Egypt.Poult.Sci.Vol (38)(II): (637-656)(2018) **(1804-1023)**

Egyptian Poultry Science Journal

http://www.epsj.journals.ekb.eg/

ISSN: **1110-5623** (**Print**) **– 2090-0570** (**Online**)

EFFECT OF VITAMIN K_3 ON CHICKEN PRODUCTION PERFORMANCE AND BONE QUALITY 1-LATE PHASE OF EGG PRODUCTION

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Received: 30/04/2018 Accepted: 23/05/2018

ABSTRACT: The present study was designed to study the direct influence of supplementing of layers diet at late phase of egg production and housed in cages with high levels of vitamin K_3 on productive performance, eggshell parameters, tibia bone composition and histological observation, hatching traits and some blood parameters. One hundred and fifty Mandarah chicken females with thirty males were individually housed in cages from 55 up to 67 weeks of age. The birds were randomly divided into 5 groups representing the dietary supplementation. The birds of the first group was served as control (T1) without any supplementation and fed diet contains 3 mg menadion (K_3) / kg diet . The rest 4 groups were supplemented with menadion as additional doses of vitamin K_3 source to be 7, 11,15 and 19mg menadion / kg diet for T2, T3, T4 and T5 groups respectively. Obtained results revealed that hens of T3, T4 and T5 groups represented significantly ($P\leq 0.05$) produced larger eggs , besides all supplemented groups represented highest ($P\leq 0.05$) egg mass and egg production% compared to those for control group (T1).Also, highest values of shell thickness (mm) and Ca% in eggshell were detected for eggs of T_3 and T_4 groups compared to the rest groups. Moreover, the best improvement of tibia measurements (length , width and breaking strength) and composition (weight, ash%,Ca% and P%) were recorded for hens T3 and T4 groups. Eggs produced from all supplemented groups represented significant increase of fertility and hatchability of fertile egg percentages compared to those for control one. Birds of the T3 groups recorded the highest values of the serum osteocalcin and plasma Ca, ICa, P and alkaline phosphatase. Histological observations of tibia bone for birds of T3, T4 and T5 groups illustrate the increase of medullary bone, thick outer cortical layer and osteoblasts cell activity. In conclusion, supplementing the layer diet at late phase of production and housed in cages with either 11 or 15 mg vitamin K_3 / kg diet could be a promising tool for realizing the best improvement of egg production, shell and bone quality and hatchability%.

Keywords: Vitamin K_3 – cage - aged layer – osteocalcin - bone parameters

INTRODUCTION

Vitamin K is fat soluble vitamin and available in natural and synthetic forms {K_3 (menadion)}, also vitamin K is important vitamin that prevents internal bleeding, biliary obstruction, bone metabolism, nerve signaling and kidney stone Monegue (2013). Rapid bone turnover and extensive calcium mobilization from bones for eggshell formation, bone fractures and osteoporosis in laying hens during the egg production are a concern in the poultry industry (Kim et al., 2007). In poultry, a condition involving bone loss as characteristic of osteoporosis was first described in caged laying hens by Couch (1955) who reported a problem termed cage layer fatigue bone brittleness, paralysis and death. Also, Knowles and Wilkins (1998) demonstrated that end of laying period of hens from battery cages have especially fragile bones and break easily. Osteoporosis in laying hens is defined as a decrease in the amount of fully mineralized structural bone leading to increased fragility and susceptibility to fracture (Whitehead and Fleming, 2000). By the end of the first production period, the earliest signals of loss structural bone, elevation of bone re-absorption, decline of bone mineralization and progressive fall in the blood estrogen levels prevents the formation of medullar bone (Rennie et al., 1997).

Some researches had been dedicated on right Ca source and the right granule size for improving Ca solubility and absorption for chicken but increasing Ca in the feed to minimize shell and bone problems had no desirable effect because the feed is consumed within 2 hours and the absorbed Ca is not retained in the bones but directly excreted (Laet, 2017). Also, Fisher (1983) reported that high levels of Ca depress feed intake and egg production. So, currently, there is some evidence that vitamin K affects the Ca balance (Fernandes et al., 2009). The predominant function of vitamin K is carboxylation reaction which affects bone metabolism and blood clotting (Hauschka and Reid, 1978). Many researches showed the positive role of vitamin K on bone quality and osteoporosis of elderly women (Booth et al., 2000 and Olson, 2000).Limited information is available on the aged layers but Fernandes et al. (2009) detected that positive linear effects of supplementation vitamin K to the diet on egg production, feed conversion and bone mineralization.

This experiment was undertaken on Mandarah chickens at late phase of egg production and housed in cages with different purposes of improving eggshell quality, productive and reproductive performance and bone quality focusing on controlling osteoporosis through supplementing the diet of with high levels of vitamin K_3.

MATERIALS AND METHODS

Experimental design:

The present study was performed at EL-Sabahia Poultry Research Station, Animal Production Research Institute, Agriculture Research Center. One hundred and fifty females with thirty males of Mandarah chicken strain were housed individually in galvanized cages from 55 up to 67 weeks of age. The birds were randomly divided into five groups representing the dietary supplementations with 3 replicates for each group. The birds of the first group was

served as control (T1) without any supplementation and fed diet contains 3 mg menadion / kg diet . The rest 4 groups were supplemented with menadion as additional doses of vitamin K_3 source to be 7, 11,15 and 19mg menadion (K_3) / kg diet for T2, T3, T4 and T5 groups respectively. The ingredient profile and nutrient composition of the basal diet are shown in Table 1 according to the feed composition for animal and poultry feed stuff in Egypt (2001). Birds were subjected to 16 hrs light and 8 hrs dark during the experimental period. Feed and water were provided *ad-libitium*.

Measurements:-

Feed consumption by (g) was detected for each hen every week for each treatment then calculated during the whole experimental laying period for all groups. Feed conversion ratio was calculated as amount of consumed feed (g/hen/period) required for producing a unit (g) of egg mass. At the end of experimental laying period, egg weight (g), egg production % and egg mass/ hen/ period were detected. Five fresh eggs from each replicate were randomly chosen at the end of experiment to estimate eggshell weight % and shell thickness without membranes by micrometer nearest 0.01mm. The quantities of crude ash of eggshells were determined by burning for one night in ashes oven and these ash were analyzed for calcium (Ca%) and phosphorus (P%) detection using atomic absorption.

At 67 weeks of age, 3 hens from each replicate were randomly chosen and sacrificed. Tibia bones of both sides were removed, cleaned from all soft tissues and weighed. Tibia length and width were detected using micrometer according to the method of Samejima (1990). Right tibia was used for breaking strength evaluation (Newton) in the laboratory of mechanical properties and test materials, Faculty of Engineering, Ain-Shams University according the method of Park et al.(2003). The tibia was oven dried at 105 C until constant weight and the quantities of crude ashes were detected according to Yi et al.(1996) then dissolved, filtered and calcium and phosphorus percentages were assayed by atomic absorption.. Left tibia was taken for histological observation in the Laboratory of Poultry Physiology, Faculty of Veterinary Medicine, Kafr EL- Shikh University.

Blood samples were taken from the same previous slaughtered hens . A portion of the fresh blood was used immediately for determining clotting time (second) beside measure serum osteocalcin protein (OC) (ng/ml) according to method of Jiang et al. (2013 b), estrogen hormone (E, Pg/ml) and parathyroid hormone (PTH, Pg/ml). In addition to, other portions' of blood were collected in heparinized tube for measuring alkaline phosphatase (ALP, I.u/L), calcium (Ca, mg/dl), ionized calcium (ICa, mg/dl) and phosphorus (P, mg/dl) by available commercial bio-diagnostic kits, Egypt.

At 58-wk of age, hens were inseminated twice a week with diluted semen (1:1) from cooks that received the same treated diets. One thousand hatching eggs produced from Mandarah hens representing the 5 experimental groups were incubated in Egyptian made incubator at 99.5 F and 55% RH during setting phase of incubation, egg trays were randomly distributed in the

incubator. At 18th day of incubation, the eggs were candled and macroscopic fertility was calculated as the apparent percentage of fertile eggs from total setting eggs (Rizk et al., 2008). Also eggs with evidence of living embryos were transferred to hatcher and incubated at 99 F and 70%RH. Hatchability of fertile eggs% was determined. Eggs that failed to hatch at the end of incubation and having full opportunity for hatching were broken out and then examined with naked eye to estimate embryonic mortalities % during intervals 1-7, 8-14 and 15-21 days of incubation. Body weights (g) for all hatched chicks at the time of removal from the hatcher were recorded and termed as chick weight at pull out.

Statistical analysis:

Data obtained were statistically analyzed using General Linear Models (GLM) of **SAS (2004).** The significant differences among treatment means were tested according to **Duncan (1955).**

The flowing model was used

$Y_{ijk}= \mu+L_i+ e_{ijk}$

Y_{ijk}= observed traits

μ= the overall mean

L_i= vitamin K_3 effect (1,2,3,4,5)

e_{ijk}= random error.

RESULTS AND DISCUSSION

Productive performance:

Results of productive performance for Mandarah hens throughout the three experimental months representing the late phase of egg production as affected by vitamin K_3 supplementation are shown in Table 2. Egg produced from birds of T3, T4 and T5 groups represented significant increase ($P\leq 0.05$) of egg weight compared to those for control group (T1). Moreover, all supplemented groups with vitamin K_3 recorded the highest ($P\leq 0.05$) egg mass and egg production% compared to control with maximum records ($P\leq 0.05$) for T3and T4 groups. In addition to, hens of T2, T3 and T4 groups significantly consumed less amount of feed compared to those for T5 and control groups. Furthermore, supplemented the diet with all vitamin K_3 levels significantly (($P\leq 0.05$) improved feed conversion ratio with better ($P\leq 0.05$) values for T3andT4 groups compared to control one.

The current results regarding the positive response of egg production% and feed conversion with vitamin K_3 supplementation are in harmony with that reported by Fernandes et al. (2009) who pointed out that there are positive linear effects of vitamin K on egg production and feed conversion. Regarding egg weight, the same previous authors found contradicted results as vitamin K supplemented diet affected egg weight in decreasing form.

The significant improvement of feed conversion for all supplemented groups with vitamin K_3 could be related to the role of vitamin K on digestive enzymes as Thijssen and Drittij-Reijnders (1994) stated that the high presence of the vitamin K on the pancreas suggests a role in activating digestive enzymes.

Eggshell parameters:

Data of Table 3 display the effect of dietary vitamin K_3 on some egg shell parameters. It can be observed from data of this table that all supplemented levels of vitamin K_3 significantly increased eggshell weight % ,shell thickness (mm), Ca% and P% compared to that for control group. Moreover, supplementing the diet with

11mg K_3 /Kg diet (T_3) represented the highest values of egg shell weight percentage compared to other groups. Furthermore, highest values of thickness and Ca% in the eggshell were detected for eggs of T_3 and T_4 groups compared to the rest groups. The detected results could be due to vitamin K_3 supplementation .Contradicted results were documented by Fernandes *et al.(*2009) who showed that vitamin K did not influence shell yield% and shell thickness. These differences in the results could be due to using different concentrations of vitamin K in both researches.

The increased values of shell weight and shell thickness for eggs of T_2, T_3, T_4 andT_5 groups could be related to the increase of Ca% compared to control. This conclusion is keeping with those reported by Juliet (2004) who showed that the egg shell quality may be affected by age of hen, breeding in cage, Ca, P, vitamins and inorganic protein of the egg shell. Also, Mona et al. (2016) mentioned that increase of eggshell Ca% could be the reason of the increase of egg shell thickness. Moreover, Laet (2017) reported that quality of shell is also determined by the quantity of Ca in the shell. In addition, the significant increase of shell weight% and shell thickness for eggs of the treated groups (T3,T4 andT5) could be related to the proven increase of egg weight (Table 2) and this conclusion is previously documented by Rizk et al.(2008).

Tibia bone measurements and composition:

Data of tibia measurements and composition as affected by vitamin K_3 supplementation are summarized in Table 4. As can be noted from these data that supplementation all levels of vitamin K_3 significantly ($P\leq 0.05$) improved tibia measurements (length, width breaking strength) and composition (weight, ash%,Ca% and P%) compared with control group. Moreover, the best improvements of all tibia measurements and composition were recorded for hens fed both concentrations of vitamin K_3 in T3 and T4 groups.

The previous results are generally in harmony with the previous research reported by Fleming *et al*. (1998) who found that significant reductions in bone losses were observed near the end of the laying period supplemented with high vitamin K levels. Also, Fernandes *et al.* (2009) indicated that the supplementation of 17.5 mg/Kg diet of vitamin K was required to achieve good bone mineralization. Moreover, Booth *et al*. (2000) and Duggan et al. (2004) observed that an insufficient vitamin K intake which caused decrease of carboxylated osteocalcin protein and this related to increase incidence of hip fracture of elderly woman.

The increase of tibia Ca% and P% for hens fed diet supplemented with vitamin K_3 could be the reason of increasing bone ash% and breaking strength. Different researches were published to support this notion as Rath *et al*. (2000) showed that the mineral matrix is predominantly Ca and P in from of hydroxyapatite which constitutes 60 to 70% of bone weight and provides stiffness and compressional strength to the bone. Also, Moreki (2005) mentioned that Ca plays an important role in bone formation and development. In addition to

Fernandes *et al.* (2009) suggested that vitamin K increase non collagenous proteins like osteocalcin in bone and contributed to bone calcification.

The detected improving of bone quality due to vitamin K_3 supplementation as shown in Table (4) could be a major factor for improving egg shell quality (Table 3) and this outcome is in harmony with the conclusion of Miller (1992) who reported that bone is intriguing in laying hens because of the phenomenal demands for Ca in eggshell formation.

Hatching traits:

As can be seen from data of Table 5 that macroscopic fertility and hatchability of fertile egg percentages were significantly higher for all supplemented groups compared to those for control one. With respect to embryonic mortality, T3 and T4 groups had the lowest records during 1-7 days of incubation, while no significant differences were observed in embryonic mortality among all groups during 8-14 days of incubation. Moreover, all supplementation levels of vitamin K significantly ($P\leq 0.05$) decreased embryonic mortalities during 15-21days of incubation. Aged layers of T3, T4 and T5 groups produced largest ($P\leq 0.05$) weight of chick at pull out compared to those for T2 and control groups.

As previously indicated there is little collaborative data on the direct response of fertility and hatching traits to vitamin K_3 supplementation. Eibhlís et al.(2017) found that vitamin K has important role on human fertility and osteocalcin is thought to up-regulate the synthesis of the enzymes needed for the biosynthesis of testosterone thereby increasing male fertility.

The increase of hatchability percentage of vitamin K_3 supplemented groups was mainly due to diminishing the number of embryonic death. Also, the combined results of increasing hatchability % and decreasing embryonic mortality due to vitamin K_3 supplementation could be related with improvement egg shell measurements as detected in Table (3). This explanation is keeping with previous report by Rizk et al. (2008) who stated that hatchability % could be affected by egg shell thickness. Also, Sergyva (1986) observed that an increase in shell thickness of one micrometer led to an increase in hatchability of about 2%. Furthermore, Wesam et al. (2017) showed that eggs with less shell thickness had higher egg weight loss, pore numbers and eggshell conductance leading to decrease hatchability % due to hypocapnia condition and consequently decrease of T3 and corticosterone hormones level. Also, Nakagawa et al.(2014) discovered that an enzyme called UBIAD1, which is involved in vitamin K_2 synthesis, is required for development of mouse embryos and when they deleted both copies of the gene coding for UBIAD1 mice embryos died in less than 8 days after ceasing to grow, and as expected, produced no vitamin K_2. Strikingly, when the mothers of these mutant mice were administered vitamin K_2, the embryos lifespan was extended to term. Baldoceda-Baldeon et al.(2014) found that vitamin K_2 supplementation significantly improved embryo production in cows and this may be due to the role of vitamin K_2 in mitochondria function, which converts sugars into energy for the cells to use and it helps regulate menstrual cycle.

It seems that chick weight increase for groups of vitamin K_3 supplementation could be due to the increase of egg weight (Table 2) for the same groups and this notion are confirms by Rizk et al. (2006) and Celen et al. (2009) who mentioned that there is a positive linear correlation between egg weight and hatched chick weight.

Blood parameters:

Data of Table 6 show the effect of dietary supplementation of vitamin K_3 on clotting time, serum OC , E and PTH hormones, besides plasma Ca, ICa, P and AP for aged Mandarah hens. All supplemented groups vitamin K_3 had numerical decreased of clotting time compared to those for control one. Also supplemented groups with all levels of vitamin K_3 represented significant ($P\leq 0.05$) increase of serum OC and plasma Ca, ICa, P and AP compared to control. Besides, birds of the T3 groups (11 mg vitamin K_3/ kg diet) showed the highest values of the previous mentioned parameters. Opposite trend was observed as serum PTH level was increased ($P\leq 0.05$) for control group compared to other supplemented groups. While all supplemented groups with vitamin K_3 had numerical increased of E hormone compared to those for control.

However, there is little actual data published concerning the effect of vitamin K_3 on the mentioned blood parameters for layer chickens. Aforementioned results are in harmony with the results of Knapen et al. (1989) who showed that, vitamin K induced increased of serum OC concentration in the postmenopausal women. Also, Zhang et al. (2003) found that, serum OC increased linear ($P\leq 0.05$) with increasing supplementation of vitamin K to broiler diet. Caroline et al. (2015) showed that the concentration of AP had a quadratic effect with increasing the level of vitamin K, whereas the same pervious author found no significant differences in Ca and AP levels by vitamin K supplementation to diet.

Taken together improvement of eggshell (Table 3) plus measurements and composition of tibia bone (Table 4) for Mandarah hens at late phase of production could be correlated with the increase of serum increase of OC and plasma Ca, P, ICa and AP due to vitamin K_3 supplementation. Fleming et al. (2006) reported that, the progressive loss of structural bone during the laying period weakness the skeleton and increase the risk of fracturing bone, characteristic of osteoporosis. Also, osteocalcin dosage in the blood is an important marker of bone formation, bone remodeling and the development of osteoporosis (Dores et al., 2001). Moreover, bone contains small protein osteocalcin rich in amino acid ɤ carboxyglutamate which is dependent on vitamin K for its synthesis (Hauschka and Reid, 1978). Also, the same authors added that, vitamin K is involved in bone metabolism via carboxylation reaction in which glutamic acid residues (GLA) transform the g – carboxyglutamic acid (γ GLA) in blood and bone resulting in γ GLA residues facilitate binding Ca^{+2} (ICa) to the OC protein. Furthermore Fernandes et al. (2009) pointed out that, low level of vitamin K induces the synthesis of non-carboxyled OC that presents poor affinity for hydroxyapatite leading to a deficient

bone mineralization. Moreover, Jiang et al. (2013a) detected that, serum OC had positive relationship with bone density and tibia bone strength.

Regarding Ca and P and their relations with vitamin K Moreki (2005) detected that special relationship between Ca and P in bone and eggshell formation and the most of Ca is used for shell formation, also they mentioned that, ICa increases bone strength and bounded to OC protein molecules. Furthermore, Jiang et al. (2010) stated that, better eggshell quality and breaking strength could be due to the higher blood Ca.

In addition, AP is a sign of mature osteoblasts and osteoblasts secrete large amounts of AP in the blood indicating active inorganic P deposit in bone matrix, therefore the greater AP activity is good indicator of bone formation and metabolism (Li et al., 2014).

The current results of Ca and ICa increase in the blood and PTH decrease due to increasing of vitamin K_3 in the diet are indirectly documented by Moreki (2005) who showed that, the level of Ca and ICa in the blood are getting low, which secretes extra PTH to induce the kidney to produced more 1.25-$(OH)_2 D_3$ and in turn losses more Ca from skeleton.

Also, the end result of lower estrogen hormone, OC increase combining with the PTH diminish due to vitamin K_3 supplementation in our results could be interpreted on the light of the results of Khosla et al. (1997) who observed that E deficiency may be responsible not only for the increase in bone turnover in early postmenopausal woman but also indirectly for hyperparathyroidism. Moreover, Hansen et al.(2003) observed that dramatic decrease in E in hens at 70-wk of age, besides the changes in egg production, shell and bone quality are attributed to changing hormone profiles (like E hormone), decreased sensitivity of tissues to hormone action, diminish ability of the hen to transport Ca at the duodenum. Moreover, Beck and Hansen (2004) added that E deficiency induces osteoclastic resorption.

In conclusion, vitamin K_3 boosts the carboxylation of OC and this protein have a higher affinity for Ca which could be incorporated into the improvement happened for bone and eggshell quality.

Histological observation of tibia bone:

Figure 1 illustrates cross sections showing the effect of dietary vitamin K_3 on tibia bone. Sections of tibia bone of control group showed marked thinning outer cortical layer, marked loss of medullary bone, incidence of osteoporosis and decreased of osteoblasts activity. While, pictures of tibia bone for birds of T3, T4 and T5groups illustrate that dense and increased of medullary bone, thick outer cortical layer and increased of osteoblasts activity. Whereas, T2 showed moderate increase of medullary bone and osteoblasts activity. All sections of tibia bone for all vitamin K groups did not show any incidence of osteoporosis.

Limited information is available on the direct histological observation of tibia bone as influenced by vitamin K supplementation to layers diet. Knapen et al. (1989) detected that vitamin K is one factor that may play important role in decreased osteoporosis in postmenopausal women. Also, Iwamoto et al. (2011) found that administration of vitamin K_2 to rats

increases bone remodeling with increasing of periosteal and endocortical bone formation. Also, Zhang et al. (2016) demonstrated that vitamin K_2 yielded beneficial effect for subchondral bone trabecula of femoral head in rats.

CONCLUSION

Data presented herein regarding the real requirements of Mandarah birds as example of local breed at late stage of egg production and housed in cages proved that supplementing the diet with high levels of vitamin K_3 either at 11 or 15 mg/ kg diet could play a vital role for improving productive performance, shell and bone quality, hatching traits besides controlling osteoporosis disease as a sign of metabolic bone disorder.

Table (1): Composition and analysis of the basal experimental layer diet

Ingredients	kg/Ton
Yellow corn (8.2 % CP)	663.30
Soybean meal (48% CP)	242.0
Limestone	75.00
Dicalcium phosphate	13.20
Vit+Min Premix[1]	2.50
Sodium chloride (NaCl)	2.50
DL-Methionine	1.50
Total	1000.00
Calculated analysis	
ME, Kcal/Kg	2777
CP, %	17.06
Ether extract , %	2.90
Crude fiber, %	4.10
Methionine, %	3.91
Meth.+Cys.(TSAA) %	0.67
Lysine, %	0.80
Calcium, %	3.10
Av.Phos,%	0.42
Chemical analysis (AOAC,2000)	
Dry matter, %	90.73
Crude protein, %	16.97
Ether extract , %	2.45
Crude fiber, %	3.96
Ash, %	6.37
Nitrogen free extract, (NFE) %	60.98

Vit+Min mixture provides per Kilogram of diet: Vit. A, 1200 IU; Vit. E, 10 IU; menadione, 3 mg; Vit. D_3, 2200 ICU; riboflavin, 10mg; Ca pantothenate, 10mg; nicotinic acid, 20 mg; Choline chloride, 500mg, Vit. $B_{12,}$ 0.01mg; Vit.$B_{6,}$ 1.5mg; Vit.$B_{1,}$ 2.2mg; Folic acid, 1mg; Biotin, 0.05mg. Trace mineral (milligrams per kilogram of diet) Mn.55; Zn. 50; Fe. 30; Cu. 10; Se. 0.10; Anti oxidant. 3mg.

Table (2) : Effect of dietary vitamin K_3 on some productive performance of Mandarah hens during the late phase of egg production (Means ±SE)

Items	Vitamin K_3 (mg/Kg diet)				
	T1 (control,3mg)	**T2 (7mg)**	**T3 (11mg)**	**T4 (15mg)**	**T5 (19mg)**
Egg weight (g)	53.14 ± 0.30^{d}	53.51 ± 0.18^{cd}	54.96 ± 0.24^{a}	54.16 ± 0.20^{bc}	54.24 ± 0.25^{b}
Egg mass (g/hen/period)	640.43 ± 17.56^{c}	728.39 ± 11.36^{b}	901.18 ± 17.64^{a}	896.38 ± 21.08^{a}	752.21 ± 10.24^{b}
Egg production (%)	42.94 ± 0.98^{c}	48.63 ± 0.66^{b}	58.28 ± 0.92^{a}	58.99 ± 1.14^{a}	49.47 ± 0.51^{b}
Feed consumption (g/hen/period)	3651.04 ± 26.99^{a}	3501.84 ± 35.89^{b}	3368.87 ± 29.02^{c}	3496.26 ± 23.58^{b}	3605.85 ± 19.33^{a}
Feed conversion ratio (g feed/ g egg mass)	6.11 ± 0.17^{a}	4.96 ± 0.08^{b}	3.83 ± 0.06^{c}	4.09 ± 0.09^{c}	4.85 ± 0.05^{b}

a,b,c and d means having different letters in the same row are significantly different ($P \leq 0.05$).

Table (3): Effect of dietary vitamin K_3 on some eggshell parameters of Mandarah hens during the late phase of egg production (Means ±SE)

Items	Vitamin K_3 (mg/Kg diet)				
	T1(control ,3mg)	T2 (7mg)	T3 (11mg)	T4 (15mg)	T5 (19mg)
Egg shell weight (%)	10.79 ± 0.12^{b}	11.62 ± 0.28^{a}	11.69 ± 0.29^{a}	11.56 ± 0.29^{a}	11.48 ± 0.13^{a}
Shell thickness without membranes (mm)	0.294 ± 0.35^{d}	0.320 ± 0.29^{c}	0.332 ± 0.50^{b}	0.344 ± 0.28^{a}	0.320 ± 0.41^{c}
Calcium % (Ca%)	30.00 ± 0.28^{c}	38.10 ± 0.28^{b}	39.20 ± 0.28^{ab}	39.00 ± 0.28^{ab}	38.11 ± 0.28^{b}
Phosphorus% (P%)	0.105 ± 0.01^{c}	0.130 ± 0.14^{b}	0.148 ± 0.01^{a}	0.139 ± 0.01^{b}	0.139 ± 0.01^{b}

a,b,c and d means having different letters in the same row are significantly different (P≤0.05).

Table (4): Effect of dietary vitamin K_3 on tibia bone measurements and composition of Mandarah hens during the late phase of egg production (Means ±SE)

Items	Vitamin K_3 (mg/Kg diet)				
	T1 (control,3mg)	T2 (7mg)	T3 (11mg)	T4 (15mg)	T5 (19mg)
Tibia bone measurements					
Tibia length (mm)	120.1 ± 0.28^{d}	130.00 ± 0.28^{c}	135.10 ± 0.28^{a}	135.30 ± 0.17^{a}	132.00 ± 0.28^{b}
Tibia width (cm)	0.63 ± 0.001^{d}	0.77 ± 0.001^{c}	0.81 ± 0.001^{a}	0.80 ± 0.001^{a}	0.79 ± 0.001^{b}
Breaking strength(N)	252.11 ± 0.02^{e}	264.70 ± 0.02^{c}	321.60 ± 0.02^{a}	301.70 ± 0.02^{b}	260.80 ± 0.02^{d}
Tibia bone composition					
weight (g)	12.50 ± 0.002^{e}	13.57 ± 0.001^{d}	15.20 ± 0.002^{b}	15.50 ± 0.002^{a}	13.73 ± 0.002^{c}
Ash (%)	44.80 ± 0.02^{c}	54.70 ± 0.02^{b}	56.21 ± 0.02^{a}	56.10 ± 0.02^{a}	55.00 ± 0.02^{ab}
Calcium % (Ca%)	19.50 ± 0.02^{b}	24.20 ± 0.02^{a}	25.00 ± 0.28^{a}	24.80 ± 0.02^{a}	24.00 ± 0.28^{a}
Phosphorus % (P%)	8.16 ± 0.01^{e}	10.05 ± 0.01^{d}	10.64 ± 0.03^{a}	10.30 ± 0.02^{b}	10.12 ± 0.03^{c}

a,b,c,d, and e means having different letters in the same row are significantly different (P≤0.05).

Table (5) : Effect of dietary vitamin K_3 on hatching traits of Mandarah hens during the late phase of egg production (Means ±SE)

Items	Vitamin K_3 (mg/Kg diet)				
	T1 (control,3mg)	**T2 (7mg)**	**T3 (11mg)**	**T4 (15mg)**	**T5 (19mg)**
Embryonic mortality %					
1-7 day	4.03 ± 0.46^{a}	4.29 ± 0.03^{a}	2.59 ± 0.87^{b}	2.02 ± 0.64^{b}	$3.18 \pm 1.04a^{b}$
8-14 day	2.58 ± 0.93	1.45 ± 0.91	1.96 ± 1.23	2.32 ± 0.74	1.66 ± 1.05
15-21 day	6.49 ± 0.44^{a}	4.29 ± 0.03^{b}	4.55 ± 0.52^{b}	3.30 ± 0.17^{c}	3.00 ± 0.96^{c}
Fertility%	93.49 ± 0.03^{c}	96.72 ± 0.03^{b}	97.38 ± 0.03^{a}	97.96 ± 0.03^{a}	96.80 ± 0.03^{b}
Hatchability of fertile eggs %	80.39 ± 1.30^{c}	85.69 ± 0.66^{b}	88.28 ± 0.64^{a}	90.33 ± 0.61^{a}	88.96 ± 0.24^{a}
Chick weight at pull out (g)	35.82 ± 0.19^{b}	36.36 ± 0.46^{b}	37.32 ± 0.33^{a}	38.22 ± 0.24^{a}	37.46 ± 0.41^{a}

a,b,c, and d means having different letters in the same row are significantly different ($P \leq 0.05$).

Table (6) : Effect of dietary vitamin K_3 on some blood parameters of Mandarah hens during the late phase of egg production (Means ±SE)

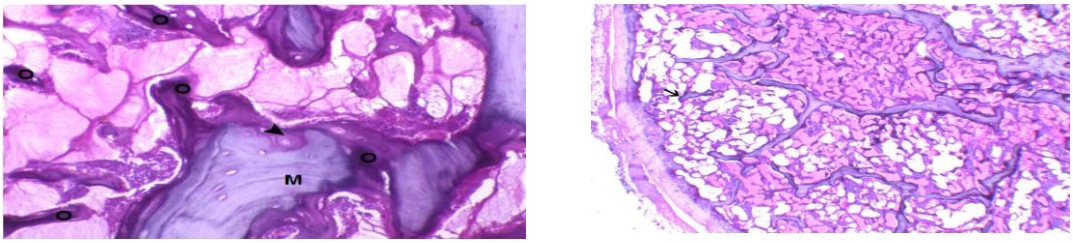
Items	Vitamin K_3 (mg/Kg diet)				
	T1(control,3mg)	**T2 (7mg)**	**T3 (11mg)**	**T4 (15mg)**	**T5 (19mg)**
Clotting time (second)	12.09±0.03	12.03±0.02	11.96±0.03	11.93±0.01	11.91±0.02
Osteocalcin protein (OC) ng/ml	3.70 ± 0.02^{d}	6.51 ± 0.02^{c}	7.2 ± 0.02^{a}	6.91 ± 0.02^{b}	6.82 ± 0.02^{b}
Calcium (Ca) mg/dl	16.81 ± 0.03^{d}	18.70 ± 0.02^{c}	22.21 ± 0.02^{a}	21.76 ± 0.84^{b}	18.55 ± 0.02^{c}
Ionized calcium(ICa) mg/dl	3.26 ± 0.01^{c}	5.80 ± 0.03^{b}	6.17 ± 0.01^{a}	6.15 ± 0.01^{a}	5.91 ± 0.02^{b}
Phosphorus (P) mg/dl	5.90 ± 0.03^{c}	6.48 ± 0.04^{a}	7.45 ± 0.01^{a}	7.38 ± 0.01^{ab}	6.84 ± 0.01^{b}
Alkalin phosphatase (AP) I.U./L	24.5 ± 0.02^{d}	35.20 ± 0.02^{c}	38.03 ± 0.02^{a}	38.00 ± 0.02^{a}	36.40 ± 0.02^{b}
Estrogen hormone(E) pg/ml	397.20 ± 0.28	400.00 ± 0.28	402.02 ± 0.28	399.72 ± 0.16	399.63 ± 0.44
Parathyroid hormone (PTH) pg/ml	23.20 ± 0.02^{a}	18.31 ± 0.01^{b}	15.70 ± 0.02^{d}	16.80 ± 0.02^{c}	16.70 ± 0.02^{c}

a,b,c and d means having different letters in the same row are significantly different ($P \leq 0.05$).

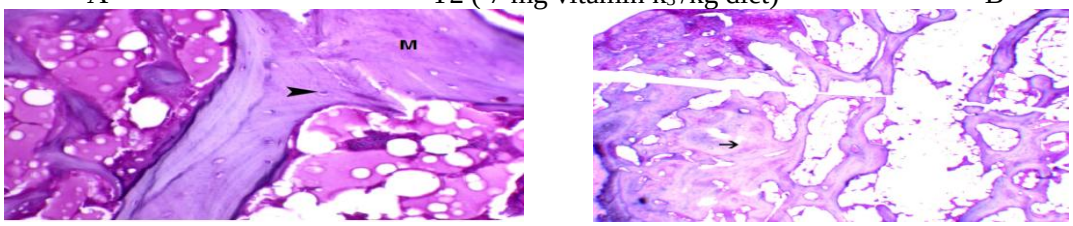
Vitamin K_3 – cage - aged layer – osteocalcin - bone parameters

Figure(1): Photomicrographs for cross-sections of hen's tibia during the late phase of egg production as affected by vitamin K_3 supplementation

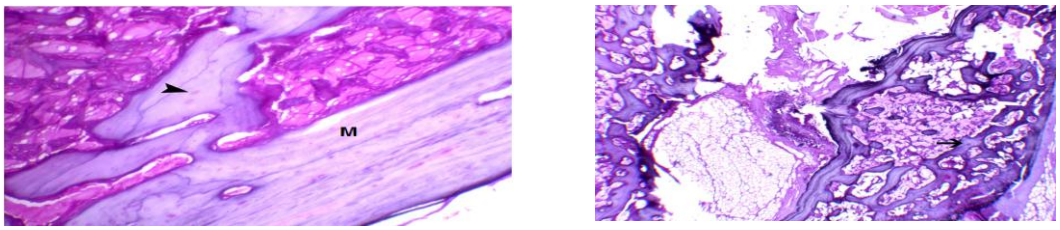
A (magnification, 200) Control (T1) B (magnification, 100)



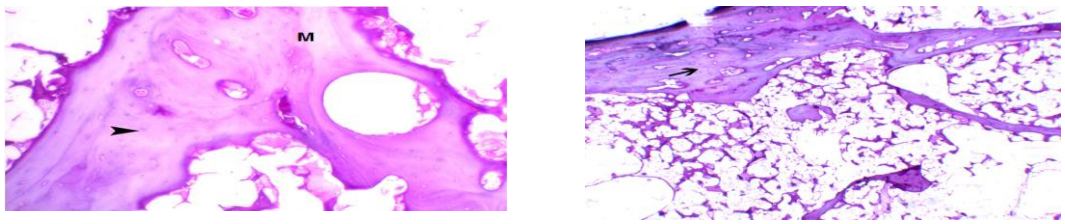
A T2 (7 mg vitamin k_3 /kg diet) B



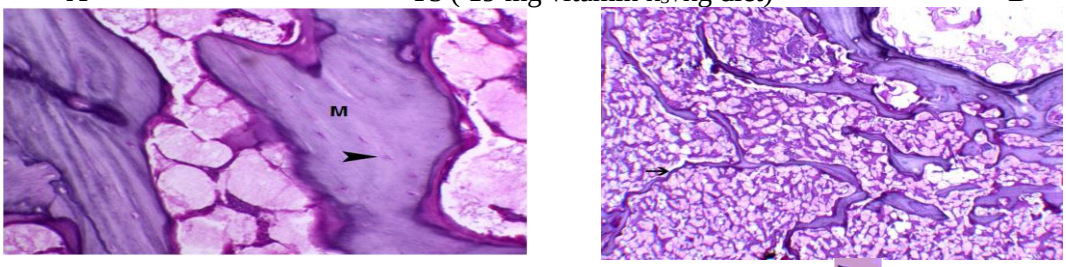
A T3 (11 g vitamin k_3 /kg diet) B



A T4 (15 mg vitamin k_3 /kg diet) B



A T5 (19 mg vitamin k_3 /kg diet) B



O:osteoporosis, M: medullary bone , → cortical and ➤: osteoblasts

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الملخص العربى

تأثير فيتامين ك3 على الاداء الأنتاجى للدجاج و جودة العظام
1. الفترة المتأخرة من انتاج البيض

وسام اديب فارس ، منى رفعت محمد أحمد ، مروه رمضان الدقن
معهد بحوث الإنتاج الحيواني- مركز البحوث الزراعية. مصر

أجريت هذه التجربة لدراسة تأثير اضافة مستويات عالية من فيتامين ك3 لعليقة الدجاج البياض عند الفترة المتاخرة من إنتاج البيض والمربى فى اقفاص وذلك على كل من الأداء الأنتاجى للبيض وصفات قشرة البيض وتركيب عظمة الساق وأيضا القطاعات الهستولوجية لعظمة الساق بجانب صفات الفقس وبعض القياسات الفسيولوجية. أستخدم فى هذه الدراسة عدد 150 دجاجة و30 ديك من سلالة دجاج المندرة والمرباه فى أقفاص من عمر 55 حتى 67 أسبوع. تم تقسيم الطيور عشوائيا إلى 5 مجاميع على حسب مستوى إضافة فيتامين ك3 للعليقة. المجموعة الأولى (T1) وهى المقارنة وفيها تغذت الطيور على العليقة الأساسية بدون اى إضافة لفيتامين ك3 وهى تحتوى فى الأساس على 3 ملجم ميناديون(ك3) / كجم عليقة. أما بالنسبة إلى باقى الأربعة مجاميع الأخرى تم إضافة الميناديون إليها كمصدر لفيتامين ك3 ليصبح مستوى فيتامين ك3 كما يلى 7، 11، 15 ،19 ملجم/ كجم عليقة لكل من المجاميع الثانية(T2) ، الثالثة(T3)، الرابعة (T4) ، الخامسة (T5) على التوالى. أشارت النتائج إلى انه: أنتجت دجاجات كل من المجاميع T3 ، T4، T5 بيض أعلى معنويا فى الوزن وأيضا زاد معنويا كل من حجم البيضة ونسبة إنتاج البيض لكل المجاميع المضاف إليها فيتامين ك3 مقارنة بمجموعة المقارنة. حدثت زيادة معنوية فى كل من سمك القشرة (مم) ونسبة تركيز الكالسيوم لبيض كل من المجموعتان T3 ، T4 مقارنة بباقى المجاميع. وأيضا قد لوحظ تحسن معنوى لكل من قياسات (طول وعرض وقوة كسر) وتركيب (وزن ونسبة كل من الرماد والكالسيوم والفسفور) عظمة الساق لدجاجات كل من المجموعتان T3 ، T4 مقارنة بباقى المجاميع . سجل البيض الناتج من كل المجاميع المضاف إليها فيتامين ك3 زياده معنوية لكل من نسبتى الخصوبة والفقس مقارنة بمجموعة المقارنة . زاد معنويا تركيز بروتين الأوستيوكالسين فى سيرم الدم وايضا تركيز كل من الكالسيوم والكالسيوم المتأين والفسفور والألكالين فوسفاتيز فى بلازما دم دجاجات المجموعة T3 . وأيضا أظهرت القطاعات الهستولوجية لكل من المجاميع T3، T4، T5 زيادة فى العظام المنسوجة لنخاع العظام ونشاط الخلايا البنائية للعظام وأيضا زيادة فى سمك طبقة القشرة الخارجية للعظم وبذلك اوضحت تلك النتائج انه من الممكن اعتبار إضافة سواء 11 أو 15 ملجم ك3 /كجم عليقة لعلف الدجاج البياض عند الفترة المتأخرة من أنتاج البيض والمربى فى أقفاص كأداه واعده للحصول على زياده فى انتاج البيض ونسب الفقس وأيضا زيادة التحسن فى جودة كل من قشرة البيضة والعظام.