Short communication

Responses of Black Neck ostrich chicks to L-carnitine dietary supplementation during the pre-starter growth period

A. Hajibabaei[#] & N.H. Casey
Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

The objective was to determine the growth responses of Black Neck ostrich chicks to different dietary levels of L-carnitine in pre-starter diets. Thirty-two day-old ostrich chicks were randomly divided into four treatments with four replicates, each containing two chicks. All birds received the same basal diet supplemented with 0 (T0, control), 125 (T125), 250 (T250) or 600 (T600) mg L-carnitine per kg. Responses were monitored over three growth phases, 0 - 15, 16 - 30 and 31 - 60 days, the total period being 60 days. T600 had the lowest live weight (LW) and live weight gain (LWG) over the 60-day treatment period. Live weight and LWG values of T125 and T250 did not differ from those of T0. T600 had the worst feed conversion ratio (FCR) during the different stages (0 - 15, 16 - 30 and 31 - 60 days) and over the total 60-day period. Feed intake (FI) was reduced significantly in the T125 and T600 treatments compared to T0 and T250 treatments over the total period. The treatment, T125, showed the lowest FI and FCR responses over the total period, whereas there was no difference between T0 and T250. The results suggest that supplementing the pre-starter diet with 125 mg/kg of L-carnitine can improve the performance of ostrich chicks by decreasing the FCR. In contrast, the suppressive effect of a high inclusion level (T600) might indicate that ostrich chicks are sensitive to a high level of inclusion that could cause adverse effects.

Keywords: *Struthio camelus*, carnitine, performance, adverse effects, feed conversion ratio
[#] Corresponding author: ali.hajibabaei@up.ac.za

L-carnitine has fundamental functions in metabolism and is acquired by both limited endogenous synthesis and from exogenous sources. The main functions of L-carnitine are fostering the oxidation of long-chain fatty acids by mitochondria and stimulating a protein-sparing action by increasing energy derived from lipids (Hajibabaei *et al.*, 2008). Moreover, L-carnitine is used in poultry for multi-functional purposes that include promoting growth, strengthening the immune system, as an antioxidant and ameliorating semen quality (Golzar Adabi *et al.*, 2011). According to Harmeyer (2002) the body cannot produce enough L-carnitine to fully cover its own needs and relies on supplementary exogenous L-carnitine that occurs naturally in most foodstuffs in varying amounts. Foodstuffs of vegetable origin normally contain very little L-carnitine and protein of animal origin (muscle tissue, blood meal, liver, etc.) and dairy products are rich in L-carnitine, though the use of animal by-products in animal feeds has become controversial. No dietary components are known to impair absorption. There is no known toxicity associated with excessive ingestion from normal dietary components (Harpaz, 2005). Reports on the effect of L-carnitine on birds' performances are contradictory. The inclusion of 50 mg/kg of L-carnitine in the diet of broiler chicks from the age of 0 - 3 weeks resulted in an improved feed conversion ratio (FCR) (Cevik & Ceylan, 2005). Similarly, other studies have shown that the use of L-carnitine at the early stage of growth has a beneficial effect on broiler performance (Rabie & Szilagyi, 1998; Kita *et al.*, 2002). Corduk *et al.* (2007) established that L-carnitine supplementation did not affect live weight gain (LWG) or feed intake (FI) in broiler chickens. Recently, Keralapurath *et al.* (2010) documented that the *in ovo* injection of L-carnitine had no effect on broiler performance or slaughter yield. There was no variation in body weight in hatching chicks (Zhai *et al.*, 2008),

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in laying hens (Deng *et al.*, 2006), in ducks (Arslan *et al.*, 2003) or in Japanese quails (*Coturnix coturnix*) (Arslan *et al.*, 2004; Sarica *et al.*, 2005; 2007) by the inclusion of dietary L-carnitine. Golzar Adabi *et al.* (2011) concluded that inclusion levels between 50 and 200 mg L-carnitine/kg feed could be added to the diets of broilers and laying hens with positive results on growth performance. No literature is available on the effect of the inclusion of dietary L-carnitine during the pre-starter period on growth performance of ostrich chicks. The hypothesis tested in this trial is whether dietary supplemented L-carnitine has beneficial effects on the performance of ostrich chicks.

A total of 32 healthy day-old, mixed-sex Black Neck ostrich chicks were obtained from a commercial production unit (Buffelskom Boerdery farm, Gondwana Co. Pty Ltd, Limpopo Province, South Africa). The birds were kept in a closed house under uniform management and environmental conditions from 22 Nov. 2010 to 22 Jan. 2011, the summer period in South Africa. The birds were randomly assigned to each of 16 floor pens (per cage 7 m × 2 m) with four treatment groups of four replicates each. Each pen was equipped with a drinker and feeder and the birds had *ad libitum* access to feed in mash form and water during the experiment. The chicks were vaccinated against NCD at 30 days of age. The diet was compiled from literature sources, using the following references as a guide: Cilliers *et al.* (1994); Cilliers *et al.* (1997);

Table 1 Composition and nutrient analysis of basal (as feed) diets

Components of diet	Amount in diet (g/kg)
Maize	46.15
Lucerne	3.5
Soybean meal (44%)	34.57
Wheat Bran	5
Barley	4.96
Salt	0.43
Monocalcium phosphate	1.37
Limestone	2.93
Methionine	0.09
Vitamin-Mineral premix*	1
Total	100
Calculated nutrient contents	
TMEn (MJ/kg DM)	13
Crude protein (g/kg)	21
Calcium (g/kg)	1.5
Non-phytate phosphorus (g/kg)	0.45
Methionine + Cysteine (g/kg)	0.07
Lysine (g/kg)	1.1
Na (g/kg)	0.2
Analytical nutrient contents	
Crude protein (g/kg)	20.88
Crude fibre (g/kg)	4.2
Calcium (g/kg)	1.59
Total phosphorus (g/kg)	1.12

*Supplied per 1000 kilogram of diet according to Cilliers & Van Schalkwyk's (1994) recommendation: vitamin A, 12 000 000 IU; cholecalciferol, 3 000 000 IU; vitamin E (dl-alphatocopherol acetate), 40 000 IU; vitamin K_3, 3000 mg; vitamin B_1, 3000 mg; riboflavin, 8000 mg; pantothenic acid, 14 000 mg; nicotinic acid, 60 000 mg; folic acid, 2000 mg; choline chloride, 500 000 mg; biotin, 2000 mg and vitamin B_{12}, 1000 mg; Mg, 5 000 mg; Mn, 120 000 mg; Zn, 80 000 mg; Fe, 35 000 mg; Cu, 15 000 mg; I, 500 mg; Se, 300 mg; and Co, 100 mg.

Deeming (1999) and Cilliers (2004). The diets were isoenergetic and isonitrogenous in a pre-starter phase (0 - 60 days). The composition of the diets is shown in Table 1, and was analysed for crude protein, crude fibre, calcium and phosphorus (AOAC, 2005). The four treatments were a non-supplemented basal diet that served as the control (T0); the basal diet supplemented with 125 mg/kg of L-carnitine (T125); the basal diet supplemented with 250 mg/kg of L-carnitine (T250) and the basal diet supplemented with 600 mg/kg of L-carnitine (T600). The supplementary L-carnitine was supplied as a white powder with 20% purity (Lohmann Co., Cuxhaven, Germany).

Performance parameters recorded were live weight (LW), LWG; FI and feed conversion ratio (FCR) over the periods, 0 - 15, 16 - 30 and 31 - 60 days. The FCR was calculated as the amount of feed consumed per unit of live weight gain. The statistical design was a completely randomized design with four treatments and four replicates. The data analysis was by the General Linear Model Procedure (SAS, 1990), and the test of significant differences was according to the Tukey HSD test. The trial conformed to the requirements of the Animal Use and Care Committee of the University of Pretoria, reference number EC030-10.

The results of the L-carnitine dietary supplementation treatments on the performance of the ostrich chicks are shown in Table 2. L-carnitine had no effect on LW at Days 15 and 30, but T600 reduced LW (P <0.01) at Day 60 by 40%, 35% and 42% compared to the T0, T125 and T250 treatments, respectively. Moreover, the highest level of L-carnitine (T600) caused a decrease (P <0.01) in final LWG. LWG values

Table 2 Effect of L-carnitine administration in pre-starter diet on growth performance of black neck ostrich chicks (mean ± SE)

Factors*	Treatments[#]				SEM	P-value
	T0	T125	T250	T600		
Live weight (kg)						
Initial	0.95 ± 0.16	0.95 ± 0.10	0.95 ± 0.16	0.95 ± 0.15	0.03	1.00
15d	1.94 ± 0.44	1.64 ± 0.10	1.88 ± 0.34	2.27 ± 0.14	0.08	0.07
30d	5.16 ± 0.20	4.19 ± 0.17	4.79 ± 1.00	3.61 ± 0.26	0.23	0.07
60d	14.99^{a} ± 0.88	13.85^{a} ± 0.70	15.46^{a} ± 1.82	9.04^{b} ± 0.11	0.70	<0.0001
Live weight gain (kg)						
0-15d	0.98^{ab} ± 0.30	0.69^{b} ± 0.02	0.92^{ab} ± 0.19	1.32^{a} ± 0.10	0.07	0.004
16-30d	3.22^{a} ± 0.76	2.54^{ab} ± 0.07	2.91^{a} ± 0.66	1.33^{b} ± 0.24	0.21	0.001
31-60	9.82^{a} ± 0.71	9.66^{a} ± 0.79	10.67^{a} ± 0.85	5.42^{b} ± 0.16	0.54	<0.0001
Total period	14.03^{a} ± 0.78	12.90^{a} ± 0.75	14.50^{a} ± 1.65	8.08^{b} ± 0.18	0.69	<0.0001
Feed intake (kg)						
0-15d	1.30^{b} ± 0.38	0.89^{b} ± 0.05	1.38^{b} ± 0.29	2.61^{a} ± 0.19	0.17	<0.0001
16-30d	6.89 ± 2.76	6.41 ± 0.32	7.56 ± 2.26	8.20 ± 1.28	0.46	0.58
31-60	25.97 ± 10.63	26.56 ± 1.80	28.86 ± 7.75	20.59 ± 5.48	1.78	0.44
Total period	22.79^{a} ± 0.70	16.93^{b} ± 0.80	21.90^{a} ± 2.01	17.25^{b} ± 0.97	0.73	<0.0001
Feed conversion ratio (kg/kg)						
0-15d	1.328^{c} ± 0.045	1.288^{c} ± 0.049	1.489^{b} ± 0.055	1.979^{a} ± 0.027	0.07	<0.0001
16-30d	1.460^{bc} ± 0.120	1.261^{c} ± 0.029	1.524^{b} ± 0.049	3.085^{a} ± 0.118	0.18	<0.0001
31-60	1.752^{b} ± 0.096	1.374^{d} ± 0.028	1.558^{c} ± 0.055	2.184^{a} ± 0.113	0.07	<0.0001
Total period	1.626^{b} ± 0.061	1.313^{c} ± 0.024	1.512^{b} ± 0.036	2.134^{a} ± 0.091	0.07	<0.0001

[a-d] Means in the same row without common letters different significantly.

[*] SEM - Standard error of the mean.

[#]T0 = Basal diet (control); T125 = Basal diet + 125 mg/kg L-carnitine; T250 = Basal diet + 250 mg/kg L-carnitine; T600 = Basal diet + 600 mg/kg L-carnitine.

for T125 and T250 were not different (P >0.05) from T0. Although FI increased (P <0.01) by inclusion of 600 mg/kg L-carnitine in the diet during the 0 - 15 day period, it decreased (P <0.01) over the total period of the experiment. Over the total study period FI was reduced (P <0.01) in the T125 and T600 compared to the T0 and T250 treatments. Likewise, the results showed that there were no differences in FI between dietary treatments during the 16 - 30 and 31 - 60 day periods. The FCR was affected by dietary supplementation of L-carnitine during the different periods (0 - 15, 16 - 30, 31 - 60) as well as the total period of the experiment. Feed conversion ratio was negatively affected (P <0.01) by the addition of 600 mg L-carnitine/kg when compare to the T0, T125 and T250 treatments by increasing FCR with 31%, 62% and 41%, respectively. In contrast, the best FCR was obtained in the group fed by dietary inclusion of 125 mg/kg L-carnitine during different stages and over the total period of the study. However, this treatment had the lowest FI compared to T0 and T250 during the total period, but LW and LWG were not different (P >0.05).

It has been reported that the supplementation of dietary L-carnitine at 0, 50 or 100 mg/kg diet did not influence LW of broiler chickens fed low-fat or high-fat diets (Barker & Sell, 1994). Lien & Horng (2001) demonstrated that feeding broilers a 160 mg/kg of L-carnitine dietary supplement had no effect on the growth performance. Xu *et al.* (2003) fed male broiler chicks with 0, 25, 50, 75 or 100 mg/kg L-carnitine and reported that L-carnitine supplementation had no effect on LWG and FCR. Deng *et al.* (2006) found no differences in growth rates, FI and/or FCR among the dietary treatments throughout the feeding of ISA-Brown cockerels with 0, 500 and 1000 mg/kg L-carnitine supplemented from day-old to 4 weeks of age. In addition, they did not report any toxicity sign by inclusion of high levels of L-carnitine.

The results of some studies suggested that L-carnitine supplementation had no effect on FI (Barker & Sell, 1994; Leibetseder, 1995; Rabie & Szilagyi, 1998; Lien & Horng, 2001; Xu *et al.*, 2003; Corduk *et al.*, 2007). Contrary to these results, some studies suggested that supplementing of L-carnitine could improve growth performance in broiler chickens and laying hens (Lettner *et al.*, 1992; Rabie & Szilagyi, 1998; Rodehutscord *et al.*, 2002; Kita *et al.*, 2002; Nouboukpo *et al.*, 2010; Cevik & Ceylan, 2005). Rabie & Szilagyi (1998) reported that supplementation with 50 mg/kg of L-carnitine caused the improvement of LWG and FCR in birds, especially from 18 to 32 days of age. They concluded that the improvement of growth performance during this period in response to dietary L-carnitine might imply that the requirement of broiler chickens for L-carnitine is higher during a period of rapid growth.

Ostrich chicks showed a very rapid growth during the pre-starter period in that LW changed from approximately 900 g at day-old to 1200 g at 60 days of age (Deeming, 1999). In the present study, birds fed on diets T0, T125 and T250 had the same LW and LWG, although final LW and LWG were lower (P <0.01) at the highest inclusion level (T600) in the diet.

There are many conflicting reports on the response of different avian species to supplementary dietary L-carnitine (Golzar Adabi *et al.*, 2011). These inconsistencies between studies could be related to differences in levels of L-carnitine supplementation, L-carnitine level of basal diet, nutritional and physiological status of the animal and the nutrient composition of their diets (such as dietary lipid and protein intake, supply or absence of essential amino acids). Additional factors are the possible effects of enzymatic breakdown of branched-chain amino acids, sparing effects of L-carnitine and its considerable precursors (lysine and methionine), interspecies differences, differences in ingredients and metabolisable energy levels, age, sex, feeding programme and managerial or environmental conditions of animals (Sarica *et al.*, 2007; Golzar Adabi *et al.*, 2011). There are hypotheses regarding the actions of L-carnitine in the improvement of the growth performance that could be epitomized. The improvements in broilers performance observed in some investigations due to added dietary L-carnitine may be attributable to an improved utilization of dietary nitrogen, reached through more effective fat oxidation by L-carnitine. Growth improvements due to addition of L-carnitine may be partly associated with its amino acid-sparing role in addition to its function in fatty acid metabolism. Functionally, an exogenous supplementation of L-carnitine could reduce the need for biosynthesis of L-carnitine from methionine, thus sparing methionine for other biological activities (Golzar Adabi *et al.*, 2011).

In conclusion, the results of the current investigation showed that increasing the L-carnitine content of the diets to 600 mg/kg was accompanied by unfavourable changes in the performance of ostrich chicks, including a significant increase in FCR and lower body weight gain. This may indicate that ostrich chicks are sensitive to a high inclusion levels that could cause adverse effects by disrupting physiological processes and suppressing feed efficiency and growth performance. The inclusion of 125 mg/kg of L-carnitine in the pre-

starter diets of black neck ostriches improved the performance of the birds by decreasing the FCR. There are a number of publications on the influence of L-carnitine in different avian species. Yet, it appears that the current investigation is the first to report the effect of L-carnitine on ostrich growth performance during the pre-starter period. According to the results of this investigation, further research is necessary to study the negative impact of L-carnitine at high dietary levels.

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References

AOAC, 2005. Association of Official Analytical Chemist, Official Methods of Analysis (15th ed.). Washington, D.C., USA.

Arslan, C., Citil, M. & Saatci, M., 2003. Effects of L-carnitine administration on growth performance, carcass traits, blood serum parameters and abdominal fatty acid composition of ducks. Archiv. Anim. Nutr. 57 (5), 381-388.

Arslan, C., Citil, M. & Saatci, M., 2004. Effects of L-carnitine administration on growth performance, carcass traits and some serum components of Japanese quail (*Coturnix cot. japonica*). Archiv. Geflugelkund. 68, 111-114.

Barker, D.L. & Sell, J.L., 1994. Dietary carnitine did not influence performance and carcass composition of broiler chickens and young turkey fed low- or high- fat diets. Poult. Sci. 73, 281-287.

Cevik, A.F. & Ceylan, N., 2005. Effects of dietary L-Carnitine supplementation on performance and carcass traits of broiler chickens. III. Ulusal Hayvan Besleme Kongresi. Adana. pp. 391-396. (in Turkish).

Cilliers, S.C., 1994. Evaluation of feedstuffs and the metabolisable energy and amino acid requirements for maintenance and growth in ostriches (*Struthio camelus*). PhD thesis, University of Stellenbosch, South Africa.

Cilliers, S.C., 2004. Husbandry and nutritional practices in chick rearing. Proceedings of the 11th Ostrich World Congress, Island Great Brijun, Croatia.

Cilliers, S.C. & Van Schalkwyk, S.J., 1994. Volstruis Produksie Klein Karoo Landbou Kooperasie. Departement Landbou, Oudtshoorn, South Africa (in Afrikaans).

Cilliers, S.C., Hayes, J.P., Maritz, J.S., Chwalibog, A. & Du Preez, J.J., 1994. True and apparent metabolisable energy values of lucerne and yellow maize in adult roosters and mature ostriches (*Struthio camelus*). Anim. Prod. 59, 309-313.

Cilliers, S.C., Hayes, J.P., Chwalibog, A., Du Preez, J.J. & Sales, J., 1997. A comparative study between mature ostriches (*Struthio camelus*) and adult cockerels with respect to true and apparent metabolisable energy values for maize, barley, oats and triticale. Br. Poult Sci. 38, 96-100.

Corduk, M., Ceylan, N. & Ildiz, F., 2007. Effects of dietary energy density and L-carnitine supplementation on growth performance, carcass traits and blood parameters of broiler chickens. S. Afr. J. Anim. Sci. 37 (2), 65-73.

Deeming, D.C., 1999. The Ostrich Biology, Production and Health. CABI Publishing, Wallingford, UK. 358 pp.

Deng, K., Wong, C.W. & Nolan, J.V., 2006. Long-term effects of early-life dietary L-carnitine on lymphoid organs and immune responses in Leghorn-type chickens. J. Anim. Physiol. Anim. Nutr. 90, 81-86.

Golzar Adabi, SH., Cooper, R.G., Ceylan, N. & Corduk M., 2011. L-carnitine and its functional effects in poultry nutrition. Wrld's Poult. Sci. J. 67, 277-296.

Hajibabaei, A., Shivazad, M., Golzar Adabi, SH., Lavaf, A. & Eila, N., 2008. L-carnitine improves egg production in black neck ostriches. Aust. J. Exp. Agric. 48, 1341-1344.

Harmeyer, J., 2002. The Physiological Role of L-carnitine. Lohman Information 27, 15-21.

Harpaz, S., 2005. L-Carnitine and its attributed functions in fish culture and nutrition. Aquaculture 249, 3-21.

Keralapurath, M.M., Corzo, A., Pulikanti, R., Zhai, W. & Peebles, E.D., 2010. Effects of *in ovo* injection of L-carnitine on hatchability and subsequent broiler performance and slaughter yield. Poult. Sci. 89, 1497-1501.

Kita, K., Kato, S., Yaman, M.A., Okumura, J. & Yokota, H., 2002. Dietary L-carnitine increases plasma insulin-like growth factor-I concentration in chicks fed a diet with adequate dietary protein level. Br. Poult. Sci. 43, 117-121.

Leibetseder, J., 1995. Studies on effects of L- carnitine in poultry. Archiv. Anim. Nutr. 48, 97-108.

Lettner, V.F., Zollitsh, W. & Halbmayer, E., 1992. Use of L-carnitine in the broiler ration. Bodenkultur. 43, 161-167.

Lien, T.F. & Horng, Y.M., 2001. The effect of supplementary dietary L-carnitine on the growth performance, serum components, carcass traits and enzyme activities in relation to fatty acid beta-oxidation of broiler chickens. Br. Poult. Sci. 42, 92-95.

Nouboukpo, K.E., Tona, K., Agbonon, A., Gbassor, M., Buyse, J. & Decuypere, E., 2010. Effects of L-carnitine supplementation in drinking water on layer-type chick juvenile performance. Archiv. Geflugelkunde 74 (2), 116-120.

Rabie, M.H. & Szilagyi, M., 1998. Effects of L-carnitine supplementation of diets differing in energy levels on performance, abdominal fat content and yield and composition of edible meat of broilers. Br. J. Nutr. 80, 391-400.

Rodehutscord, M., Timmler, R. & Dieckmann, A., 2002. Effect of L-carnitine supplementation on utilisation of energy and protein in broiler chicken fed different dietary fat levels. Archiv. Anim. Nutr. 56, 431-441.

Sarica, S., Corduk, M. & Kilinc, K., 2005. The effect of dietary L-carnitine supplementation on growth performance, carcass traits and composition of edible meat in Japanese quail (*Coturnix coturnix japonica*). J. Appl. Poult. Res. 14, 709-715.

Sarica, S., Corduk, M., Ensoy, U., Basmacioglu, H. & Karatas, U., 2007. Effects of dietary supplementation of L-carnitine on performance, carcass and meat characteristics of quails. S. Afr. J. Anim. Sci. 37, 189-201.

SAS, 1990. Statistical Analysis Systems user's guide (6.03th ed.). SAS institute Inc., Statistics. SAS Institute Inc., Cary, North Carolina, USA.

Xu, Z.R., Wang, M.Q., Mao, H.X., Zhan, X.A. & Hu, C.H., 2003. Effects of L-carnitine in growth performance, carcass compositin, and metabolism of lipids in male broilers. Poult. Sci. 82, 408-413.

Zhai, W., Neuman, S., Latour, M.A. & Hester, P.Y., 2008. The effect of *in ovo* injection of L-carnitine on hatchability of white leghorns. Poult. Sci. 87, 569-572.