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Effect of adding L-carnitine and Protexin® probiotic on performance and some blood parameters of ostrich chickens

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Abstract. This study was conducted to investigate the effects of adding L-carnitine and Protexin® probiotic on performance and some blood parameters of ostrich chickens. In this study, a total of 48 one-day old ostrich chicks randomly divided into four treatment groups. Each treatment comprised of 4 replicates and 3 animals in each replicate and reared for 8 week. The experiment was arranged in a completely randomized design. The dietary treatments were: Treatment 1 (Control): Basal diet without supplementation; Treatment 2: Protexin® probiotic with level of 1 kg/t; Treatment 3: L-carnitine 500 mg/kg diet; Treatment 4: Protexin® probiotic with level of 500 kg/t + L-carnitine 250 mg/kg diet. The results of this study indicated that diet supplementation with L-carnitine and Protexin® probiotic increased ostrich chickens weight and feed intake at 8 weeks of age in comparison to other treatment groups. The other results showed no significant differences in feed conversion ratio (FCR) among different treatments at 8 week of ages and Broilers receiving L-carnitine + Protexin® probiotic had lowest FCR compared to the other tratment groups. Furthermore, diet supplementation with L-carnitine and Protexin® probiotic increased blood glucose concentration of ostrich chickens at 8 weeks of age in comparison to other treatment groups. Futher result showed that birds received L-carnitine + Protexin® probiotic had lowest total cholesterol in compersion to other treatment groups and birds receiving L-carnitine and Protexin® probiotic had lower HDL, LDL, and VLDL concentrations in compersion control group. There were no significant effect in calcium and phosphorus concentrations between control and other treatment groups.

Keywords: L-carnitine; Protoxin; Probiotic; Growth promoters; Blood parameters; Nutritional supplements.

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Introduction

Ostrich farming has been established in South Africa for 150 years. In recent years, increasing demand for meat and leather products has to this type of farming to expand into many countries, including Korea, USA, Belgium, Italy, Australia and Russia (Huchzermeyer, 2002; Carbajo, 2006). There is a high mortality rate amongst ostrich chicks are associated with pathogenic infection (Shivaprasad, 1993; Huchzermeyer, 2002). Chicks which lack a well established microbiota are more susceptible to infection, thus the mortality rate could potentially be decreased by ensuring the establishment of the correct intestinal bacteria. Also, feed antibiotics used as growth promoters allow better performance (Dibner and Richards, 2005). However, the possible relationship between antimicrobials in feed and increase bacterial resistance in animals and humans to antibiotics resulted in the adoption of new measures to control this type of chemical composition (Jin, 1997; Ferket, 2003).

Probiotics have been defined as live microbial food supplements which beneficially affect the host animal by improving its intestinal microbial balance (Gomes and Malcata, 1999). Probiotics are increasingly used as a tool to improve the health of farmed animals. This strategy is employed due to the observed effects of the gastrointestinal microbiota of broiler chickens on intestinal infections and the immune response, both of which are important in the prevention of pathogenic infections in the gut (Lu et al., 2003). The effects of a probiotic on a host include modifying the microbiota, competitive exclusion, release of nutrients and regulation of the immune system. The primary effector of this beneficial effect is hypothesised to be competitive exclusion, whereby the colonisation of the gut by these commensals prevents the establishment of pathogenic strains (Netherwood et al., 1999). While the precise mechanism of competitive exclusion remains unknown, several factors have been implicated; competition of a probiotic with a pathogen for nutrients, as well as receptors in the gut (Mead, 2000; O'Sullivan et al., 2005). The effects of probiotics on poultry have been mainly focused on broilers and little information has been reported in the literature regarding its effects on ostriches. Ostriches have a different gastrointestinal tract compared to broilers, which allows them to digest dietary fibre more efficiently (Cilliers et al., 1997; Brand et al., 2000; Sales, 2006). The length of the colon in an adult ostrich represents approximately 57% of the intestines compared to only 3% in an adult broiler (Angel, 1996). This may explain the higher apparent metabolizable energy of feed ingredients in adult ostriches compared to cockerels (Cilliers et al., 1997). This important difference in gastrointestinal tract physiology may also allow the ostrich to have different microbiota populations in terms of diversity and amount (Ahir et al., 2012; Oakley et al., 2014; Waite and Taylor, 2014). Thus, it may be expected that the effects of probiotics in ostriches may differ to those in broilers. Protexin® is one of the commercial probiotics preparations containing *Lactobacillus acidophilus* and *Bifidobacterium*. Each gram of protoxin contained 0.1 x 10 CFU (EFSA, 2003). The manufactures of the product (Probiotics Internationals Limited, UK) claims that it exerts its beneficial effects on the performance of broilers. Studies with broiler chickens indicated a positive effect to dietary supplementation of probiotics (Mohan et al., 1996). Probiotics reduce the production of toxic components by bacteria and modify the morphology of the intestinal walls and reduce colonization of pathogens on the intestine walls, thus preventing damage to the epithelial cells (Longhout, 2000). Rezaie et al. (2013) reported that inclusion of Primalac probiotics (included *Lactobacillus acidophilus, Lactobacillus casei*, *Bifidobacterium thermophilum* and *Enterococcus faecium*) in the basal diet of ostrich chickens, improved body weight (BW), feed conversion ratio (FCR) and blood parameters, and those given 0.135% Primalac had the highest body weight, lowest FCR and lowest amounts of blood cholesterol and uric acid ($p < 0.05$). Xu et al. (2010) reported that the morbidity and mortality in ostriches fed probiotics (15% and 2.6%) was lower than ostriches fed a control diet (24.1% and 3.8%), respectively, while the daily gain was higher ($p \leq 0.01$).

L-carnitine is a water-soluble quaternary amine that occurs naturally in microorganisms, plants and animals (Bremer, 1983). L-carnitine is biosynthesized in the kidneys and liver from lysine and methionine amino acids, and it is formed with contributions from vitamins ascorbate, niacin, pyridoxine and folic acid, as well as iron (Rebouche, 1991; Rebouche, 1992; Leibestseder, 1995; Rabie and Szilágyi, 1998). L-carnitine as feed additives in poultry diets used to increase yield and to improve feed efficiency (Bell et al., 1987). 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). Although studies on the effect of L-carnitine on ostriches are limited, there are studies which have been conducted on other bird species. Results on the effect of L-carnitine on birds' performances are contradictory. A diet containing of 50 mg/kg L-carnitine in broiler chicks from 0-3 week of age, resulted in an improved feed conversion ratio (Cevik and Ceylan, 2005). Considering this and similar reports it would appear that using L-carnitine during early stages of growth in poultry has a better effect on performance (Rabie and Szilagyi, 1998; Kita et al., 2002). Other studies have shown that addition of L-carnitine at the early stage of growth has a beneficial effect on broiler performance (Rabie and Szilagyi, 1998; Kita et al., 2002). Corduk et al. (2007) reported that L-carnitine supplementation did not affect live weight gain (LWG) or feed intake (FI) in broiler chickens. This study was aimed at determining the effect of adding L-Carnitine and Protexin® probiotic on performance and some blood parameters of ostrich chickens.

Materials and methods

Birds and diets

This study examined the effect of L-carnitine and Protexin® probiotic on growth performance and some blood parameters of ostrich chickens. A total of 48 one-day old ostrich chicks were purchased from a local hatchery, randomly divided into four treatment groups. Each treatment comprised of 4 replicates and 3 animals in each replicate. The experiment was arranged in a completely randomized design. The chicks were reared individually, in cages of 2.5 m x 1.5 m, with an open area of 1 m x 1 m for 60 days. Each pen was equipped with a drinker and feeder and the birds had *ad libitum* access to feed and water during the experiment. The chicks were vaccinated against newcastle disease at 30 days of age. The ostrich chickens were randomly allocated to the following treatment groups:

- Treatment 1 (Control): Basal diet without supplementation.
- Treatment 2: Protexin® probiotic with level of 1 kg/t.
- Treatment 3: L-carnitine 500 mg/kg diet.
- Treatment 4: Protexin® probiotic with level of 500 kg/t + L-carnitine 250 mg/kg diet.

The composition and chemical analysis of the basal diet are presented in (Tables 1 and 2).

The experimental diets were formulated to meet minimum nutrient requirements of ostrich chickens, as established by the National Research Council (1994). They were fed a starter diet (21% CP and 3,100 kcal of ME/kg) from hatch to 8 week of age. Approval for the animal trials was obtained from the Animal Ethics Committee, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.

Data collection

The growth performance of ostrich chickens were evaluated by recording body weight, feed intake, and feed conversion ratio. Individual live body weights of ostrichs were recorded at the beginning of the experiment and on a weekly basis there after. Feed intake was determined as the difference between the amount of feed given and the residual feed at the end of each experimental day. Feed conversion Ratio was determined as the ratio between feed intake and body weight gain at each week of the experimental period.

Table 1. Composition of the basal diet.

Ingredient (%)	0-8 weeks
Corn	46.14
Alfalfa	3.50
Soybean meal	34.57
Wheat bran	5.00
Barley	4.97
DCP	1.37
DL-Methionine	0.09
Vitamin and mineral premix[1]	1.00
Limestone	2.93
Sodium chloride	0.43
Total	100.00

1. Vitamin premix per kg of diet: vitamin A (retinol), 2.7 mg; vitamin D3 (Cholecalciferol), 0.05 mg; vitamin E (tocopheryl acetate), 18 mg; vitamin K3, 2 mg; thiamine 1.8 mg; riboflavin, 6.6 mg; panthothenic acid, 10 mg; pyridoxine, 3 mg; cyanocobalamin, 0.015 mg; niacin, 30 mg; biotin, 0.1 mg; folic acid, 1 mg; choline chloride, 250 mg; antioxidant 100 mg; Mineral premix per kg of diet: Fe ($FeSO_4.7H_2O$, 20.09% Fe), 50 mg; Mn ($MnSO_4.H_2O$, 32.49% Mn), 100 mg; Zn (ZnO, 80.35% Zn), 100 mg; Cu ($CuSO_4.5H_2O$), 10 mg; I (KI, 58% I), 1 mg; Se ($NaSeO_3$, 45.56% Se), 0.2 mg.

Table 2. Calculated composition of the basal diet.

Calculated composition	0-8 weeks
Energy (kcal/kg)	3100
Protein (%)	21
Lysine (%)	1.1
Met+Cys (%)	0.07
Calcium (%)	1.5
Available phosphorous (%)	0.45
Crude fiber (%)	4.2

Serum biochemical parameters

At the end of experiment, blood samples were taken from wing vein of two ostrich chicks per pen using a syringe containing heparin were taken without anesthesia. Blood plasma was isolated by centrifugation at 3,000 rpm for 20 min at 4 ºC and aliquots were stored at -20 ºC for analysis. Aliquots were analyzed for glucose (Barham and Trinder, 1972), uric acid, total cholesterol, triglycerides, high density lipoproteins (HDL), low density lipoproteins (LDL) and very low density lipoproteins (VLDL) cholesterol, calcium and phosphorus (Thomas, 1998). All the reagents and kits used to analyses the blood sample were provided by Teif Azmoon Pars, Co. (Tehran, Iran).

Statistical analysis

The data obtained were analyzed using SAS (9.1) with a General Linear Model procedure for ANOVA. Differences between means were analyzed with Duncan’s multiple range test. The significant difference statements were based on the probability of $p < 0.05$, unless explained in another way.

Results and discussion

The results of adding different levels of L-carnitine and Protexin® probiotic on the growth performance of ostrich chickens at hatch to 8 weeks of age are presented in (Table 3, 4 and 5). Diet supplementation with L-carnitine and Protexin® probiotic increased ostrich chickens weight at 8 weeks of age in comparison to other treatment groups. Treatment with adding terbutaline + L-carnitine had the highest total body weight (11,870 g) and the lowest total body weight was observed in the control groups (10,270 g) at 8 weeks of age.

Table 3. Body weight (means ± SE) in grams of ostrich chickens fed diets containing levels of L-carnitine and Protexin® probiotic from hatch to 8 weeks of age.

Week	Control (g)	L-Carnitine (g)	Protexin® probiotic (g)	L-carnitine + Protexin® probiotic (g)
1	760 ± 16.48	780 ± 16.28	750 ± 17.83	790 ± 16.62
2	1,280 ± 26.82	1,350 ± 27.38	1,370 ± 28.68	1,380 ± 28.86
3	1,780 ± 32.83	1,860 ± 35.49	1,890 ± 37.57	1,940 ± 33.26
4	3,120 ± 72.65	3,260 ± 74.19	3,580 ± 76.85	3,720 ± 73.24
5	5,180 ± 84.28	5,350 ± 86.27	5,630 ± 82.43[b]	5,680 ± 85.36b
6	6,480 ± 113.86[b]	6,920 ± 115.36[b]	7,130 ± 116.42[a]	7,280 ± 118.63[a]
7	9,280 ± 125.28[b]	9,540 ± 128.42[b]	9,830 ± 126.37[b]	10,220 ± 127.92[a]
8	10,270 ± 137.28[b]	11,320 ± 138.56[a]	11,250 ± 136.85[a]	11,870 ± 138.72[a]

[abc]Means in the same row with the different letter superscripts are significantly different at $p < 0.05$; SEM: standard error of the mean.

Table 4. Feed intake (means ± SE) in grams of ostrich chickens fed diets containing levels of L-carnitine and Protexin® probiotic from hatch to 8 weeks of age.

Week	Control (g)	L-Carnitine (g)	Protexin® probiotic (g)	L-carnitine + Protexin® probiotic (g)
1	620±23.68	650±25.42	630±26.18	640±28.35
2	1,110±53.62	1,150±57.28	1,130±55.38	1,180±56.78
3	2,180±75.82	2,260±76.26	2,320±78.45	2,380±72.38
4	4,760±112.69 [b]	5,280±118.42 [a]	5,420±115.63 [a]	5,680±118.69 [a]
5	8,250±226.74	8,730±227.65	8,850±224.58	8,940±228.12
6	10,600±346.47 [b]	11,280±348.25 [a]	11,350±349.35[a]	11,460±352.68 [a]
7	15,810±425.63 [b]	16,060±423.51 [a]	16,270±426.48 [a]	16,380±428.28 [a]
8	18,600±524.82 [b]	19,380±526.48 [a]	19,420±527.45 [a]	19,680±528.43 [a]

[abc]Means in the same row with the different letter superscripts are significantly different at $p < 0.05$; SEM: standard error of the mean.

There were significant differences in body weight among different treatment groups at 6, 7 and 8 weeks of ages ($p < 0.05$). The groups fed with L-carnitine + Protexin® probiotic had highest feed intake (19,680 g) and the lowest feed intake was observed in the control groups (18,600 g) at 8 weeks of age. There were significant effect in feed intake among control and other treatment groups at 4, 6, 7 and 8 weeks of ages ($p < 0.05$).

The results in (Table 5) showed no significant differences in FCR among different treatments at 8 week of ages. Broilers receiving L-carnitine + Protexin® probiotic had lowest FCR (1.65) in compared to the other tratment groups and the highest FCR was shown in control group (1.73).

The overal results of this investigation showed that adding L-carnitine and Protexin® probiotic increased total body weight, feed intake and decreased FCR at end of 8 weeks of age.

Table 5. FCR (means ± SE) in ostrich chickens fed diets containing levels of L-carnitine and Protexin® probiotic from hatch to 8 weeks of age.

Week	Control (g)	L-Carnitine (g)	Protexin® probiotic (g)	L-carnitine + Protexin® probiotic (g)
1	0.81±0.02	0.83± 0.03	0.84±0.04	0.81±0.03
2	0.86±0.03	0.85±0.05	0.82±0.04	0.85±0.02
3	1.22±0.04	1.21±0.05	1.22±0.06	1.22±0.08
4	1.52±0.02	1.61±0.04	1.51±0.06	1.52±0.03
5	1.59±0.05	1.63±0.02	1.57±0.04	1.57±0.02
6	1.63±0.03	1.63±0.05	1.59±0.02	1.57±0.05
7	1.70±0.05	1.68±0.03	1.65±0.04	1.60±0.02
8	1.73±0.03	1.71±0.04	1.72±0.02	1.65±0.05

[abc]Means in the same row with the different letter superscripts are significantly different at $p < 0.05$; SEM: standard error of the mean.

Table 6. Blood biochemical parameters (means ± SE) in ostrich chickens fed diets containing levels of L-carnitine and Protexin® probiotic at 8 weeks of age.

Parameters	Control	L-Carnitine	Protexin® probiotic	L-carnitine + Protexin® probiotic
Glucose (mg/dL)	182.85±15.83	195.68±16.25	217.62±18.42	213.46±17.28
Uric acid (mg/dL)	10.62±1.65	9.38±1.89	9.32±1.43	9.25±1.28
Total cholesterol (mg/dL)	147.25±12.52^{a}	125.48±11.86^{b}	128.42±12.87^{b}	92.37 ± 11.25^{c}
Triglycerides (mg/dL)	126.75±47.86^{a}	87.75± 43.58^{c}	96.12±45.63^{b}	83.26±42.78^{c}
HDL cholesterol (mg/dL)	82.39± 8.52^{ab}	76.48±6.29^{b}	71.25±7.58^{b}	53.82±6.45^{c}
LDL cholesterol (mg/dL)	47.72±7.38^{ab}	33.27±6.52^{b}	38.65±6.81^{b}	24.75±7.45^{c}
VLDL cholesterol (mg/dL)	18.52±6.71	16.25± 6.47	17.72±5.84	15.83±5.32
Calcium (mg/dL)	10.25± 0.58	10.68± 0.65	11.58± 0.68	11.82±0.63
Phosphorus (mg/dL)	7.28± 0.52	8.83± 0.55	7.52± 0.54	8.15± 0.57

[abc]Means in the same row with the different letter superscripts are significantly different at $p < 0.05$; SEM: standard error of the mean.

The results of adding different levels of L-carnitine and Protexin® probiotic on blood biochemical parameters of ostrich chickens at 8 weeks of age are presented in (Table 6). Diet supplementation with L-carnitine and Protexin® probiotic increased blood glucose concentration of ostrich chickens at 8 weeks of age in comparison to other treatment groups. The highest amount of glucose concentration was shown in Protexin® probiotic treatment (217.62 mg/dL) and the lowest of this (182.85 mg/dL) parameter was shown in control groups. Further results showed that the lowest uric acid concentration (9.25 mg/dL) was shown in the L-carnitine + Protexin® probiotic groups and the highest amount of uric acid (10.62 mg/dL) was shown in control groups. The highest total cholesterol (147.25 mg/dL) were obseved in control groups and the lowest of this (92.37 mg/dL) was shown in groups feed with L-carnitine + Protexin® probiotic.

There were significant effect in total cholesterol concentrations between control and other treatment groups. Futher results showed that birds recived L-carnitine + Protexin® probiotic had lowest triglycerides concentrations (83.26 mg/dL), and the highest amount of this parameters was shown in control groups (126.75 mg/dL). There were significant effect in triglycerides concentrations between control and other treatment groups. The highest HDL, LDL and VLDL concentrations was shown in control groups and the lowest amount of these parameters was shown in birds feed with L-carnitine + Protexin® probiotic. There were significant effect in HDL and LDL concentrations between control and L-carnitine + Protexin® probiotic treatment at 8 weeks of age. Futher results showed that birds recived L-carnitine + Protexin® probiotic had highest calcium concentrations (11.82 mg/dL), and the lowest amount of this parameter was shown in control groups (10.25 mg/dL). The highest phosphorus concentrations (8.83 mg/dL) was shown in birds feed with L-carnitine and the lowest amount of this parameter was shown in control groups (7.28 mg/dL). There were no significant effect in calcium and phosphorus concentrations between control and other treatment groups.

The present study demonstrate that inclusion of L-carnitine and Protexin® probiotic increase body weeight, feed intake and FCR of ostrich chickens at 8 week of age. The improved Body weight and FCR of the birds in this study is matched with the results of Jin et al. (1998) who studied the effect of lactobacillus cultures in broilers and found that BW significantly increased in comparison with control group.

In the case of ostrich chicks, probiotics such as natural yoghourt has been used in order to colonize the gut with useful species of bacteria (Deeming et al., 1996). Due to the fact that young ostrich chicks can not use fibers as well as old ostriches (Cooper et al., 2004), here synbiotic may has contributed in development of healthy microflora in the hindgut, to get more energy from the nutrient fermentation in the cecum and consequently have improved the performance of the birds. In contrast to these results, Gri et al. (2008) failed to show any significant impact of probiotics in rhea chicks. The addition of probiotic to diets may influence broiler weight gain (Langhout, 2000). The mechanism that explained the action of probiotics was probably focused on gastrointestinal tract, as many of these products are not absorbed and had been shown to be not efficient as growth promoters in germ free animals (Coates et al., 1995). Edens (2003) reported that the addition of probiotic, did not affect body weight of broilers at 42 days of age; however, it improved feed conversion ratio.

Jin et al. (1998) studied the effect of probiotic on broilers and they found that body weight significantly increased in comparison with the control group. However the efficiency of probiotics will depend on the quantitative and qualitative characteristics of the microorganisms used in the production (Tournuyt, 1998). The results of some studies suggested that L-carnitine supplementation had no effect on feed intake (Barker and Sell, 1994; Leibetseder, 1995; Rabie and Szilagyi, 1998; Lien and Horng 2001; Xu et al., 2003; Corduk et al., 2007). Contrary to these results, some studies suggested that dietry supplementation of L-carnitine could improve growth performance in broiler chickens and laying hens (Lettner et al., 1992; Rabie and Szilagyi, 1998; Kita et al., 2002; Rodehutscord et al., 2002; Cevik and Ceylan, 2005; Nouboukpo et al., 2010).

Rabie and Szilagyi (1998) reported that supplementation with 50 mg/kg of L-carnitine caused the improvement of body weight gain 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. Previous studies have shown that the inclusion of commercial probiotics (e.g. Thepax® and Protexin®) in diets for broiler chickens, increased several growth performance variables (e.g. BW, FCR) (Mohan et al., 1996; Yeo and Kim, 1997; Kabir et al., 2004; Gunal et al., 2006; Nayebpor et al., 2007; Paryad and Mahmoudi, 2008). In this study, the higher growth performance observed in the ostrich chicks consuming the diets containing probiotics may be due to a change in their gastrointestinal tract microbiota populations, as reported for broiler chickens (Schrezenmier and Vrese, 2001; Gunal et al., 2006; Alloui et al., 2013). Dietary L-carnitine supplementation (50 mg kg^{-1}) has been found an increase in feed intake (Sayed et al., 2001). It should be noted that L-carnitine, was given in combination with either 2% or 4% dietary sunflower oil, and that may have influenced the observed increase in feed intake. A second study (Xu et al., 2003), however, some reports showed that L-carnitine given between 0 and 100 mg kg^{-1} in the diet had no effects on the feed intake of broilers.

The results of this study show that birds receiving L-carnitine + Protexin® probiotic had lowest uric acid, triglycerides, total cholesterol, HDL, LDL and VLDL concentrations of ostrich chickens at 8 weeks of age. Shamsshargh et al. (2008) studied probiotics effect on blood uric acid of broilers and they found that uric acid concentration significantly decreased in comparison with the control group. However, the ostrich chicks fed the diet containing the Protexin® probiotic reduced the concentration of total cholesterol as reported in broiler chickens fed diets containing the same probiotic (*Saccharomyces cerevisiae*) (Onifade, 1997; Paryad and Mahmoudi, 2008). Fat deposition is commonly accepted to be correlated with total cholesterol, LDL and VLDL blood concentration, which mainly depends on the removed of triglycerides from the plasma (Hermier 1997; Musa et al., 2006).

The serum cholesterol concentration reduced by dietary inclusion of diffrent levels of Protexin® probiotic. Similarly, Ashayerzadeh et al. (2010) reported that the lowest serum cholesterol was shown in birds fed diets containing synbiotics. These results might attribute to the decreased absorption or synthesis of cholesterol in the gastrointestinal tract through dietary probiotic supplementation (Mohan, 1996). Furthermore, reduced blood cholesterol was reported by Abdulrahim et al. (1996) when Lactobacillus acidophilus supplemented in the broilers diet. It may help deconjugating bile salts in the intestine, and subsequently avoiding them to act as precursors in cholesterol synthesis.

Conclusion

The performance parameters of ostrich chicks affected by using different levels of L-carnitine and Protexin® probiotic and favorable results obtained by feeding L-carnitine + Protexin® probiotic. Futher results of this study show that addation of L-carnitine and Protexin® probiotic decrease uric acid, total cholesterol, HDL, LDL and triglyceride concentrations. The highest calcium and phosphorus concentrations was observed in birds fed with L-carnitine + Protexin® probiotic.

Conflict of interest statement

Authors declare that they have no conflict of interests.

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