or 4.69, depending on egg weight, for eggs less than 60 g, between 60 and 70 g, or greater than 70 g, respectively.

Relative economical efficiency:

Relative economical efficiency was calculated from the input-output analysis as the economical efficiency of the treatment over the economical efficiency of control one by 100. The values of economical efficiency were calculated according to the price of the experimental diets and eggs produced as the net revenue per unit of total costs of consumed feed. Prices of the supplemented Vit. A was taken in the consideration.

Statistical methods:

The data pooled through the experiment were statistically analyzed by General Linear Model procedures (GLM) described in SAS User's Guide (SAS, Institute, 2004). The differences among treatments means were subjected to significance by Duncan's Multiple Range-test (Duncan, 1955), where the statistical model was:

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

Y_{ij} = Observed value of a given dependent variable.

μ = Overall adjusted mean.

T_i = Fixed effect of treatments, where i=1, 2… etc.

e_{ij} = Random error associated to each observation.

RESULTS AND DISCUSSIONS

Productive performance

Table 2 are summarized the productive performance parameters affected by the experimental treatments including egg production %, egg weight g, egg mass g/hen/day, feed intake g/hen/day, feed conversion ratio (FCR) and the change in body (weight) g/hen/day.

Significant differences (p<0.05) were detected due to Vit. A supplementations in egg production%, egg mass and FCR while no significant effect on the other performance parameters (Table 2). The best performance records were obtained with group which received high level of Vit. A compared with other groups where differences were significant only with the group received 30000 IU of Vit. A/kg diet. The impact of Vit. A supplementation on egg production percentage at 5, 20, 65% and peak intervals are presented in figures from 1 to 4. The date showed that Vit. A supplementation pre and during early egg production was beneficial for hens during the peak production period especially the highest level of Vit. A supplementation (50000 IU of Vit. A/kg diet).

This experiment concluded that dietary Vit. A supplementation had beneficial effect on egg production %, average egg mass, and FCR of laying hens. Egg production % at beak period was higher with Vit. A supplementation levels from 30000 to 50000 IU than either 10000 or 20000 IU. Squires and Naber (1993) reported that Vit. A maintain the integrity of epithelial tissue and possibly the lining of reproductive tract including magnum and ovaries so, higher dietary V it. A can improve the overall integrity and functioning of reproductive tract resulting into increased egg weight especially in heat-stressed laying hens. On the same trend, the mechanism of improving egg production may be due to Vit. A regulating ovarian expression of hormone receptors and inhibiting apoptosis by means of the active metabolite, retinoic acid (Chen et al., 2016). Moreover, Vit. A supplementation more than NRC (1994) recommendations is reported to play an important role in membrane integrity restoration and, hence, normal functions of reproductive organs in heat-stressed laying hens (Lin et al., 2002; Kaya and Yildirim, 2011). The results of performance were confirmed by Mori et al. (2003) who noticed that egg weight not affected by Vit. A supplementation but egg production was enhanced. On the other hand, Mori et al. (2003) observed that feed consumption was increased and FCR was not influenced by Vit. A supplementation at 30000 IU of Vit A/kg diet compared with 0 and 15000 IU of Vit A/kg diet. Lin et al. (2002) observed that high level of Vit. A supplementation (9,000 IU/kg) had a beneficial effect on laying performance of hens compared to control group (3,000 IU/kg), but no significant effects on egg weight and feed efficiency were observed. Also, the Vit. A supplemental levels did not have a significant effect on feed intake, egg production%, and body weight loss of experimental birds (p>0.05). However, egg weight, was significantly affected by different levels of Vit. A supplementation. Moreover, feed efficiency was not influenced by the supplementation of Vit. A, but was decreased significantly by the high level of Vit. A. Chen et al. (2015) noticed significant (p<0.05) increase in egg production%, egg mass and FCR values due to Vit. A supplementation. Egg production % in birds fed diet containing 21,600 IU Vit. A /kg was significantly more than those birds fed 5,400 IU Vit. A/kg. On the other hand, Sule et al. (2001)

reported that Vit. A addition (0 and 10000 IU/kg diet) resulted in no significant differences in body weight, egg production %, egg weight, feed intake and feed conversion among the groups of hens receiving experimental diets. Ahmad et al. (2013) observed that the higher egg weight and mass of hens fed higher Vit. A supplementation (10000 IU/kg diet) than those fed 3000 IU Vit. A/kg diet. Yuan et al. (2014) noticed that average egg weight was not affected by different levels of Vit. A from 5000 to 35000 IU/kg.

Egg quality:

The effect of Vit. A supplementation on egg quality parameters are presented in Tables 3 and 4. No significant differences due to Vit. A supplementation were detected on all studied parameters either external (shell weight, percentage thickness and index and shape index %) or internal (yolk weight and percentage, albumen index, weight and percentage) egg quality except yolk index. Data showed significant decrease in yolk index with increasing Vit. A level in the diet.

Mori et al. (2003) concluded that egg quality parameters (shell index, shell thickness, and Haugh units) were not affected by Vit. A supplementations with 15000 and 30000 IU/kg diet. Also, Ahmad et al. (2013) observed that yolk weight, yolk weight as % of egg weight, yolk index, albumen weight as % of egg weight, Haugh unit, shell weight, shell thickness and shell breaking strength were not affected by Vit. A supplementation.

On the same trend, Yuan et al. (2014) was found that different supplemental levels from 5000 to 35000 IU/kg diet of Vit. A did not affect albumin height, Hugh unit, yolk color, eggshell strength, or eggshell thickness.

Economical efficiency:

Results in Table 5 are summarized the relative economical efficiency of different treatments. Supplementation of Vit. A to laying hen diets before and during early egg production did not have any additional effect on net revenue, economical efficiency and relative economical efficiency compared with hens received the control diet. However, group received 20,000 IU of Vit. A/kg diet recorded the best relative economical efficiency compared to the other groups and control.

CONCLUSION

It could be concluded that supplementation of Vit. A to pre-layer and layer diets may be beneficial to first period of lay and peak production periods. Although, the improvement of performance with Vit. A supplementation were observed, no differences were detected in relative economical efficiency.

Table(1): Chemical composition of pre-layer and layer experimental diets

Period / Ingredients	Pre-layer diet	Layer diet
Corn Grain	64.7	63.61
Soybean Meal-48.5%	22.9	24.50
Wheat Bran	5.79	0.00
Soybean Oil	0.00	0.80
Limestone	4.00	8.80
Di-Calcium Phosphate	1.78	1.42
Salt	0.35	0.35
Vitamin & mineral premix[1]	0.30	0.30
DL-Methionine	0.08	0.12
Anti-Mycotoxins	0.10	0.10
Total	100.0	100.0
Calculated analysis[2]		
Metabolizable energy K.Cal/kg	2801	2800
Crude protein %	17.52	17.3
Calcium%	2.00	3.73
Available Phosphorus %	0.45	0.38
Methionine %	0.38	0.40
Lysine%	0.88	0.89
Methionine + Cysteine %	0.68	0.69

Vitamin A as retinol (1 million IU/g) was used to formulate the experimental diets.
[1]Each 1 kg basal diet contains: vitamin D3, 2500 IU; vitamin E, 20 mg; vitamin K3, 3.0 mg; vitamin B_1, 1.0 mg; vitamin B_2, 5.0 mg; vitamin B_6, 3.0 mg; Vitamin B_{12}, 0.015 mg; pantothenic acid, 10.0 mg; nicotinic acid, 30 mg; folic acid, 1.0 mg; Biotin, 0.05 mg; manganese, 100 mg; zinc, 60 mg; iron, 33 mg; copper, 9 mg; iodine, 1.0 mg; selenium, 0.3 mg; and cobalt, 0.20 mg.
[2] According to NRC (1994).

Table (2): Effect of vitamin A supplementation before and during egg production on productive performance of laying hens from 16 to 30 wks of age

Parameters / Treatments*	Egg production %	Egg weight (g)	Egg mass (g)	Feed Intake (g)	FCR	The change in daily body weight (g)/hen	
						To first egg	To peak production
Treatment 1	61.1^{a}±0.58	58.5±0.46	35.8^{ab}±0.22	101.2±0.53	2.83^{ab}±0.02	12.9±0.77	3.43±0.24
Treatment 2	61.6^{a}±0.49	58.0±0.21	35.8^{ab}±0.34	101.6±0.78	2.84^{ab}±0.02	13.0±0.85	3.62 ±0.44
Treatment 3	59.7^{b}±0.51	57.5±0.58	34.3^{b}±0.54	100.4±0.97	2.92^{a}±0.05	12.2±0.84	4.27±0.47
Treatment 4	61.7^{a}±0.15	58.0±0.53	35.8^{ab}±0.39	102.6±0.50	2.87^{ab}±0.02	12.6±0.44	4.01±0.25
Treatment 5	62.2^{a}±0.22	59.1±0.65	36.7^{a}±0.46	102.9±0.67	2.80^{b}±0.02	13.0±0.89	3.56 ±0.23
P value	0.005	0.11	0.01	0.21	0.05	0.95	0.45

* Treatment 1 is control diet was supplemented with 10000 IU vitamin A/kg and the treatments from 2 to 5 were supplemented with 20000, 30000, 40000 and 50000 IU vitamin A/kg, respectively.

a, b … Means in each column bearing the same superscripts are not significantly different ($p<0.05$).

Table (3): Effect of vitamin A supplementation before and during egg production on yolk and albumen quality of laying hens from 16 to 30 wks of age

Parameters / Treatments*	Yolk			Albumen		
	index (%)	**Weight (g)**	**Percentage (%)**	**index (%)**	**weight (g)**	**Percentage (%)**
Treatment 1	42.5^{a}±0.28	13.8±0.37	22.0±0.51	13.1±0.82	42.6±0.74	67.8±40
Treatment 2	40.9^{b}±0.19	13.8±0.50	22.8±0.50	13.0±0.70	40.5±0.88	66.7±0.58
Treatment 3	39.9^{c}±0.53	14.1±0.07	22.1±0.31	13.5±0.56	43.4±0.83	68.0±0.38
Treatment 4	39.3^{c}±0.63	14.6±0.50	23.2±0.64	13.5±0.54	42.1±0.22	66.6±0.57
Treatment 5	39.9^{c}±0.89	13.9±0.21	22.3±0.24	12.0±0.32	42.1±0.42	67.4±0.22
P value	0.02	0.53	0.35	0.38	0.11	0.14

* Treatment 1 is control diet was supplemented with 10000 IU vitamin A/kg and the treatments from 2 to 5 were supplemented with 20000, 30000, 40000 and 50000 IU vitamin A/kg, respectively.

a, b, c… Means in each column bearing the same superscripts are not significantly different ($p<0.05$).

Table (4): Effect of vitamin A supplementation before and during egg production on shell quality, Haugh units and shape index of laying hens from 16 to 30 wks of age

Parameters / Treatments*	Shape index (%)	Haugh Units (%)	Shell			
			Thickness mm	Weight g	Percentage%	Index%
Treatment 1	79.9±0.57	93.0±2.32	0.436±0.008	6.37±0.23	10.1±0.23	8.61±0.23
Treatment 2	79.1±0.36	93.7±1.77	0.444±0.013	6.40±0.19	10.5±0.17	8.86±0.15
Treatment 3	80.3±0.66	94.0±1.48	0.431±0.010	6.37±0.21	10.0±0.27	8.52±0.24
Treatment 4	79.6±0.60	94.2±1.54	0.440±0.007	6.47±0.07	10.3±0.12	8.72±0.09
Treatment 5	79.8±0.48	90.7±1.36	0.433±0.004	6.44±0.06	10.3±0.07	8.74±0.06
P value	0.66	0.56	0.85	0.99	0.29	0.65

* Treatment 1 is control diet was supplemented with 10000 IU vitamin A/kg and the treatments from 2 to 5 were supplemented with 20000, 30000, 40000 and 50000 IU vitamin A/kg, respectively.

Table (5): Effect of experimental treatments on relative economical efficiency

Parameters[1] / Treatments[2]	Input			Output			EE	REE (%)
	FC	PF	TFC	TEP	TR	NR		
Treatment 1	8.50	4.925	41.87	51.3	64.155	22.29	0.53	100.0
Treatment 2	8.53	4.930	42.08	51.7	64.680	22.60	0.54	100.9
Treatment 3	8.43	4.935	41.62	50.1	62.685	21.06	0.51	95.1
Treatment 4	8.62	4.940	42.58	51.8	64.785	22.21	0.52	98.0
Treatment 5	8.64	4.945	42.74	52.2	65.310	22.57	0.53	99.2

[1]FC= feed consumed/hen (kg), PF= price of 1 kg feed (LE), TFC = total feed cost (FC*PF) (LE), TEP = total egg produced (number), TR=Total revenue = TEP * price of one egg (1.25 LE), NR = net revenue = TR-TFC (LE), EE = NR/TFC and REE = relative economical efficiency = EE of treatment/EE of control treatment.

[2]Treatment 1 is control diet was supplemented with 10000 IU vitamin A/kg and the treatments from 2 to 5 were supplemented with 20000, 30000, 40000 and 50000 IU vitamin A/kg, respectively.

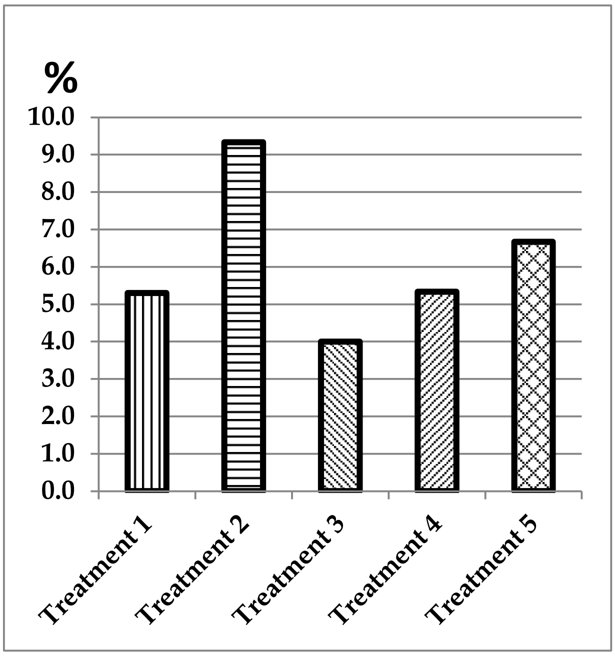

Figure 1: Effect of vitamin A supplementation from 10000 to 50000 IU/kg on 5% hen-day egg production.

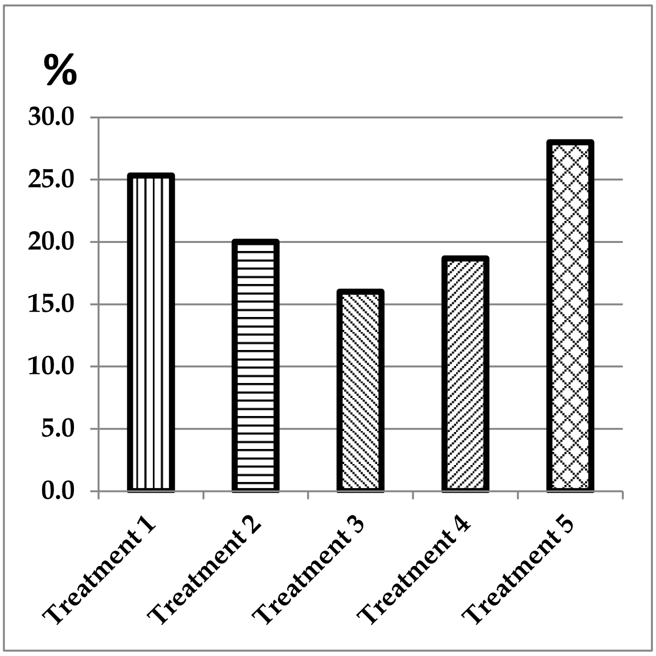

Figure 2: Effect of vitamin A supplementation from 10000 to 50000 IU/kg on 20% hen-day egg production.

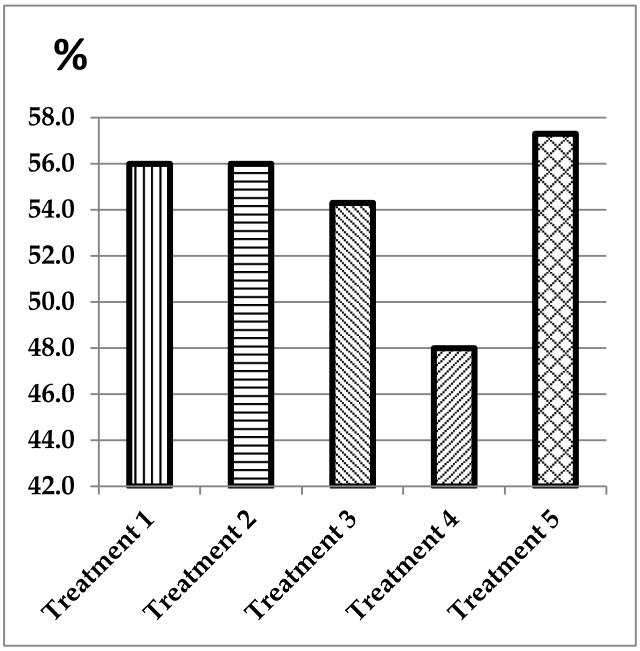

Figure 3: Effect of vitamin A supplementation from 10000 to 50000 IU/kg on 65% hen-day egg production.

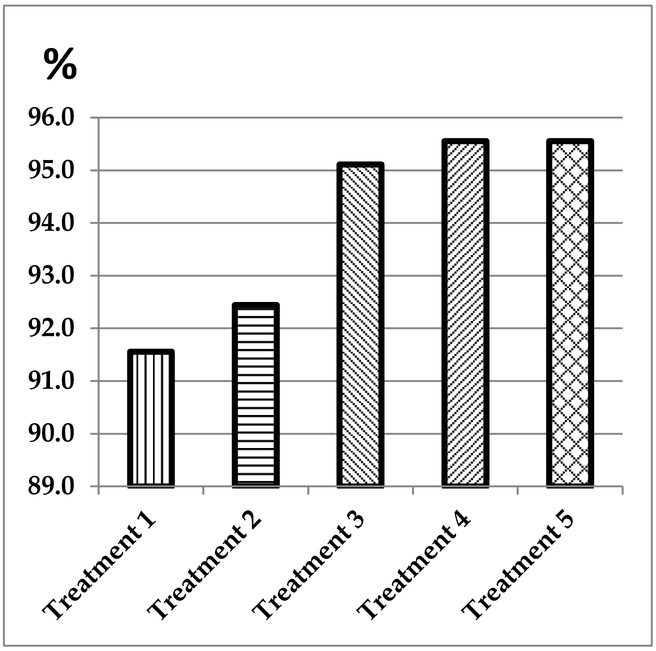

Figure 4: Effect of vitamin A supplementation from 10000 to 50000 IU/kg on peak hen-day egg production%.

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الملخص العربى

أثر فيتامين أ فى عليقتى قبل الإنتاج وبداية الإنتاج على الأداء الإنتاجى للدجاج البياض

هانى محمد رمضان الشريف

قسم الإنتاج الحيوانى- كلية الزراعة – جامعة القاهرة – الجيزة – جمهورية مصر العربية

تم دراسة تأثير إضافة فيتامين أ قبل وأثناء إنتاج البيض خلال المرحلة الأولى على الأداء الإنتاجي وجودة البيضة والكفاءة الإقتصادية للدجاج البياض. تم تغذية عدد 375 دجاجة من نوع اللوهمان البنى على عليقة أساسية تحتوى على مستويات متدرجة من فيتامين أ : 10000 ، 20000، 30000، 40000 ، 50000 وحدة دولية/كجم. تم تقسيم الطيور فى كل مجموعة عشوائياً إلى 5 مكررات و15 طائر لكل مكرر. تم تقديم العلف والمياه حتى الشبع تحت نظام إضاءة 16 ساعة/يوم طوال فترة التجربة. تم تسكين الطيور فى بطاريات هرمية نظيفة تحت ظروف متشابهة حتى الاسبوع 30 من العمر.

وكانت النتائج المتحصل عليها كالتالى:

تحسن كلاً من إنتاج البيض % و كتلة البيضة وكفاءة التحويل الغذائى معنوياً مع إضافة فيتامين أ. تحسن إنتاج البيض % عند أقصى إنتاج فى المجاميع المغذاة على مستوى 30000 و 40000 و 50000 وحدة دولية من فيتامين أ/كجم بالمقارنة بكلاً من تلك المغذاة على 10000 او 20000 وحدة دولية فيتامين أ/كجم. لم يؤثر إضافة فيتامين أ فى العلائق على أياً من مقاييس جودة البيضة الداخلية أوالخارجية عدا دليل الصفار الذى إنخفض معنوياً مع زيادة فيتامين أ فى العلائق. أعطت المجموعة المغذاة على 20000 وحدة دولية فيتامين أ/كجم أفضل كفاءة إقتصادية نسبية بالمقارنة بباقى المجاميع.

نستنتج من تلك التجربة أنه بالرغم من أن المجموعة المغذاة على 50000 وحدة دوية فيتامين أ/كجم قبل وأثناء بداية إنتاج البيض حسنت من الأداء إلا أن المجموعة المغذاة على 20000 وحدة دولية فيتامين أ/كجم أعطت أفضل كفاءة إقتصادية نسبية مقارنة بباقى المجموعات.

الكلمات المفتاحية: فيتامين أ، الأداء الإنتاجى، دجاج إنتاج البيض.