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Effect of L-Carnitine and Yeast Chromium Supplementation on Productive Performance in Pekin and Sudani Duckling during Growth Period

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ABSTRACT

The present study aimed to evaluate the effect of L-carnitine and Yeast chromium supplementation on the productive performance of Pekin and Sudani duckling breeds. A total number of 450 both unsexed Pekin and Sudani ducklings (225 per each breed) one-day-old were investigated in the current study. The experimental period lasted 12 weeks of age. Experimental ducklings were randomly divided into the 5 equal treatments with 90 ducklings (45 number from both Pekin and Sudani ducklings per each). Each experimental treatment was randomly divided into 3 equal replicates of 30 ducklings (15 ducklings in each breed). The five experimental treatments were as follows: the first treatment was the control with basal diets, treatments 2 and 3 received basal diets supplemented with 300 and 450 mg/kg diet L-carnitine (LC), respectively, while treatments 4 and 5 received basal diets supplemented with 400 and 600 µg/kg diets Yeast chromium (Cr), respectively. The results indicated that growing duckling fed diets supplemented with LC and Cr were significantly improved in live body weight, body weight gain, feed intake, and feed conversion ratio. The relative weight of carcass quality and weight of lymphoid organs significantly increased with supplemented diets. Therefore, both duckling breeds fed on diets supplemented with 450 mg LC/kg resulted in better performance without any adverse effect on carcass quality as well as economic efficiency.

Keywords: L-carnitine, Pekin ducks, Productive Performance, Sudani ducks, Yeast chromium.

INTRODUCTION

Demand for animal-sourced protein has increased as a result of elevating human population growth leading to rising in animal production especially poultry meat production (Adeola, 2006). Ducks production in Egypt is about 42,000 tons representing 1.7% of total world production in 2006 (Soltan et al., 2014). Duck carcasses contain about 30% fat while broiler carcasses have 15% fat in a marketing age. Therefore, an increase in consumer's desire for leaner meat has stimulated interest in reducing abdominal fat deposition in ducks. Excessive fat in ducks is unattractive for consumers who are concerned about the negative effects of saturated fat intake on diet (Arslan et al., 2003). This fat represents a waste product from ducks, so numerous attempts have been made to minimize this fat accumulation either genetically or by dietary manipulation with different degrees of success (Awad et al., 2014). Therefore, improving growth performance and carcass composition by using natural feed additives is the main target for poultry research (Taklimi et al., 2015). Ducks industry in Egypt is under constant pressure to provide high-quality and more economical products for consumers. Egyptian Sudani ducks is a local breed with low growth performance as a meat type duck. Growth performance is subject to significant factors including genetics, gender, and environmental variables (Awad et al., 2014). The L-carnitine (LC) is synthesized in the body from lysine and methionine, and it is formed with contributions from vitamins B_3, B_6, B_{12}, C and folic acid, as well as iron (Michalczuk et al., 2012). According to Harmeyer (2002), the body cannot produce enough LC to fully cover its own needs because some conditions such as stress, disease, and physical strain may result in LC deficiency. Therefore, LC supplementation resulted in improving growth rate, feed conversion breast, thigh meat yield, and reduced abdominal fat in broilers.

Moreover, LC is used in poultry for a multi-functional purpose that includes promoting growth and improving antioxidant status (Adabi et al., 2011). Animals and birds under any stressors are needed to Chromium (Cr) elements to achieve biological responses (Piva et al., 2003). Several varieties of Chromium (Cr) exist, but Cr from yeast, picolinate, and chloride forms ($CrCl_2$) have been cited mostly for their biological activities (Khan et al., 2014). The Cr is one of the essential minerals which is required for improving productive performance in poultry due to its important functions in metabolism, growth, and reduction of lipid and protein peroxidation (Farag et al., 2017).

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The present study aimed to evaluate the differences of two dietary supplementations that included LC and Cr on growth performance and some physiological parameters in both Pekin (foreign) and Sudani (local) ducklings under the Egyptian environmental conditions.

MATERIALS AND METHODS

Ethical approval

The Institute's ethical rules for animal research were followed and the study plan was approved by the Institute's Research Committee on 1 May 2016 (code no. 020203429).

Experimental design

The current study was carried out at El-Serw Research Station, Water Fowl Research Department, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Giza, Egypt. The experiment was carried out during the summer season from June to August of 2016. A total number of 450 both unsexed Pekin and Sudani ducklings (225 per each breed) one-day-old were used in the present study. The experimental period lasted until 12 weeks of age. Experimental ducklings were randomly divided into the five equal treatments with 90 ducklings (45 numbers from both of Pekin and Sudani ducklings per each). Each experimental treatment was randomly divided into three equal replicates of 30 ducklings (15 ducklings of each breed). The five experimental treatments were as follows: Number one was control treatment received basal diets, treatments 2, 3 received basal diets supplemented with 300 and 450 mg/kg diet L-carnitine (LC), while treatments 4, 5 received basal diets supplemented with 400 and 600 µg/kg diets Yeast chromium (Cr), respectively. Ducklings were maintained in deep-litter floor pens. Natural light system (16 hours was light and 8 hours was dark per day) was used all over the experiment. The experimental ducklings were examined clinically for having diseases, being healthy and receiving vaccines (at 3 days of age ducklings had been vaccinated against duck hepatitis viral disease $(DHVD)_1$, at 7 days of age ducklings had been vaccinated against Bird flow (Avian Influenza), at 10 days of age ducklings had been vaccinated against Duck $plague_1$ (Duck virus Enteritis) and Duck $Cholera_1$, at 30 days of age ducklings had been vaccinated against Duck $plague_2$ (Duck virus Enteritis), at 45 days of age ducklings had been vaccinated against Duck hepatitis viral disease $(DHVD)_2$ and Duck $Cholera_2$. Also, ducklings had been vaccinated against coccidiosis at 3 days of age in food). Fresh water and food were available *ad libitum*. All ducklings were fed on a starter ration from first to 12 weeks of age which contained 19.20% crude protein and 2868 kcal/kg metabolized energy during the first four weeks of age followed by a grower diet contains 15.20% crud protein and 2690 kcal/kg, and also supplemented by adequate levels of nutrients recommended by NRC (2005). Compositions of starter and grower ration were presented in Table 1.

Table 1. Composition of the starter and grower rations that ducklings were fed during the experiment

Ingredients %	Basal diet	
	Starter	Grower
Yellow corn (%)	65.00	63.00
Soya bean meal (44%)	30.45	15.50
Wheat bran	0.65	17.78
DI-Calcium phosphate	1.80	1.25
Calcium carbonate ($Ca\ Co_3$)	1.40	1.80
Vitamin & minerals mixture	0.30	0.30
Sodium chloride (Na Cl)	0.30	0.30
D.L. Methionine	0.10	0.07
Total	100.00	100.00
Crude protein (%)	19.20	15.20
Metabolic energy (Kcal/Kg)	2868.00	2690.00

Each 2.5 kg of vitamins and minerals mixture contain; 12000.000 IU vitamin A acetate; 2000.000 IU vitamin D3; 10.000 mg vitamin E acetate; 2000 mg vitamin K3; 100 mg vitamin B; 4000 mg vitamin B2; 1500 mg vitamin B6; 10 mg vitamin B12; 10.000 mg Pantothenic acid; 20.000 mg Nicotininc acid; 1000 mg Folic acid; 50 mg Bioten; 500.000 mg Chorine; 10.000 mg Copper; 1000 mg Iodine; 30.00 mg Iron; 55.000 mg Manganese; 55.000 mg Zinc; and 100 mg Selnium.

Growth performance

Birds were weighed every four weeks to measure their body weight gain, feed consumption, feed conversion ratio (feed consumed (g)/ weight gain (g)). The mortality of the ducklings was also calculated during the experimental period. By the end of the experiment, three ducklings from each treatment group were weighed and slaughtered by slitting the jugular vein, then scalded and de-feathered and the carcasses were manually eviscerated and weighted. The liver, heart, gizzard, digestive tract, and abdominal fat were removed and their relative percentages of live body weight were estimated. Chemical analyses of breast and thigh muscle meat were determined according to AOAC (2000).

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Economic efficiency

The economic efficiency was calculated based on the price of L-carnitine (68.7%) was traded 50 LE per one kg and Yeast chromium traded was 17 LE per one kg. L-Carnitine and Yeast Chromium were respectively derived from Carniking (Longsha Company in Hong Kong, L-Carnitine in it) and Yeast Chromium (Alltech Biology Company in Beijing). One kg of live body weight coasted 28 and 22 LE for Sudani and Pekin ducklings, respectively, while the prices of one duckling which is one-day-old were 8 LE and 3 LE, respectively for Sudani and Pekin, which were prevailing during 2016.

Statistical analysis

Data were analyzed by the least-squares analysis of variance using the General Linear Models procedure of the statistical analysis model (SAS, 2001), all results were analyzed using two-way ANOVA. The statistical model was as follows: $Y_{ijk} = \mu + T_i + B_j + (TB)_{ij} + E_{ijk}$.

Y_{ijk} = An observation; μ = Overall mean; T_i = Effect of dietary supplementation ($_i$ = 1, 2, 3, 4, 5); B_j = Effect of duck breeds ($_j$ = 1, 2); $(TB)_{ij}$ = Interaction effect between dietary supplementation and breed of ducks and E_{ijk}= Random error component assumed to be normally distributed. The significant differences among means of treatments were compared using Duncan's multiple range tests ($p\leq0.05$) (Duncan, 1955).

RESULTS AND DISCUSSION

Productive performance

Live body weight and body weight gain

Data in Table 2 indicated that Live Body Weight (LBW) in this study was significantly changed with duckling breeds of all ages. It was significantly ($p\leq0.01$) affected due to LC or Cr supplementation during all ages except the first week of age. The live body weight of Sudani ducklings was significantly higher by 33.58, 35.16, 45.97, and 26.62% than Pekin ducklings aged 1, 4, 8, and 12 weeks, respectively. The heaviest bodyweight values were recorded for duckling treatment with 450 mg/kg diet L-carnitine (LC) compared to other groups, including the control. These results might be due to Sudani ducklings have a greater growth rate than Pekin and it tends to mature earlier as well as they consumed more feed (Gouda, 2015).

Duckling which received dietary by 300 or 450 (mg LC/kg) LC and 400 or 600 (μg Cr/kg) Cr supplementation had significantly higher ($p\leq0.01$) LBW by 9.92, 10.40, 6.29 and 6.53% than the control group at 12 weeks of age, respectively. Additionally, Interaction between duckling breeds and fed ration supplementation significantly affected LBW at different ages as LBW of Sudani ducklings were significantly higher ($p\leq0.01$) than Pekin ducklings with any diet supplementation. A similar trend was obtained for Body Weight Gain (BWG) values (Table 2). Bodyweight of Sudani ducklings was significantly higher ($p\leq0.01$) by 35.26, 54.70, and 26.49% than Pekin ducklings during (0-4), (4-8), and (0-12) weeks of age, respectively. All duckling which fed ration supplemented with LC and Cr had significantly higher ($p\leq0.01$) of BWG than control once during (0-4), (8-12), and (0-12) weeks of age. Improvement of BWG values were 10.08, 10.57, 6.39 and 6.67 % for duckling fed ration supplemented with LC (300 or 450 mg/kg) and Cr (400 or 600 μg/kg), compared to those fed the control ration during 0-12 weeks of age, respectively.

These improvements might be due to LC plays a major role by increasing plasma insulin-like growth factor I concentration, which serves as stimulating substances for chicken's growth (Xu et al., 2003). Also, it might be due to the improvement in the utilization of dietary ingredients as a result of LC transfer the long-chain fatty acids across the liner mitochondrial membranes and controls the rates of β-oxidation of long-chain fatty acids as well as it plays a pivotal role in energy metabolism (Arslan et al., 2003). Moreover, improvement in growth performance in Cr treatment might be due to the activity of Cr in controlling the anabolic action of insulin.

These results were in agreement with those of El-Hommosany (2008) who reported that Cr supplementation (125 and 250 μg/kg feed) was associated with a significant increase in body weight and weight gain than in the control group in Japanese quails at 6 weeks of age. Abdel-Fattah et al. (2014) indicated that dietary supplementation of LC (200-400 mg/kg) significantly increased LBW and cumulative BWG for Japanese quails. Awad et al. (2016) reported that ducklings LBW was enhanced by 7.14, 11.20, 12.74 and 9.74% for Domyati ducklings fed a diet supplemented with 150, 300, 450, and 600 mg LC/kg as compared with those fed the control diets at 84 days of age, respectively. BWG was improved by 8.95, 15.11, 16.50, and 12.92% during the periods from 21 to 84 days of age, respectively. El-Kelawy (2019) reported that Cr supplementation improved body weight at 28 and 49 days of age and BWG during periods (14-28), (29-49), and (14-49) days of Japanese quails age compared with the control group.

Interaction between duckling breed and dietary supplementation significantly affected the BWG during different experimental periods; Sudani ducklings had significantly higher BWG than Pekin ducklings with any diet supplementation.

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Table 2. Effects of breed and dietary supplementation on live body weight and body weight gain in Sudani and Pekin ducks during 12 weeks of age.

Age (weeks)	DB	Treatments					AV	Probability		
		Control	L-carnitine		Yeast chromium					
			300	450	400	600		B	T	BT
Live body weight (g)										
0	S	50.11^{a}±0.11	50.17^{a}±0.10	50.01^{a}±0.12	50.12^{a}±0.11	50.19^{a}±0.15	50.12^{a}	*	NS	*
	P	37.51^{b}±0.09	37.41^{b}±0.08	37.57^{b}±0.09	37.58^{b}±0.07	37.55^{b}±0.11	37.52^{b}			
	AV	43.81	43.79	43.79	43.85	43.87				
4	S	817.93^{b}±2.32	952.54^{a}±2.39	955.18^{a}±2.42	890.57^{b}±2.30	895.35^{b}±2.31	902.31^{a}	**	**	**
	P	590.61^{e}±2.30	714.45^{c}±2.28	720.74^{c}±2.33	650.57^{d}±2.39	661.48^{d}±2.31	667.57^{b}			
	AV	704.27^{c}	833.50^{a}	837.96^{a}	770.57^{b}	778.42^{b}				
8	S	2084.21^{c}±7.95	2245.35^{a}±8.15	2270.27^{a}±8.91	2146.74^{b}±7.16	2158.97^{b}±8.92	2181.11^{a}	**	**	**
	P	1338.69^{f}±7.16	1587.94^{d}±9.11	1592.41^{d}±7.13	1464.72^{e}±7.05	1487.24^{e}±8.13	1494.20^{b}			
	AV	1711.45^{c}	1916.65^{a}	1931.34^{a}	1805.73^{b}	1823.11^{b}				
12	S	3131.32^{c}±14.83	3354.41^{a}±14.22	3375.24^{a}±13.81	3257.27^{b}±14.07	3261.25^{b}±13.11	3275.90^{a}	**	**	**
	P	2367.44^{f}±14.12	2689.74^{d}±14.02	2695.41^{d}±14.18	2587.25^{e}±13.25	2596.46^{e}±14.11	2587.26^{b}			
	AV	2749.38^{c}	3022.08^{a}	3035.33^{a}	2922.26^{b}	2928.86^{b}				
Body weight gain (g)										
0-4	S	767.82^{c}±7.12	902.37^{a}±7.36	905.17^{a}±7.23	840.45^{b}±6.15	845.16^{b}±6.55	852.19^{a}	**	**	**
	P	553.10^{e}±7.14	677.04^{d}±6.11	683.17^{d}±7.21	612.99^{d}±6.28	623.93^{d}±7.30	630.05^{b}			
	AV	660.46^{b}	789.71^{a}	794.17^{a}	726.72^{a}	734.55^{a}				
4-8	S	1266.28^{a}±16.26	1292.81^{a}±16.35	1315.09^{a}±15.24	1256.17^{a}±16.31	1263.62^{a}±15.21	1278.79^{a}	**	NS	**
	P	748.08^{c}±14.21	873.49^{b}±15.16	871.67^{b}±16.27	814.15^{b}±16.14	825.76^{b}±15.75	826.63^{b}			
	AV	1007.18	1083.15	1093.38	1035.16	1044.69				
8-12	S	447.11^{d}±27.14	509.06^{c}±27.75	504.97^{c}±28.11	510.53^{c}±26.15	502.28^{c}±27.04	494.79^{b}	**	**	**
	P	1028.75^{b}±27.39	1101.80^{a}±25.11	1103.00^{a}±26.30	1122.53^{a}±27.14	1109.22^{a}±25.12	1093.06^{a}			
	AV	737.93^{b}	805.43^{a}	803.99^{a}	816.53^{a}	805.75^{a}				
0-12	S	3081.21^{c}±31.54	3304.24^{a}±31.71	3325.23^{a}±32.41	3207.14^{b}±31.59	3211.06^{b}±32.54	3225.78^{a}	**	**	**
	P	2329.93^{f}±28.87	2652.33^{d}±29.52	2657.84^{d}±30.41	2549.67^{e}±28.97	2560.91^{e}±30.45	2550.14^{b}			
	AV	2705.57^{c}	2978.29^{a}	2991.54^{a}	2878.41^{b}	2885.99^{b}				

a, b, c, d, e, f: Means with different superscripts in the same row within item differ significantly; NS: Not significant; *: ($p \leq 0.05$); **: $p \leq 0.01$); DB: Duckling breed; S: Sudani ducks; P: Pekin ducks; AV: Overall mean.

Feed intake

The effect of different treatments and breeds on Feed Intake (FI) has been presented in Table 3. The FI was significantly affected by duckling breeds of all ages; it could be observed that Sudani ducklings had consumed significantly higher amounts of ration than Pekin ducklings during the different experimental periods by about 18.75% during 0-12 weeks of age. These results might be due to Pekin duckling have a poor growth rate so consumed less feed which reflects in decreasing body weights compared to Sudani ducklings (Gouda, 2015). Duckling fed ration supplemented with LC 300 or 450 mg/kg and Cr 400 or 600 µg/kg consumed more feed by 3.76, 4.10, 2.79, and 2.97% than control during 0-12 weeks of age, respectively. This might be due to ducklings can compensate their FI according to their energy requirements as well as the experimental diet had similar metabolizable energy. These results agreed with El-Kelawy (2019) who reported that Cr supplementation improved FI during periods 14-49 days of age of Japanese quails, compared with the control group. Interaction between duckling breed and dietary supplementation significantly affected FI during different experimental periods as the Sudani ducklings had significantly higher FI than Pekin ducklings with any diet supplementation.

Feed conversion ratio

Feed Conversion Ratio (FCR) was significantly affected by duckling breed at all ages as Table 3 indicated that Pekin ducklings were significantly attenuated than Sudani ducklings during 0-4, 4-8, and 0-12 weeks of age. The FCR was improved by 6.33% for Sudani than Pekin ducklings during 0-12 weeks of age. These findings might be due to Sudani ducklings had lighter BWG than Pekin during the growth period.

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Duckling breed fed ration supplemented with LC and Cr had the best FCR compared with the control during 0-4, 4-8, 8-12, and 0-12 weeks of age (Table 3). The improvement of FCR values were 6.87, 7.19, 4.07, and 4.37% for duckling fed ration supplemented with LC and Cr as compared with control during (0-12) weeks of age, respectively. Generally, the improvement in FCR was associated with increasing LBW values which might be attributed to improving BWG of ducklings. Feed conversion improved since LC increases fatty acid burning and improves intestinal mucous membrane by active and passive mechanisms **(**Fathi and Farahzadi, 2014). These findings are in agreement with Debski et al. (2004) and El-Kelawy (2019) who observed a slightly improving feed conversion in the group that received Cr. Parsaeimehr et al. (2014) reported that dietary LC supplementation (200-30 mg/kg diet) resulted in improving FCR of broiler chickens during the growing period (45 days). Also, Abdel-Fattah et al. (2014) found that a significant improvement in the feed conversion ratio of quails occurred as a result of dietary supplementation with LC (200-30 mg LC/kg diet) in comparison with control. However, Awad et al. (2016) reported that FCR was numerically similar for ducklings fed on different LC diets with 150, 300, 450, and 600 mg LC/kg as compared with those fed the control diets during the overall experimental period (21-84 days of age). Interaction between duckling breed and dietary supplementation significantly affected FCR during different experimental periods, Pekin ducklings had significantly worst FCR than Sudani ducklings with any diet supplementation during different all experimental periods except 8-12 weeks of age.

Table 3. Effect of breed and dietary supplementation on feed intake and feed conversion ratio in Sudani and Pekin ducks during 12 weeks of age.

Age (weeks)	DB	Treatments					AV	Probability		
		Control	L-carnitine		Yeast chromium					
			300	450	400	600		B	T	BT
Feed intake (g / duckling)										
0-4	S	2439^a±14.67	2580^a±12.27	2591^a±13.21	2531^a±13.69	2557^a±14.67	2539.6^a			
	P	1895^c±13.51	1940^b ±14.11	1953^b ±12.13	1914^b±14.26	1925^b±14.26	1925.4^b	**	NS	**
	AV	2167	2260	2272	2222.50	2241				
4-8	S	3350^b±16.11	3457^a±14.29	3486^a±16.37	3435^a±14.21	3420^a±13.37	3430^a			
	P	3277^c±15.41	3371^b±14.34	3356^b±13.55	3328^b±16.30	3319^b±15.22	3330.2^b	**	**	**
	AV	3313.5^b	3414^a	3421^a	3382.5^b	3369.5^b				
8-12	S	4570^b±17.74	4772^a±18.78	4793^a±17.73	4753^a±16.37	4761^a±17.22	4729.8^a			
	P	3655^d±18.36	3787^c±16.11	3794^c±13.51	3761^c±17.90	3774^c±15.81	3754.2^b	**	**	**
	AV	4112.5^b	4279.5^a	4293.5^a	4257^a	4267.5^a				
0-12	S	10359^c±18.52	10809^a±19.59	10870^a±17.12	10719^b±18.66	10738^b±16.97	10699^a			
	P	8827^e±18.36	9098^d±17.58	9103^d±16.33	9003^d±18.77	9018^d±17.53	9009.8^b	**	**	**
	AV	9593^c	9953.5^a	9986.5^a	9861^b	9878^b				
Feed conversion ratio (g feed/ g gain)										
0-4	S	3.18^a±0.05	2.86^b±0.07	2.86^b±0.04	3.01^a±0.05	3.03^a±0.07	2.98^b			
	P	3.43^a±0.07	2.87^b±0.04	2.86^b±0.05	3.12^a±0.07	3.09^a±0.06	3.06^a	**	**	**
	AV	3.30^a	2.86^b	2.86^b	3.07^a	3.06^a				
4-8	S	2.65^c±0.07	2.67^c±0.12	2.65^c±0.05	2.73^c±0.13	2.71^c±0.09	2.68^b			
	P	4.38^a±0.13	3.86^b±0.17	3.85^b±0.09	4.09^a±0.07	4.02^a±0.06	4.03^a	**	**	**
	AV	3.51^a	3.27^b	3.25^b	3.41^b	3.37^b				
8-12	S	10.22^a±0.27	9.37^b±0.22	9.49^b±0.25	9.31^b±0.27	9.48^b±0.19	9.56^a			
	P	3.55^c±0.18	3.44^c±0.22	3.44^c±0.24	3.35^c±0.17	3.40^c±0.22	3.43^b	**	**	**
	AV	8.36^a	6.41^b	6.47^b	6.33^b	6.44^b				
0-12	S	3.36^b±0.11	3.27^c±0.09	3.27^c±0.12	3.34^c±0.08	3.34^c±0.13	3.32^b			
	P	3.79^a±0.12	3.43^b±0.09	3.42^b±0.11	3.53^b±0.15	3.52^b±0.07	3.53^a	**	**	**
	AV	3.58^a	3.35^b	3.34^b	3.44^b	3.43^b				
Mortality%										
0-12	S	2.92^b	2.85^b	2.86^b	2.90^b	2.91^b	2.89^b			
	P	5.21^a	5.00^a	5.11^a	5.13^a	5.15^a	5.12^a	*	NS	*
	AV	4.07	3.93	3.99	4.02	4.03				

a, b, c, d, e, f: Means with different superscripts in the same row within item differ significantly; NS: Not significant; *: ($p\leq0.05$); **: $p\leq0.01$); DB: Duckling breed; S: Sudani ducks; P: Pekin ducks; AV: Overall mean.

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Mortality rate

It can be observed from Table 3 that the mortality rate during 12 weeks of age was significantly higher ($p \leq 0.05$) in Pekin (5.12%) than Sudani (2.89%) breeds. It might be due to Pekin was more sensitive and Sudani was more adapted to the Egyptian conditions. These results agreed with Ali (2005) who indicated that the mortality percentage was 4% for Domyati during the periods (0-12) weeks of age. Also, Ali et al. (2017) reported that the mortality rate during 12 weeks of age was significantly higher in Pekin (4.79%) than Domyati (3.07%). Duckling dietary supplemented with different LC and Cr levels significantly recorded a reduction in mortality rate than those fed on control ration from 4.07 to 3.93%. This improvement in mortality could be due to the fact that LC and Cr had played important roles in increasing resistance to stress as well as the immunity system. Interaction between duckling breeds and fed ration supplementation significantly affected on mortality rate during different experimental periods. Pekin ducklings had a significantly higher rate of mortality than Sudani ducklings with any diet supplementation during all different experimental periods.

Carcass traits

The overall means of carcass weight (%) and the proportional weight of some body organs are presented in Table 4. Carcass, total edible parts, and abdominal fat percentages significantly increased ($p \leq 0.05$) based on duckling breed. Carcass and total edible parts percentages were significantly increased ($p \leq 0.01$) by 2.06 and 2.99% for Sudani duckling than Pekin, respectively. All carcass characteristics were significantly affected due to treatments that supplemented with LC and Cr as compared with control at 12 weeks of age, respectively. Carcass percentage significantly increased ($p \leq 0.01$) by 3.03, 2.93, 3.12, and 3.44%, respectively for ducklings Sudani and Pekin dietary supplemented with 300 or 450 mg/kg diet LC and 400 or 600 µg /kg diet Yeast Cr as compared with control. Total edible parts percentage significantly increased ($p \leq 0.01$) by 3.48, 3.49, 3.21, and 3.62%, respectively for duckling breed fed ration supplemented with 300 or 450 mg/kg diet LC and 400 or 600 µg /kg diet Yeast Cr as compared with control. Carcass percentage follows the same trend of LBW and BWG, where body weight and carcass characteristics have a high positive phenotypic and genetic correlation. (Pramod et al., 2002).

Generally, the improvement of eviscerated carcass and edible parts percentage might be due to improvement in final live weight and decreasing un-edible parts as a result of supplementing LC and Cr addition to the diet. The current finding is in agreement with those obtained by Wang et al. (2003) who reported that adding Cr (400-600 µg/kg) alone decreased abdominal fat percentage by 22.92% and 22.54% and adding LC (30, 50, and 100 mg/kg) alone decreased abdominal fat percentage by 33.33%, 28.16%, and 31.61% for broiler chickens at 7 weeks of age. Ibrahiem et al. (2011) reported that the carcass percentage of geese was significantly improved by supplementing 150 mg LC/kg, compared to the control group. Oladele et al. (2011) found that dressing carcass percentage significantly increased by increasing inclusion levels of LC in broilers diets. Also, Abdel-Fattah et al. (2014) presented that supplemental LC (400 mg/kg diet) significantly increased the dressing percent of quail.

The abdominal fat % was significantly ($p \leq 0.05$) decreased by supplemented the LC (300 or 450 mg/kg) and Cr (400 or 600 µg/kg) as compared with control. The decrease in abdominal fat might be due to LC prevents fatty tissues buildup, decreased the calorie requirement, and increased tolerance to effort because it may play major roles in facilitating the removal of short and medium-chain fatty acids from the mitochondria that accumulate as a result of normal and abnormal metabolism and promotes the β-oxidation of these fatty acids to generate Adenosine triphosphate (ATP) energy and improved energy utilization by reducing the amount of long-chain fatty acids availability for etherification to triacylglycerols and storage in the adipose tissue (Xu et al., 2003).

Parsaeimehr et al. (2014) and Huang et al. (2016) reported that supplementing LC (300 mg/kg) and Cr enhanced dressing percentage and decreased abdominal fat percentage of broiler chickens that had been exposed to heat stress in comparison with control groups. Also, Awad et al. (2016) reported that the improvement of eviscerated carcass and edible parts reached from 3.54 to 4.57% and 3.94 to 4.47%, respectively, for Domyati ducklings fed the diet supplemented with different LC levels (150, 300, 450 and 600 mg/kg diet) as compared to control, while the abdominal fat percentage was decreased by 36.14 to 45.18%. Ali et al. (2017) confirmed that carcass and total edible parts percentages were significantly increased due to duckling breed by 3.35 and 4.00% for Pekin ducklings than Domyati, respectively. El-Kelawy (2019) reported that Cr supplementation improved the percentage of carcass weight and decreased abdominal fat at 49 days of the age of Japanese quails compared with control groups. However, there were no significant effects of different Cr levels on inner body organs including liver, gizzard, and heart.

Lymphoid organs

Table 4 has been presented the effect of dietary supplementation on some relative lymphoid organ weights. The LC and Cr levels significantly improved ($p \leq 0.05$) the relative weights of lymphoid organs compared with the control group as reflected by immune status. This result agrees with Ali et al. (2017) who reported that spleen and thymus percentage were significantly increased due to duckling breeds by 33.33 and 60.0% for Domyati ducklings than Pekin, respectively.

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Table 4. Effect of breed and dietary supplementation on carcass traits and some lymphoid organs in Sudani and Pekin ducks during 12 weeks of age.

Items	DB	Treatments					AV	Probability		
		Control	L-carnitine		Yeast chromium					
			300	450	400	600		B	T	BT
Carcass traits										
Carcass%	S	72.41^{b} ±0.87	74.58^{a} ±0.77	74.28^{a} ±0.81	73.57^{ab} ±0.79	73.84^{ab}±0.77	73.74^{a}	**	**	**
	P	70.11^{c} ±0.56	72.25^{b} ±0.64	72.41^{b} ±0.67	73.39^{ab} ±0.88	73.57^{ab}±0.88	72.35^{b}			
	AV	71.26^{b}	73.42^{a}	73.35^{a}	73.48^{a}	73.71^{a}				
Gizzard%	S	3.15^{a}±0.08	3.32^{a}±0.08	3.54^{a}±0.09	3.19^{a}±0.09	3.25^{a}±0.06	3.29^{a}	*	*	*
	P	2.81^{b}±0.08	3.01^{ab}±0.06	3.05^{ab}±0.07	2.86^{b}±0.08	2.95^{b}±0.05	2.94^{b}			
	AV	2.98^{b}	3.17^{a}	3.30^{a}	3.03^{a}	3.10^{a}				
Liver%	S	2.09^{ab}±0.07	2.55^{a}±0.08	2.41^{a}±0.07	2.35^{a}±0.07	2.40^{a}±0.08	2.36^{a}	*	*	*
	P	1.89^{c}±0.08	1.99^{b}±0.09	2.00^{b}±0.06	1.95^{b}±0.06	1.98^{b}±0.09	1.96^{b}			
	AV	1.99^{b}	2.27^{a}	2.21^{a}	2.15^{a}	2.19^{a}				
Heart%	S	0.79±0.04	0.86±0.05	0.88±0.03	0.85±0.04	0.82±0.06	0.84	NS	NS	NS
	P	0.71±0.06	0.75±0.05	0.77±0.05	0.73±0.03	0.72±0.05	0.74			
	AV	0.75	0.81	0.83	0.79	0.77				
Total Giblets%	S	6.03^{ab}±0.15	6.73^{a}±0.24	6.83^{a}±0.16	6.39^{a}±0.20	6.47^{a}±0.34	6.49^{a}	*	*	*
	P	5.41^{b}±0.22	5.75^{b}±0.22	5.82^{b}±0.18	5.54^{b}±0.22	5.65^{b}±0.15	5.63^{b}			
	AV	5.72^{b}	6.24^{a}	6.33^{a}	5.97^{b}	6. 06^{a}				
Edible parts%	S	78.^{44b}±0.98	81.31^{a}±0.95	81.11^{a}±1.05	79.96^{b}±0.95	80.31^{a}±1.06	80.23^{a}	*	**	**
	P	75.52^{c}±1.02	78.00^{b}±0.94	78.23^{b}±0.92	79.93^{b}±1.01	79.22^{b}±0.91	77.98^{b}			
	AV	76.98	79.66	79.67	79.45	79.77				
Abdominal fat%	S	1.17^{b}±0.05	0.92^{c} ±0.04	0.91^{c}±0.03	0.95^{c}±0.02	0.93^{c}±0.02	0.98^{b}	*	*	*
	P	1.79^{a} ±0.04	0.99^{c} ±0.02	0.97^{c} ±0.04	1.09^{ab}±0.05	1.08^{ab}±0.06	1.18^{a}			
	AV	1.48^{a}	0.96^{b}	0.94^{b}	1.02^{ab}	1.01^{ab}				
Lymphoid Organs										
Spleen%	S	0.07^{b} ±0.03	0.08^{a} ±0.02	0.09^{a} ±0.02	0.08^{a} ±0.03	0.08^{a} ±0.03	0.08^{a}	*	*	*
	P	0.05^{c}±0.02	0.07^{b} ±0.01	0.07^{b} ±0.03	0.07^{b} ±0.01	0.06^{c} ±0.01	0.06^{b}			
	AV	0.06^{c}	0.08^{a}	0.08^{a}	0.08^{a}	0.07^{b}				
Thymus%	S	0.006^{b} ±0.02	0.008^{a} ±0.03	0.009^{a} ±0.01	0.008^{a} ±0.01	0.008^{a} ±0.02	0.008^{a}	*	*	*
	P	0.003^{d} ±0.01	0.005^{c} ±0.01	0.006^{b} ±0.02	0.005^{b} ±0.03	0.005^{b} ±0.03	0.005^{b}			
	AV	0.005^{b}	0.007^{a}	0.008^{a}	0.007^{a}	0.007^{a}				

a, b, c, d, e, f: Means with different superscripts in the same row within item differ significantly; NS: Not significant; *: ($p\leq0.05$); **: $p\leq0.01$); DB: Duckling breed; S: Sudani ducks; P: Pekin ducks; AV: Overall mean.

Chemical analysis of breast and thigh

Chemical compositions of duckling meat at 12 weeks of age are presented in Table 5. Dietary LC and Cr supplementation had significant effects on moisture; crude protein and ether extract content percentage of breast and thigh meat, while ash% was not significantly affected. Crude protein content% was significantly increased ($p\leq0.01$) by increasing both LC and Cr supplementation levels for breast and thigh meat than the control group. However, ether extract content% was significantly decreased ($p\leq0.01$). Crude protein% was significantly higher ($p\leq0.01$) by 24.82-35.04 and 6.05-14.64%, respectively in breast and thigh meat for duckling breed fed ration supplemented with LC and Cr as compared with control. The reduced of ether extract content in breast and thigh muscles by supplementing LC diet might be because LC acts by reducing the total activities of glucose-6-phosphate dehydrogenize, malic dehydrogenize, isocitrate dehydrogenize, lipoprotein lipase, and total activities of carnitine palmitoyltransferase-I in breast muscles (Xu et al., 2003). On the other hand, it may accelerate lipid flux into oxidative metabolism, and consequently reduces the body lipid accumulation (Shuenn et al., 2012). These results were partially in agreement with Zhang et al. (2005) who indicated that enrichment of diet with yeast could favorably improve the quality of edible meat from broiler chickens. Awad et al. (2016) reported that crude protein percentage was significantly increased by 8.13, 11.91, 22.54, and 22.62 in breast muscles, whereas, ether extract percentage was significantly decreased by 16.73, 21.10, 52.77 and 50.72% in breast muscles for Domyati ducklings fed diets supplemented with different LC levels (150, 300, 450 and 600 mg/kg of diet), respectively as compared to control diet. El-Fiky et al. (2019) reported that moisture and crude protein percentage

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were significantly increased in the meat of the Mulard ducks (74.33 and 19.45%) compared with Muscovy ducks (73.72 and 18.90%), while, the ether extract and ash percentage were significantly high (3.82 and 1.50%) in the meat of the Muscovy ducks, compared with the Mulard ducks (1.35 and 1.35%). On the other hand, these results were in contrast with the results obtained by Younis (2015) who reported that the chemical composition of breast muscles were not affected due to the addition of LC supplementation by 500 mg/kg.

Economic efficiency

Calculations of Economic Efficiency (EE) have been listed in Table 6. Different levels of LC and Cr supplementation had effects on total coast and returns as well as economic efficiency values. Generally, net return and EE values were higher by feeding diet supplemented with different LC and Cr levels than the control diet. Economic efficiency values for Sudani ducklings were improved by 3.97, 1.77, 1.28 and 0.16% for ducklings fed the diet supplemented with both LC and YC, respectively than those fed the control diet. However, Economic efficiency values for Pekin ducklings were improved by 56.85, 50.88, 45.61 and 44.15% for ducklings fed the diet supplemented with both LC and Cr, respectively than those fed the control diet. These results agreed with Awad et al. (2016) who conferred that economic efficiency value was significantly higher for Domyati breed which fed ratio supplementing with different levels of LC than those fed the control diets. Awad et al. (2017) observed that total cost had insignificantly improved by supplementing different levels of LC to the diet. The total return had significantly improved for Sudani breeds which fed ratio supplemented with 150, 300, 450, 600, and 750 mg LC/kg, respectively than those fed the control diets. El-Kelawy (2019) found that economic efficiency was improved by Cr supplementation during 14-49 days of Japanese quail's age.

Table 5. Effect of breed and dietary supplementation on the chemical composition of meat in Sudani and Pekin ducks during 12 weeks of age

Age (weeks)	DB	Treatments					AV	Probability		
		Control	L-carnitine		Yeast chromium					
			300	450	400	600		B	T	BT
Breast meat										
Mo (%)	S	70.11^{c}±0.31	74.52^{a}±0.28	74.97^{a}±0.37	72.58^{b}±0.30	72.87^{b}±0.29	73.01^{a}	*	*	*
	P	70.02^{c}±0.18	74.50^{a}±0.22	74.81^{a}±0.19	72.50^{b}±0.20	72.71b±0.21	72.91^{b}			
	AV	70.07^{c}	74.51^{a}	74.89^{a}	72.54^{b}	72.79^{b}				
CP (%)	S	15.45e±0.22	20.39^{ab} ±0.17	21.15^{a}±0.19	19.87^{b}±0.21	20.11^{ab}±0.18	19.39^{a}	**	**	**
	P	14.68^{f}±0.15	18.91^{c}±0.12	19.55^{b}±0.17	17.75^{d}±0.11	18.45^{c}±0.16	17.87^{b}			
	AV	15.07^{d}	19.65^{b}	20.35^{a}	18.81^{c}	19.28^{b}				
EE (%)	S	5.57^{b}±0.08	2.84^{e} ±0.07	2.45^{e}±0.09	3.45^{d}±0.11	3.16^{d}±0.15	3.49^{b}	**	**	**
	P	8.64^{a}±0.17	4.48^{c}±0.13	4.17^{c}±0.19	5.57^{b}±0.21	5.24^{b}±0.16	5.62^{a}			
	AV	7.11^{a}	3.66^{c}	3.31^{c}	4.51^{b}	4.20^{b}				
Ash (%)	S	1.12±0.05	1.96 ±0.06	1.42±0.07	1.75±0.09	1.35±0.11	1.52	NS	NS	NS
	P	1.00±0.08	1.92±0.09	1.40±0.07	1.65±0.6	1.31±0.07	1.46			
	AV	1.06	1.94	1.41	1.70	1.33				
Thigh meat										
Mo (%)	S	72.64^{d}±0.23	75.30^{a}±0.25	75.61^{a}±0.29	74.74^{b}±0.22	74.93^{b}±0.23	74.64^{a}	*	*	*
	P	71.67^{e}±0.25	74.60^{b} ±0.23	74.96^{b}±0.21	73.67^{c}±0.22	73.97^{c}±0.21	73.77^{b}			
	AV	72.16^{c}	74.95^{b}	75.29^{a}	74.21^{b}	74.45^{b}				
CP (%)	S	16.74^{d}±0.22	18.19^{b} ±0.21	19.01^{a}±0.23	18.15^{b}±0.25	18.17^{b}±0.26	18.05^{a}	**	**	**
	P	14.67^{f}±0.15	16.80^{d}±0.13	17.01^{c}±0.16	15.16^{e}±0.11	15·87^{e}±0.19	15.90^{b}			
	AV	15.71^{d}	17.50^{b}	18.01^{a}	16.66^{c}	17.02^{b}				
EE (%)	S	7.47^{b}±0.09	4.57^{e} ±0.08	4.15^{e}±0.11	5.65^{d}±0.07	5.47^{d}±0.08	5.46^{b}	**	**	**
	P	9.11^{a}±0.13	6.40^{c}±0.11	6.02^{c}±0.18	7.61^{b}±0.21	7.00^{b}±0.151	7.23^{a}			
	AV	8.29^{a}	5.49^{c}	5.09^{c}	6.63^{b}	6.24^{b}				
Ash (%)	S	1.11±0.08	1.41±0.06	1.33±0.09	1.31±0.07	1.24±0.08	1.28	NS	NS	NS
	P	1.00±0.07	1.15±0.09	1.29±0.11	1.12±0.08	1.02±0.12	1.12			
	AV	1.06	1.28	1.31	1.22	1.13				

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Table 6. Effect of dietary treatments on the economic efficiency of Sudani and Pekin ducks during 12 weeks of age

Items	Sudani					Pekin				
	Control	L-carnitine (mg/kg diet)		Yeast chromium (µg/kg diet)		Control	L-carnitine (mg/kg diet)		Yeast chromium (µg/kg diet)	
		300	450	400	600		300	450	400	600
Price diet/kg (LE)	4.7	4.8	4.85	4.73	4.75	4.7	4.8	4.85	4.73	4.75
Total feed coast (LE)	56.69	59.88	60.72	58.70	59.01	44.49	46.67	47.15	45.58	45.84
Total return (LE)	87.68	93.92	94.51	91.20	91.32	52.08	59.17	59.30	56.92	57.12
Net return (LE)	30.99	34.04	33.78	32.50	32.31	7.60	12.50	12.15	11.34	11.29
Economic efficiency (EE)	54.67	56.84	55.64	55.37	54.76	17.08	26.79	25.77	24.87	24.62

Total cost: feed cost + LC or YC cost + duckling price; LE: Egyptian pound; Net Revenue: Total Revenue - Total feed cost; Economic efficiency: (Net Revenue / Total feed cost) ×100.

CONCLUSION

It could be concluded that both duckling breeds that received dietary supplemented with L-carnitine by 450 mg LC/kg diets resulted in better performance without any adverse effects on physiological responses and carcass quality as well as economic efficiency.

DECLARATIONS

Author's contributions

Conceptualization done by Sobhy Hassan HM and Ahmed Ali KhAE-M; formal analysis done by Sobhy Hassan HM and Ahmed Ali KhAE-M; data curation done by Sobhy Hassan HM, Ahmed Ali KhAE-M and Gouda ARAE-H; methodology done by Sobhy Hassan HM, Ahmed Ali KhAE-M and Gouda ARAE-H; supervision done by project Gouda ARAE-H; administration done by Sobhy Hassan HM, Ahmed Ali KhAE-M and Gouda ARAE-H; writing done by review and editing done by Sobhy Hassan HM, Ahmed Ali KhAE-M and Gouda ARAE-H. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declared no conflict of interest.

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