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Exogenous Estradiol: Productive and Reproductive Performance and Physiological Profile of Japanese Quail Hens

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Abstract: Seventy two, 3 weeks old female quails were distributed among 2 treatments to study the effect of estradiol administration, on their productive and reproductive performance. Birds of the first group were intramuscularly injected at 3 weeks of age daily with 100 µg E_2/bird/day for 14 consecutive days. Birds of the second group served as control. Birds injected with E_2 from 3-5 weeks of age had a significantly higher body weight at sexual maturity and matured significantly earlier compared to control. Egg number, egg weight and egg mass had significantly increased due to E_2 injection. Ovaries and oviducts relative weight, oviducts length, magnum length were none significantly increased while, shell gland length increased significantly by 17% due to estradiol injection. Serum calcium increased significantly due to E_2 injections. This was also accompanied with significant increase in Tibia weight (22%) and calcium content (10%) in compare to the untreated females. Estradiol injections resulted in a significant increase in egg shell percent and calcium content. Data indicated a stimulated pancreatic activity, as plasma glucose decreased while liver glycogen increased due to the treatment. Plasma total lipids, cholesterol and triglycerides levels were increased by 25, 20 and 22%, respectively. Similar trend was observed with liver lipids content, which was reflected on yolk lipids content. There were no significant differences observed on egg quality due to estradiol treatment. Serum transaminases (GOT and GPT) activities increased with E_2 treatment while T_3 decreased. It can be concluded that treating immature Japanese quails daily (for 2 weeks) with E_2 can enhance their reproductive and productive functions without affecting their physiological profile or their egg quality.

Key words: Japanese quail hens, egg quality, liver, lipids content

INTRODUCTION

Estrogens (estradiol-17ß), which are synthesized and secreted by the gonads during avian embryonic development, regulate growth and differentiation of the sex accessory structures Johnson (1990). Steroid hormones have been implicated in the regulation of calcium metabolism in laying hens, throughout several modes of action. Shortly before sexual maturity, the formation of medullary bone and a parallel increase in calcium retention are induced by the action of estrogen (Nys *et al*., 1989). Estrogens stimulate vitellogenesis, via its action on the liver, feed intake and the deposition of calcium within the medullary portion of long bones (Johnson, 1986; Bacon *et al*., 1980). In addition, gonadal hormones regulate the rapid development of the oviduct, which occurs before and during sexual maturation. Treatment of immature Japanese quail and young female chickens with estradiol enhances growth of the oviduct and formation of tubular secretory glands and epithelial differentiation (Forgó *et al*., 1996). There is no sufficient information about some physiological parameters of a new developed Japanese quail strains in our country, also about the physiological effect of estrogens on productive and reproductive characteristics. Results showing the effect of estrogen hormone on regulation of metabolism in Japanese quail hens are limited, therefore, the aim of this work was mainly to study the effect of estradiol administration at early ages, on the productive and reproductive performance of Japanese quail hens.

MATERIALS AND METHODS

The present study was carried out at the poultry research center, Faculty of Agriculture, Alexandria University, over the period from March 2002 to 2003. Using new developed quail females (egg line) resulted from a 17 generations selection program through 10 successive years (1992-2001) (Ali *et al*., 2002) rose at the poultry research center.

Preparation of E_2 solution: Estradiol-17ß (E_2) used in this study was a liquid in folone ampules (5 mg estradiol benzoate/ml) in oily solution purchased from Misr Co. for Pharm. Ind. S.A.A. Egypt. The injection solution was prepared by dissolving 2ml of estradiol benzoate in 18 ml ethanol-sesame oil to give a concentration of 100 µg E_2 in 0.2 ml final solution.

Experimental design: A total of seventy two, 3 weeks old female quails were randomly and equally distributed among 2 treatment groups each of 6 sub groups (6 birds each) which were housed in one quail battery cages. Birds of the first group were individually intramuscularly injected at 3 weeks of age daily with 0.2

ml of the injection solution to provide 100 µg E_2/bird/day for 14 consecutive days. Birds of the second group served as control and were injected with ethanol-sesame oil solution. Feed and water were provided *ad libitum* throughout the experimental period, birds were fed on starter ration (24.6% CP, 2902 kcal ME/kg and 0.96% Ca) from 3-6 weeks of age and on a breeder ration (20.1% CP, 2854 kcal ME/kg and 3.54% Ca) starting from 7 weeks of age.

Data collected: Quail's age and body weight at sexual maturity (first egg laid) was recorded. Number of eggs laid in the period from sexual maturity till 90 days of production was recorded and weighed and egg mass was calculated. Feed consumption as (g/bird/day) was determined for the 90 days period and feed conversion was calculated as (g feed/g egg).

Three birds of each treatment were slaughtered at three intervals 6, 8 and 13 weeks of age resembling three stages of production; "before sexual maturity, BSM", "at sexual maturity, SM" and "at peak of production, PP", respectively for blood and carcass analysis. Plasma total lipids concentration (mg/dl) was estimated according to Fringes *et al.* (1972). Plasma cholesterol concentration (mg/dl) was determined according to Richmond (1973) using commercial kits (Diamond diagnostics: El-Nasr Pharmaceutical Chemicals Co.). Triglycerides concentration (mg/dl) was determined according to Jacobs and VanDemark (1960) using commercial kits. Plasma glucose concentration (mg/dl) was estimated according to the method of Trinder (1969) using commercial kits. Serum calcium concentration (mg/dl) was measured according to the method of Tietz (1970) using commercial kits. The activities of serum Aspartate Amino Transferase (AST) (U/L) and serum Alanine Amino Transferase (ALT) (U/L) were assayed by the method of Reitman and Frankel (1957). Serum triiodothyronine hormone (T_3) concentration (ng/ml) was determined with enzyme immunoassay using commercial kits obtained from International Immuno-Diagnostics (1155 Chess Drives, Suite 121 Foster city, CA 94404 USA). Serum estradiol-17ß hormone (E_2) concentration (pg/ml) was determined with enzyme immunoassay using commercial kits purchased from Biochem Immuno Systems. Serum progesterone hormone (P4) concentration (ng/ml) was determined with enzyme immunoassay using commercial kits obtained from International Immuno-Diagnostics. Estradiol-17ß (E_2)/ Progesterone (P4) ratio was calculated.

Carcasses were manually eviscerated and weighed. Livers, ovaries and oviducts were removed and weighed separately. The length of magnum, uterus and tibia bone were measured to the nearest millimeter (mm.) then weighed separately. Liver glycogen content (%) was determined as described by Allen and Ruff (1981). Liver lipids content (mg/g) was determined according to Fringes *et al.* (1972). Liver cholesterol content (mg/g) was determined as mentioned before by the method of Richmond (1973). Left tibia bones were dissected out, cleaned from muscles and connective tissues, weighed and stored frozen before oven drying at 60°C and burned at 600°C for 6 h in muffle furnace and ash content were weighed and prepared for calcium determination by atomic absorption spectrophotometer (Perkin, 1973).

Measurements of egg quality were performed on 12 eggs chosen randomly from each group at 13 weeks of age. Eggs were broken to estimate the yolk and the shell weights (to the nearest 0.1 g) while albumen weight was taken by subtracting weight of yolk plus that of shell from the whole egg weight (Amer, 1972). The shell with its membranes was carefully washed to remove the albumin, and then dried at room temperature for two days. Relative yolk, albumen and shell weights were calculated as a percentage of egg weight. Shell thickness was measured to the nearest micron using a metric micrometer (mm). Estimates were done at the midsection of each egg and the two polarizes of the egg. Eggshell was dried at 60°C to constant weight, then it was burned at 600°C for 6 h in muffle furnace, then the ash content was weighed and prepared for calcium determination. Calcium was determined using atomic absorption spectrophotometer. Egg albumen height was measured with tripode micrometer (in mm). The Micro Kjeldahl Technique was used to determine the egg albumin total protein content (Scales and Harrison, 1920). Egg yolk index was calculated according to Romanoff and Romanoff (1949) by dividing the height of the yolk by its diameter [Yolk index = (yolk height/yolk diameter) x 100].

Egg yolk/albumin (Y/A) ratio was calculated by dividing the yolk weight by the albumen weight. The Micro Kjeldahl Technique was used to determine egg yolk protein content (Scales and Harrison, 1920). Yolk lipids and cholesterol contents were determined using the extraction procedure of Fisher and Leveille (1957). Weighed samples of yolk (approximately 2 g) were extracted for 1-2 h in 125 of ml of a mixture of chloroform: methanol (2:1 V/V). The contents were filtered then the filtrate was brought to 50 ml volume in a volumetric flask. A sample of 0.2 ml aliquot was then analyzed for yolk lipids according to Fringes *et al.* (1972) using commercial kits (Diamond diagnostics). Yolk cholesterol was determined by the method of Richmond (1973) using commercial kits.

Statistical analysis: Means and standard errors were estimated for each studied trait. Data were analyzed using SAS program, using general linear model. Significant differences among treatments means were separated using Duncan's multiple range procedure (Duncan, 1955).

RESULTS AND DISCUSSION

Productive performance

Body weight and age at sexual maturity: Data concerning age and body weight at sexual maturity as influenced by E_2 administration are presented in Table 1. Birds injected with E_2 from 3-5 weeks of age had a significantly higher body weight at sexual maturity compared to the untreated females ($p \leq 0.0001$), the difference was about 3% in the favor of the treated groups.

The increase in body weight at sexual maturity may be due to the changes in carbohydrate metabolism induced by E_2 treatment which is intimately involved in glucose metabolism (Bell and Freeman, 1971) which has been also noted in this study (Table 3). Results herein are in agreement with that of Detwiler *et al.* (1950) and Almquist and Merritt (1952) who found that implanting chickens with stilbestrol improved carcass weight, quality and increased chickens body gain. Also Woody *et al.* (1969) and Herrick *et al.* (1970) reported that feeding 140 mg dienestrol diacetate/kg of diet to Leghorn type pullets (14-18 weeks of age) increased their body weight and improved broiler's weight gain. Douglas *et al.* (1989) recorded an increase in body weight gain of layers fed diets supplemented with synthetic estrogen (dienestrol diacetate). Moreover, Elghalid (2005) reported an increase in quails' body weight at sexual maturity as a result of estradiol treatment and related that to increased organs weight as liver's, ovaries' and oviduct's relative weights showed significant increases associated with E_2 treatment.

Birds injected with E_2 matured significantly ($p \leq 0.05$) earlier compared to the untreated ones. This comes in contrast with the findings of Schimke *et al.* (1975) and Boogard and Fnnengan (1976) who reported that treatment of immature Japanese quail and young female chickens with estradiol enhances growth of the oviduct and promotes the formation of tubular secretory glands and epithelial differentiation.

Egg production: Results concerning effects of exogenous E_2 on egg production are illustrated in Table 1. Egg number had significantly ($p \leq 0.05$) increased to reach 106% of the untreated females production due to E_2 injection. The increase in egg production due to E_2 treatment was accompanied by a significant ($p \leq 0.0001$) increase in egg weight (110% of the untreated birds). Accordingly, egg mass showed a similar significant ($p \leq 0.0001$) trend, as it increased by 18% compared to the untreated females. These findings are in harmony with those of El-Afifi and Abu Table (2002); Hamdy *et al.* (2002) and Elghalid (2005) who reported that egg number and egg mass were significantly improved when Leghorn pullets and immature quail females were treated with estradiol and found a significant positive correlation between egg mass and plasma estrogen concentrations, which was also observed in this study (Table 2).

Feed consumption and feed conversion: Feed consumption and feed conversion data of quail hens treated with E_2 are illustrated in (Table 1). Results indicate that feed consumption did not differ significantly between the two groups studied, Meanwhile, feed conversion ratio presented as (g feed/g egg) showed a significant ($p \leq 0.001$) improvement by 10% as a result of E_2 treatment compared to the untreated birds. Similar trend was observed by Elghalid (2005), who reported a non significant improvement of quail hens' feed conversion when they were treated with E_2.

Reproductive status

Serum sex hormones: Effects of E_2 administration on quail hen's serum E_2 and P_4 concentrations and E_2/P_4 ratio are presented in (Table 2). Estrogen-progesterone ratio was with reverse relation to egg production ($p \leq 0.0001$). Whereas regarding phase of production, the lowest E_2/P_4 ratio was observed at peak of production ($p \leq 0.0001$). This supports the findings of Nagwa *et al.* (1998) who found that the higher E_2/P_4 ratio in Fayoumi hens was associated with their lower egg production compared to the lower E_2/P_4 ratio found in LSL hens which was associated with their higher egg production.

Reproductive system: Ovaries and oviducts relative weight, oviducts length, magnum length were non significantly increased while, shell gland length increased significantly by 17% due to estradiol injection (Table 2). Which comes in agreement with the findings of Schimke *et al.* (1975) and Boogard and Fnnengan, (1976) who reported that treatment of immature Japanese quail and young female chickens with estradiol enhanced growth of the oviduct and promotes the formation of tubular secretory glands and epithelial differentiation. Estradiol treatment caused ovarian follicles (F1-F3) relative weights (% of ovary weight) to significantly ($p \leq 0.05$) increase by 27, 25 and 17% for the F1, F2 and F3, respectively (Fig. 1). Ovarian follicles F1 and F2 diameters showed a slight non significant increase by 4 and 2% due to the hormone treatment, whereas F3's diameter increased significantly by 10% compared to the untreated females. While regarding phase of production, the highest follicles relative weights and diameters were observed at peak of production and the lowest were before sexual maturity, without reaching significance.

Calcium profile

Serum and Tibia calcium: Serum calcium increased significantly ($p \leq 0.05$) due to E_2 injections reaching 105% of control, also with development of reproductive stage reaching the highest concentration at peak of production

Table 1: Effect of Estradiol daily injections from 3-5 weeks of age on productive performance of Japanese quail hens (Mean±S.E)

Items	Body weight at sexual maturity (g)	Age at sexual maturity (day)	Egg number At 90 days (egg)	Egg weight (g)	Egg Mass (g)	Feed consumption (g/bird/day)	Feed conversion (g feed/g egg)
Control	199.77±0.466B	52.33±0.494 A	31.54±0.509B	10.89±0.061B	343.45±4.646B	28.37±0.121	3.32±0.046A
3-5 wk injection	205.75±0.635A	49.00±0.365B	33.58±0.255A	12.03±0.076A	404.03±4.347A	28.58±0.116	2.99±0.039B
Propability level	***	*	**	***	***	NS	**

A,B,C Different letters within a column denote significant differences between treatments

Table 2: Effect of Estradiol daily injections from 3-5 weeks of age and reproductive stage on reproductive performance of Japanese quail hens (Mean ±S.E)

Items	Ovary (%)	Oviduct (%)	Oviduct length (cm)	Magnum length (cm)	Shell gland length (cm)	Serum E_2 (pg/ml)	Serum P_4 (ng/ml)	E_2/P_4 ratio
Control	0.90±0.04	5.73±0.17	30.84±0.71	22.62±0.72	4.74±0.13B	139.73±7.65B	2.37±0.454B	71.028±8.50A
3-5 wk injection	1.11±0.09	6.14±0.18	31.32±0.62	23.99±0.56	5.74±0.07A	184.87±1.83A	4.45±0.230A	42.358±2.134B
Probability level	*	*NS*	*NS*	*NS*	***	***	***	***
Before sexual maturity	0.91±0.06	5.70±0.20	30.23±0.87	22.83±0.73	5.18±0.30	172.70±8.40A	2.86±0.542B	70.361±10.54A
At sexual maturity	1.14±0.14	6.02±0.27	31.30±0.69	23.50±0.68	5.20±0.22	145.58±15.5B	2.93±0.739B	61.22±9.22B
At peak of production	0.98±0.06	6.08±0.21	31.71±0.83	23.58±1.11	5.35±0.24	168.63±7.59A	4.45±0.331A	38.498±2.01C
Probability level	NS	NS	NS	NS	NS	***	***	***
Control								
BSM	0.78±0.07	5.38±0.03	30.07±1.57	22.13±1.28B	4.70±0.44	190.40±0.10A	4.07±0.088A	46.86±1.021C
SM	0.96±0.06	5.85±0.49	31.60±1.12	23.97±1.31AB	4.73±0.13	180.17±1.97A	4.50±0.529A	41.23±5.05CD
PP	0.97±0.01	5.97±0.16	30.87±1.33	21.77±1.27 B	4.80±0.06	184.07±3.11A	4.80±0.461A	38.99±3.40CD
3-5 wk injection								
BSM	1.03±0.02	6.02±0.31	30.40±1.17	23.53±0.72AB	5.67±0.17	155.00±6.32B	1.65±0.038B	93.86±1.703A
SM	1.31±0.25	6.19±0.33	31.00±1.00	23.03±0.64AB	5.67±0.12	111.00±1.38C	1.36±0.012B	81.21±0.387B
PP	0.99±0.13	6.21±0.42	32.57±0.98	25.40±1.16 A	5.90±0.06	153.20±6.35B	4.10±0.462A	38.01±2.893D
Probability level	NS	NS	NS	*	NS	***	**	**

A,B,C Different letters within a column denote significant differences between treatments. BSM = Before sexual maturity. SM = Sexual maturity.
PP: Peak of production

Table 3: Effect of Estradiol daily injections from 3-5 weeks of age and productive stage on Carbohydrate and Protein profile of Japanese quail hens (Mean±S.E)

	Carbohydrate profile		Protein profile				
Items	Plasma glucose (mg/dl)	Liver glycogen (%)	Plasma total protein (g/dl)	Plasma Albumin (g/dl)	Plasma Globulin (g/dl)	Egg Albumin Protein (%)	Egg Yolk Protein (%)
Control	167.94±7.58A	1.53±0.062B	4.36±0.15A	2.15±0.17A	2.21±0.14	56.03±0.92B	27.30±0.12B
3-5wk injection	139.02±4.87B	2.12±0.071A	3.59±0.17B	1.82±0.12B	1.77±0.11	69.53±0.75A	34.17±0.26A
Probability level	***	**	***	**	NS	***	***
Before sexual maturity	173.80±11.35A	1.68±0.079B	4.42±0.19A	2.44±0.09A	1.98±0.17	-----	-----
At sexual maturity	144.87±4.24B	1.85±0.043AB	3.92±0.25B	1.85±0.18B	2.08±0.11	-----	-----
At peak of production	141.78±6.99B	2.03±0.042A	3.59±0.21B	1.67±0.12B	1.93±0.26	-----	-----
P value	***	**	**	***	NS	-----	-----
Control							
BSM	197.0±3.91A	1.57± 0.088	4.68±0.26	2.59±0.12A	2.08±0.29	-----	-----
SM	152.4±3.61B	1.33±0.088	4.42±0.18	2.22±0.13A	2.19±0.05	-----	-----
PP	154.4±5.00B	1.67±0.033	3.99±0.26	1.64±0.27B	2.36±0.37	-----	-----
3-5 wk injection							
BSM	150.57±9.44BC	1.93±0.033	4.17±0.21	2.30±0.03A	1.87±0.19	-----	-----
SM	137.33±4.46CD	2.13±0.15	3.42±0.21	1.47±0.02B	1.96±0.22	-----	-----
PP	129.17±7.73D	2.10±0.058	3.20±0.07	1.71±0.05B	1.49±0.09	-----	-----
P value	*	NS	NS	*	NS	-----	-----

A,B,C Different letters within a column denote significant differences between treatments. BSM = Before sexual maturity. SM = Sexual maturity.
PP: Peak of production

(Fig. 2). This was also accompanied with significant ($p \leq 0.05$) increase in Tibia weight (22%) and calcium content (10%) in compare to the untreated females. Which can be attributed to estrogen increasing total blood calcium, primarily by stimulating the production of blood-calcium binding proteins (Bacon *et al*., 1980) and that in the fowl, the medullary bone develops under the influence of ovarian hormones and that estrogen stimulates deposition of calcium within the medullary portion of long bones (Redshaw and Follet, 1972).

Egg shell calcium: Estradiol injections resulted in a significant 22% increase ($p \leq 0.001$) in egg shell calcium content compared to the untreated birds (Fig. 2). This can be attributed to the findings of Soares (1984) who suggested that exogenous estradiol can stimulate

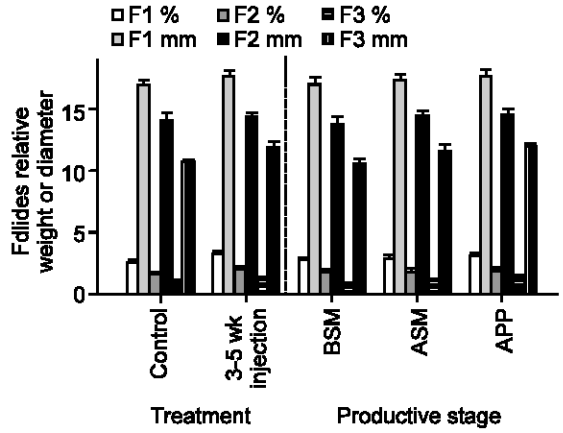

Fig. 1: Effect of Estradiol daily injection from 3-5 weeks of age and productive stage on reproductive performance [follicles 1-3 relative weight (%) and diameter (mm)] of Japanese Quail hens

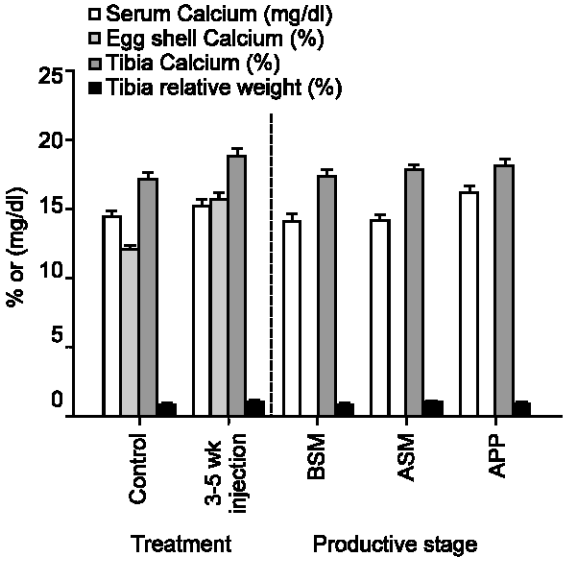

Fig. 2: Effect of Estradiol daily injection from 3-5 weeks of age and productive stage on Calcium profile [Serum calcium (mg/dl), Egg shell calcium (%), Tibia calcium (%) and Tibia relative weight (%)] of Japanese Quail hens

synthesis of 1,25 dihydroxycholicalciferol which save calcium required for egg shell deposition by increasing calcium absorption.

Carbohydrate profile

Plasma glucose and liver glycogen: Plasma glucose decreased ($p \leq 0.0001$) with E_2 treatments and was 83% of control (Table 3). Also, development of reproductive stage caused a decrease in plasma glucose in compare to before sexual maturity, as it decreased by 16 and 18% at sexual maturity and at peak of production, respectively compared to before sexual maturity. These decreasing trends was accompanied by a significantly ($p \leq 0.05$) increased liver glycogen (39% higher than the control birds) and same with the development of the reproductive stage, as it increased by 10 and 21% at sexual maturity and at peak of production, respectively compared to before sexual maturity. Table 3, indicating a stimulated pancreatic activity, which comes in agreement with the findings of Schulz (1940) who reported that in pigeons, the pancreatic islets of Langerhans increase in size and number during the laying period of the female.

Protein profile

Serum total protein, albumin and globulin: Data concerning plasma total protein, albumin and globulin levels are presented in Table 3, plasma total proteins decreased by 18% with E_2 injection from 3-5 weeks of age ($p \leq 0.0001$). Similar trend was observed with plasma albumin and globulin as they decreased by 15 and 20%, respectively ($p \leq 0.001$). Development of reproductive stage also caused decreases in plasma total proteins and albumin where they reached their lowest values at peak of production (81 and 68% of before sexual maturity, respectively). These decreases in plasma proteins can be attributed to the fact that estradiol activates protein synthesis and deposition in the liver of immature chicks (Muramatsu *et al*., 1992) and young turkey hens (Rosebrough *et al*., 1982) reducing it in the blood stream. Moreover these findings are in good agreement with the findings of Tanabe *et al.* (1987) who reported that after oestrogen administration to 5 month old Japanese Quails, the intensity of plasma albumin band decreased considerably, also Yousaf *et al.* (1998) who observed minimum blood protein at peak of production of White Leghorn layers.

Egg albumin and yolk protein contents: Egg albumin and yolk protein contents increased significantly ($p \leq 0.0001$) by 24 and 25%, respectively due to E_2 injections (Table 3). These increases can be related to the fact that Estradiol stimulates the production of yolk proteins vitellogenin II and apolipoprotein by the liver and supports the oviductal epithelial cells (Koch *et al*., 2007), this effect of estrogen on vitellogenin is so evident that vitellogenin is used as a biomarker for environmental estrogenic pollution (Tada *et al*., 2008)

Lipids profile

Plasma total lipids, cholesterol and triglycerides: Data concerning plasma total lipids, cholesterol and triglycerides levels are presented in Table 4. Plasma total lipids increased by 25% with E_2 injection from 3-5 weeks of age ($p \leq 0.0001$). Similar trend was observed with plasma cholesterol and triglycerides as they increased by 20 and 22%, respectively ($p \leq 0.0001$).

Table 4: Effect of Estradiol daily injections from 3-5 weeks of age and productive stage on Lipids profile of Japanese quail hens (Mean±S.E)

Items	Plasma total lipids (mg/dl)	Plasma cholesterol (mg/dl)	Plasma triglycerides (mg/dl)	Liver total lipids (mg/g)	Liver cholesterol (mg/g)	Yolk total lipids (mg/g)	Yolk cholesterol (mg/g)
Control	271.11±6.47B	127.30±5.62B	113.08±4.46B	31.78±0.14B	23.50±0.85	5.40±0.05 B	22.50±0.29
3-5wk injection	338.06±3.22A	153.21±5.25A	138.12±3.02A	31.93±0.17A	23.89±0.61	7.49±0.22 A	25.00±1.53
Probability level	***	***	***	*	NS	**	NS
Before sexual maturity (BSM)	295.42±18.32B	137.42±6.84	119.43±8.06	31.33±0.04C	22.58±0.79	-----	-----
At sexual maturity (SM)	299.17±16.62B	139.07±5.79	125.32±7.67	31.93±0.15B	24.17±0.79	-----	-----
At peak of production (PP)	319.17±10.98A	144.28±5.21	132.05±4.91	32.30±0.04A	24.33±1.02	-----	-----
Probability level	***	NS	NS	***	NS	-----	-----
Control							
BSM	255.83±4.64C	110.73±2.04D	103.57± 5.60	31.40±0.06C	21.33±0.73	-----	-----
SM	262.50±5.20C	124.47±2.80C	109.43±2.63	31.63±0.12B	24.33±0.73	-----	-----
PP	295.00±3.81B	146.70±6.12B	126.23±7.88	32.30±0.06A	24.83±2.03	-----	-----
3-5wk injection							
BSM	335.00±9.46A	141.87±9.62B	135.30±6.47	31.27±0.03C	23.83±1.01	-----	-----
SM	335.83±3.00A	150.37±7.63B	137.87±4.94	32.23±0.12A	23.83±0.93	-----	-----
PP	343.33±2.20A	167.40±3.29A	141.20±5.89	32.30±0.06A	24.00±1.61	-----	-----
Probability level	**	***	NS	**	NS	-----	-----

A,B,C Different letters within a column denote significant differences between treatments. BSM = Before sexual maturity. SM = Sexual maturity. PP: Peak of production

Development of reproductive stage also caused increases in plasma total lipids, cholesterol and triglycerides where they reached their highest values at peak of production (108, 105 and 110% of before sexual maturity, respectively). These increases in plasma lipids can be attributed to the fact that estradiol activates lipids metabolism during vitellogensis Walzem (1996) and comes in agreement with the findings of Johnson (1986) who reported that laying hens with short-term administration had significantly higher plasma total lipids and that development of sexual maturity of the fowl increases lipid metabolism to provide yolk lipids. Moreover, Tufa *et al*. (2001) found that in laying Leghorn hens the triacylglycerol concentration during the laying period was about 12-folds higher than in the growing period. The phospholipids, cholesterol, glycerol and nonesterified fatty acid in the laying period were also higher than those in the growing period. Also, Stanton *et al*. (2001) reported that male birds treated with oestrogen had increased total triacylglyceride concentrations with specific increases in the Δ9 desaturase products 16:1n7, 18:1n7, 18:1n9 and 20:1n9. In addition, oestrogen treatment specifically increased 22:6n3 concentrations in both triacylglycerides and phospholipids.

Liver total lipids and cholesterol: Data illustrated in (Table 4) indicates that liver total lipids and cholesterol contents increased by 0.5 and 1.7% with E_2 injections, respectively. Development of reproductive stage also had an increasing effect on liver total lipids and cholesterol contents, both reaching their highest values at peak of production, as they reached 103 and 108% of their values before sexual maturity, respectively. These effects of estradiol on liver total lipids and cholesterol contents are in good agreement with the findings of Walzem (1996) who stated that yolk lipids are synthesized in the liver under the influence of estrogen.

Yolk total lipids and cholesterol: The increase in lipids of the blood and liver was reflected on yolk lipids content (Table 4), as yolk total lipids and cholesterol contents increased by 39 and 11% with E_2 injections, respectively. These effects of estradiol on yolk total lipids and cholesterol contents can be attributed to the findings of Walzem (1996) who stated that yolk lipids are synthesized in the liver under the influence of estrogen.

Egg quality: There were no significant differences observed on yolk percent, albumin percent, yolk/albumin ratio, shell thickness, yolk index and Haugh unit due to estradiol treatment. Shell percent on the other hand has increased significantly ($p \leq 0.05$) due to estradiol treatment from 13.97 in the untreated birds to 16.36% in the treated birds. This increase in shell percent can be explained by the increase in shell calcium content observed in this study.

Serum transaminases activity and T_3 concentration: Serum transaminases activities data of quail hens treated with E_2 indicate that serum transaminases (GOT and GPT) activities increased with E_2 treatment to reach 105 and 113% compared to control. Meanwhile they reached their lowest levels at peak of production.

Data reflected the normal reverse relationship between T_3 and E_2 where T_3 significantly ($p \leq 0.0001$) decreased with the E_2 treatment and with developing of the productive stage ($p \leq 0.05$), which comes in harmony with the findings of Maiti and Sahu (1982) who reported an antithyroidal activity of estrogen in juvenile ducks.

Conclusion: It can be concluded that treating immature Japanese quails daily (for 2 weeks) with E_2 can enhance their reproductive and productive functions without affecting their physiological profile or their egg quality.

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