Kafrelsheikh Vet. Med. J. Vol. 7 No. 2 (2009) (158-172)

EFFECT OF DIETARY L-CARNITINE ON GRWOTH PERFORMANCE, AND IMMUNE RESPONCE IN GROWING NEWZEALAND RABBITS

Elgazzar O.B.[*]; *Abou Ghanema E. E.*[**]*and Akalaba Z.*[**]

[*] Biochemistry[*], Physiology Departments [**], Faculty of Veterinary Medicine, Damnhour Branch, Alexandria University

[***]Dept. of Animal Production, Division of Poultry, Faculty of Agriculture, Mansora University

ABSTRACT

The present study was conducted to evaluate the effect of three dietary L-carnitine inclusion levels on growth performance, serum components and immune response in growing New Zealand rabbits. Twenty, 4-weeks-old growing Newzealand rabbits were assigned to four groups, each with five replicates. Four experimental diets were formulated by adding four levels of supplemental L-carnitine (0, 25, 50, and 100 mg/ kg diet) to a basal diet and used in pellets form from 4 up to 8 weeks of age. Daily Live body weight were recorded during the experimental period and body weight change of growing rabbits every week during the growing period from 4 to 8 weeks of age. When the rabbits were 6 weeks age two rabbits from each treatment were immunized intravenously with 1 ml of 25% sheep red blood cells (SRBC), a thymus-dependent antigen suspension. After 7 days, all immunized rabbits were bled and the corresponding plasma samples were collected to determine the primary antibody response. At the end of the 8th week of age; rabbits were slaughtered to take blood samples for biochemical and hematological studies. The obtained

results revealed that, the growth performance was significantly higher in all treated groups than the control. Moreover, there was a significant increase in both total protein and globulin while the albumin globulin ratio was decreased in all treated groups specially in G4 when compared with the control. In conclusion, L-carnitine supplementation induces an improvement in growth performance and immune response of the animals.

Keywords: L-carnitine; Growth performance; Serum Components; Immunity; Rabbits.

INTRODUCTION

L-carnitine is a naturally occurring B-vitamin-like compound found in humans and other animals. Its primary function is to facilitate the transport of long chain fatty acids into mitochondria for energy production (adenosine triphosphate) via β-oxidation and oxidative phosphorylation ***(Owen et. al., 1996).*** L-carnitine has been described as a conditionally essential nutrient for human and animals, about 75% of the carnitine source for the body store comes from the diet. In man the liver and the kidney synthesize the remaining 25% from the immediate precursor gamma butyrobetain. Carnitine in blood is much less concentrated than in tissue. Consequently carnitine, introduced in the diet or synthesized de novo in the liver and kidney, must be actively concentrated from the blood into fatty acid metabolizing organs ***(Maritza et. al., 2006).***

Torreele et. al., (1993) noted that L-carnitine supplementation may stimulate protein-sparing action by increasing energy derived from lipids and reported that many studies on chickens, pigs, dogs, rats, sea bass

(Dicentrarchus labrax) and trout (Onchorynchus mykiss) demonstrated a growth improvement by feeding extra dietary L-carnitine. Studies on broiler chicks suggested that, the effectiveness of the supplemental L-carnitine improve body weight gain and reduce the abdominal fat content of broilers ***(Rabie, 1997a and b)***. Excessive accumulation of lipids in the adipose tissue of rabbits was a major concern for producers, as most fat depots are lost during evisceration and processing of meat, so it was reported that supplementation of L-carnitine to the diets altered fat metabolism and reduced body fat ***(Burtle and Liu 1994). Owen et al., (2001)*** reported that, in newborn rats, plasma levels of L-carnitine were increased rapidly after birth and decreased only when the pups were weaned and fed only dry diets. Dietary L-carnitine play a role in reducing heat stress of broilers and deposition of undesirable fat in market poultry ***Celik and Ozturkcan (2002).***

L-carnitine has an immunomodulatory effects. In vitro, L-carnitine supplementation increased the proliferative responses of both murine and human lymphocytes following mutagenic stimulation ***(Cavazza,1983)***. Furthermore, the defective proliferative capability of peripheral blood lymphocytes of elderly people and patients with acquired immune deficiency syndrome was considerably improved by L-carnitine treatment ***(De Simone et. al.,1982 and Franceschi et. al., 1990))***. Furthermore, there are indications that L-carnitine increases polymorphonuclear chemotaxis ***(De Simone et. al.,1982).***

The aim of the present study was conducted to determine whether supplemental L-Carnitine in the diet would influence growth performance and immune response of growing rabbits.

MATERIALS AND METHODS

2.1. Experimental animals and diets:

Twenty growing Newzealand rabbits, 4-weeks-old were assigned to four equal experimental groups of 5 rabbits each. All rabbits were kept in community battery cages (5 rabbits per cage), set up in an open-sided rabbit house, and managed similarly.

Experimental diets were formulated with a partial composition of 19% crude protein, 2% crude fat, 10% crude Fiber and 40% nitrogen free extract and water "ad libitum". L-carnitine was obtained from (MEPACO, Egypt) each ml contain 300mg added to the diet formula where diet one (which served as a control) contain no L-carnitine, diets 2, 3 and 4 contained supplemental L-carnitine levels of 25, 50 and 100 mg/kg diet, respectively. All the experimental groups of rabbits were fed their respective diets (in pellets form) from 4 up to 8 weeks of age.

Daily Live body weight was recorded during the experimental period and body weight gain of growing rabbits every week during the growing period from 4 to 8 weeks of age was calculated.

Composition of the experimental diets were shown in the following table:

Ingredient	[g/kg]
Yellow Corn	62.2
Soybean meal, 44%	223.3
Wheat bran	233.3
Barley	150.0
Alfalfa hay	301.2
Ground limestone	10.0
Dialcium phosphate	12.0
Common salt	5.0
Vit.+Min. Premix†	3.0
Total	**1000 gm**

†. Each 3 Kg premix contains: Vit. A, 12,000,000 IU; Vit. D_3, 3,000,000 IU; Vit. E, 10,0 mg; Vit. K_3, 3,0 mg; Vit. B_1, 200 mg; Vit B_2, 5,0 mg, Vit. B_6, 3,0 mg; Vit. B_{12}, 15.0 mg; Biotin, 50.0 mg; Folic acid 1,0 mg; Nicotinic acid 35,0 mg; Pantothenic acid 10,0 mg; Mn 80 g; Cu 8.8 g; Zn 70 g; Fe 35 g, I 1 g; Co 0.15 g and Se 0.3 g.

2.2. Criteria of response:

These included the productive performance of growing rabbits (in terms of live body weight, and body weight gain), mortality rate and some biochemical changes and hemogram.

2.3. Sampling:

At the end of the 8th week of age; rabbits were slaughtered. Two groups of individual blood samples were collected from the jugular vein of rabbits. The 1st group of blood samples were collected into a centrifuge tubes without anticoagulant. The serum was separated by centrifugation of blood samples at 4000 r.p.m for 15 minutes and kept frozen at -20 ^{O}C till assayed. The 2nd group of blood samples were collected into a test tubes containing EDTA 10% as an anticoagulant and used for hematological studies.

2.4. Analysis:

A- Biochemical analysis:

The obtained sera were used for spectrophotometric analysis of serum total protein, albumin, globulin and A/G ratio ***(Gornall, et. al., 1949 and Doumas et. al.,1971):***

B- Hematological analysis:

Blood pH was measured by a pH-meter. Blood hemoglobin was determined according to the method of ***Van Kampenand Zijlstra (1961)***. Hematocrit (packed cell volume) and counts of red blood cells (erythrocytes) and white blood cells (leukocytes) were measured following the standard procedures described by ***(Brown, 1980).***

C- Determination of plasma antibody titers of growing rabbit:

When the rabbits were 6 weeks of age, sheep red blood cells (SRBC), a thymus-dependent antigen, were used as a test antigen to quantify the specific antibody response as a measure of humoral immunocompetence. Two rabbits from each treatment were immunized intravenously with 1 ml of 25% SRBC suspension, prepared in 0.9% sterile saline. After 7 days, all immunized rabbits were bleed and the corresponding plasma samples were collected to determine the primary antibody response. Determination of the antibody titers to SRBC was performed using the microtiter technique ***(Trout et. al., 1996).***

D- Experimental design and statistical analysis:

A completely randomized design in one way, with four levels of supplemental dietary L-carnitine was used in the present study. Statistical analyses for various variables were performed, using ***(SAS, 1987)***. The differences were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

The results of this investigation showed that, L-carnitine supplementation significantly improved body weight gain during the experimental period (4-8 weeks of age). Reports on the effects of dietary L-carnitine on growth performance are conflicting. Studies with layers, young pigs and fish have shown some favorable responses to dietary L-carnitine supplementation ***(Torreele et. al.,1993, Weeden et. al., 1991 and Rabie et. al.,1997c)***. This effect is probably due to the increased requirement in the period of rapid growth of broilers ***(Rabie and SzilaÂ gy, 1998)***. Former experiments have shown that the effectiveness of

supplemental L-carnitine for improving body weight gain and/or decreasing abdominal fat of broilers may depend on the age at which L-carnitine is added ***(Rabie et. al., 1997b)***. On the other side, our findings were disagreement with that of other authers who recorded that L-carnitine supplementation did not influence the performance and carcass characteristics of the broilers significantly ***(Buyse et al., 2001 and Lien and Horng, 2001))***. In contrast, many authers observed that, a significant reductions in abdominal fat contents of broilers in response to dietary L-carnitine supplementation ***(Rabie, 1997a and b)***. L-Carnitine supplementation increased body-weight gain, reduced carcass fat and improved feed conversion in weaned pigs ***(Weeden et. al., 1991)*** and broiler chickens ***(Von Lettner et. al.,1992 and Rabie, 1997a and b).*** Dietary L carnitine supplementation could improve fatty acid and energy utilization and therefore gain and feed efficiency, especially in young animals where synthesis is insufficient to meet endogenous requirements ***(Gropp et. al., 1994)***.

Concerning the effect of L-carnitine supplementation on serum protein, total protein significantly increased specially in G4, this increase is attributed to the marked increase of serum globulin which led to marked decrease in the A/G ratio. The elevated globulin is attributed to the significant increase in antibody titer which significantly increased specially in G4. These results support the hypothesis that dietary L-carnitine supplementation was shown to exert an immunomodulatory effect on antigen-specific total Ig and IgG responses. This finding is consistent with the observations of other authers who claimed that the use of L-carnitine or its precursors stimulates an improved antigenic

response in mice ***(Shug & Gravenstein, 1996)***, and corroborates the results of many authers who found that L carnitine stimulates antibody production by murine hybridoma cells***(Typlt et. al.,1991*** *and* ***Berchiche et.al.,1994).***

In this study the additions of L-carnitine led to significant increase in total leukocyte count. These results agree with the results of other authers who found that , L-Carnitine supplementation could be increase the proliferative responses of lymphocytes in murine and human lymphocytes either in vivo or in vitro ***(Cavazza,1983 and De Simone et. al.,1982).*** Previous results in aged rat explain the observed results in this study concerned with the phagocytic activity where L-Carnitine could enhance the chemotaxis and phagocytic activity of neutrophils through decreasing the activity of super oxide anion production in the cell as approved by ***(Lzgut-Uysal et. al.,2003 and Kargo and Basel, 2003)*** .

L-carnitine has been found to exhibit immunomodulatory effects. In vitro, L-carnitine supplementation increased the proliferative responses of both murine and human lymphocytes following mitogenic stimulation ***(Cavazza C, 1983)***. Further, the defective proliferative capability of peripheral blood lymphocytes of elderly people and patients with acquired immune deficiency syndrome was considerably improved by L-carnitine treatment ***(De Simone et, al.,1982*** and ***Franceschi et. al.,1990)***:. Furthermore, on activation of human mononuclear phagocytes, more than 50% of indications that L-carnitine increases polymorphonuclear chemotaxis ***(De Simone et, al.,1982***). And more than 50% of acetyl carnitine is transformed into L-carnitine, indicating that acetyl carnitine plays an important metabolic role when mononuclear phagocytes initiate an immune response***(Kurth et.al., 1994).***

It could be concluded from this study that L-carnitine supplementation to animals induces an improvement in growth performance and immune response.

Table (1): Effect of L-carnitine supplementation on Serum Total Protein, Albumin, Globulin, A/G Ratio and Antibody Titer.

parameter / GrOUP	t.protein, G %	AlbUMIN, G %	Globulin, G %	A/G rATIO	Antibody TITER
Control	6.19±0.11^{b}	3.67±0.13^{a}	2.52±0.14^{c}	1.47±0.11^{a}	3.06±0.06^{d}
25mg Carnitine	6.48±0.16^{b}	3.53±0.09^{a}	2.95±0.11^{b}	1.20±0.05^{b}	4.16±0.07^{c}
50 mg Carnitine	6.31±0.12^{b}	3.37±0.09^{b}	2.94±0.10^{b}	1.14±0.05^{b}	4.63±0.12^{b}
100mg Carnitine	7.74±0.15^{a}	3.07±0.1^{b}	4.67±0.10^{a}	0.65±0.02^{c}	6.43±0.13^{a}

Means within the column carry different superscripts a-d are significantly different at level (P<0.01).

Table (3): Effect of L-carnitine supplementation on the Hemogram.

parameter / Group	WBCs ($X10^3/mm^3$)	PCV (%)	Hb (g)	RBCs ($X10^6/mm^3$)
Control	8.54 ± 0.30d	37.60 ± 1.36a	12.51 ± 0.42a	5.62 ± 0.33a
25mg Carnitine	12.30 ± 0.27c	32.80 ± 1.35a	10.95 ± 0.43b	5.32 ± 0.32a
50 mg Carnitine	15.12 ± 0.42b	37.00 ± 1.14a	12.32 ± 0.37ab	5.14 ± 0.29a
100mg Carnitine	20.56 ± 0.69a	34.20 ± 1.95a	11.46 ± 0.63ab	4.78 ± 0.33a

Means within the column carry different superscripts a-d are significantly different at level (P<0.01)

Table (4): Live body weight and body weight gain of growing rabbits fed diet supplemented with L-Carnitine during the hot climate of Egyptian summer (4-8 weeks of age).

Dietary treatment	Live body weight (g)					Body weight gain (g)				
week / group	4	5	6	7	8	4-5	5-6	6-7	7-8	4-8
Control	752.0	896.67^{d}	1085.34^{d}	1330.67^{d}	1455.77^{d}	144.66^{d}	188.66^{c}	245.33^{b}	121.15^{d}	703.46^{d}
25mg Carnitine	747.67	949.34^{c}	1139.67^{c}	1402.00^{c}	1585.00^{c}	201.66^{c}	190.33^{c}	262.33a^{b}	180.71^{c}	836.78^{c}
50 mg Carnitine	748.67	1069.34^{b}	1362.00^{b}	1674.00^{b}	1894.67^{b}	320.66^{b}	292.66^{b}	312.00^{a}	220.66^{b}	1146.00^{b}
100mg Carnitine	750.34	1125.34^{a}	1494.00^{a}	1708.00^{a}	1976.67^{a}	375.00^{a}	368.66^{a}	412.00^{b}	268.66^{a}	1226.33^{a}

Means within the column carry different superscripts $^{a-d}$ are significantly different at level ($P<0.01$).

REFERENCES

- ***Owen K. Q., Nelssen J.L., Goodband R.D., Weeden T.L. and Blum S.A. (1996):*** Effect of L-carnitine and soybean oil on growth performance and body composition of early-Weaned pigs. J.Anim. Sci. 74:1612-1619.

- ***Maritza F. D., Julio A. U., Flor L. and Frank H. R. (2006):*** L-carnitine-induced modulation of plasma fatty acids metabolism in hyperlipidemic rabbits. Rev Electron Biomed/Electron J Biomed. 1:33-41.

- ***Torreele E., Sluiszen A. V. D. and Verreth J. (1993):*** The effect of dietary L-carnitine on growth performance in fingerlings of the African catfish (Clarias gariepinus) in relation to dietary lipid. British J. Nutr.69, 289-299.

- ***Rabie, M.H., Szila´ gyi, M. and Gippert, T. (1997a)*** Effects of dietary L-carnitine supplementation and protein level on performance and degree of meatness and fatness of broilers. Acta Biologica Hungarica, 48, 221–239.

- ***Rabie,M.H., Szila´ gyi, M., Gippert, T., Votisky, E. and Gerendai, D. (1997b)*** Influence of dietary L-carnitine on performance and carcass quality of broiler chickens. Acta Biologica Hungarica, 48, 241 – 252.

- ***Burtle G. J., Liu Q. (1994):*** Dietary L-carnitine and Lysine affect channel catfish lipid and protein composition. J. worled Aquacult. Soc., 25: 169-174.

- ***Owen K. Q., Nelssen J.L., Goodband R.D., Tokach M.D. and Friesen K.G. (2001):*** Effect of dietary L-carnitine on growth performance and body composition in nursery and growing-finishing pigs. J.Anim. Sci. 79:1509-1515.

- ***Celik L. and Ozturkcan O. (2002) :*** Effect of dietary supplemental L-carnitine and ascorbic acid on performance, carcass composition and plasma L-carnitine concentration of broiler chicks reared under different temperature. Arch. Anim. Nutr., 57: 27-38.

- ***Cavazza C (1983) :*** Therapeutical method of treating patients with impaired immune system. United States Patent 4 415 588.

- ***De Simone C, Ferrari M, Lozzi A, Meli D, Ricca D & Sorice F (1982):*** Vitamins and immunity: II. Influence of L-carnitine on the immune system. Acta Vitaminology and Enzymology 4, 135–140.

- *Cavazza C (1983)*: High dose L-carnitine improves immunologic and metabolic parameters in AIDS patients. Immunopharmacology and Immunotoxicology 15, 1–12.

- *De Simone C, Famularo G, Tzantzoglou S, Trinchieri V, Moretti S & Sorice F (1994)* :Carnitine depletion in peripheral blood mononuclear cells from patients with AIDS: effect of oral L-carnitine. AIDS 8, 655–660.

- *Franceschi C, Cossarizza A, Troiano L, Salati R & Monti D (1990)*: Immunological parameters in aging: studies on natural immunomodulatory and immunoprotective substances. International Journal of Clinical Pharmacology Research 10, 53–57.

- ***Gornall,A.G.; C.J. Bardawill, and M.M. David (1949):*** Determination of serum protein by means of the biuret reaction. J. Biol. Chem., 177: 751-766.

- ***Doumas, B.T. ; W.A. Watson and H.G. Biggs (1971):*** Albumin standards and the measurement of serum albumin with bromocresol green. Clin. Chim. Acta, 31: 87-96.

- ***Van Kampen, E. and W.G. Zijlstra (1961):*** Standardization of haemoglobinometry. II. The hemiglobincyanide method. Clin. Chim. Acta, 6: 538-544.

- ***Brown, B.A. (1980):*** Hematology: Principles and Procedures. The 3rd ed, Lea and Febiger, Philadelphia, PA.le,

- ***Trout, J.M., M.M. Mashaly, and H.S. Siegel (1996):*** Changes in blood and spleen lymphocyte populations following antigen challenge in immature male chickens. British Poultry Sci., 37 (4): 819–827.

- ***Statistical Analysis System (SAS) (1987):*** User's Guid "SAS" Institue Carry , North Carolina.

- ***Weeden, T.L., Nelssen, J.L.,Hansen, J.A., Fitzner,G.E. and Goodband, R.D. (1991):*** The effect of L-carnitine onstarter pig performance and carcass composition. J. Anim. Sci., 69, Suppl. 105 Abstr.

- ***Rabie,M.H., Szila´ gyi, M. and Gippert, T. (1997c)*** :Influence of supplemental dietary L-carnitine on performanceand egg quality of pullets during the early laying period. A ´llattenye´szte´s e´s Takarma´nyoza´s, 46, 457 – 468.

- ***Rabie, M.H. and SzilaÂ gyi, 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. Brit. J. Nutr., 80, 391 ± 400.

- ***Buyse, J., Janssens, G.P. and Decuypere, E. (2001):*** The effects of dietary L-carnitine supplementation on theperformance, organ weights and circulating hormone and metabolite concentrations of broiler chickens reared under a normal or low temperature schedule. Brit. Poult. Sci., 42, 230 – 241.

- ***Lien, T.F. and Horng, Y.M. (2001):***The effect of dietary L-carnitine on the growth performance, serumcomponents, carcase traits and enzyme activities in relation to fatty acid beta oxidation of broiler chickens.Brit. Poult. Sci., 42, 92 – 95.

- ***Von Lettner F,Zollitsch W & Halbmayer E (1992) :*** Use of Lcarnitine in the broiler ration. Bodenkultur 43, 161–171.

- ***Gropp JM, Schumacher A & Schweigert FJ (1994) :*** Recent research in vitamin nutrition with special emphasis to vitamin A, β-carotene and L-carnitine. In Proceedings of the Meeting of the Arkansas Nutrition Conference, pp. 124–134. Fayetteville, AR: Arkansas Poultry Federation.

- ***Shug AL & Gravenstein S (1996)*** : Method of stimulating antibody formation. United States Patent 5 569 457.

- ***Typlt H, Claus R & Nitzsche K (1991)*** :Influence of carnitine on thegrowth and productivity of murine hybridoma cells. Journal of Biotechnology.

- ***Berchiche L, Legrand C, Capiaumont J, Belleville F & Nabet P, Dietary L-carnitineincreases IgG production(1994)*** :Effect of L-carnitine and acylcarnitine derivatives on theproliferation and monoclonal antibody production of mouse hybridoma cells in culture. Journal of Biotechnology 34, 175–183.

- ***Lzgut-Uysal VN,Agac A,Kardogan I and Derin N. (2003)*** : Effect of L-carnitine on neutrophils functions in aged rats . Mech.Ageing Dev. ,124(3):341-347.

- ***Kargo S and Basel AG (2003) :*** Effect of L-carnitine on Carrageenan –induced inflammation in aged rats .Gerontology ,49:287-292.

- ***Kurth L, Fraker P & Bieber L (1994)*** Utilization of intracellular acylcarnitine pools by mononuclear phagocytes. Biochimica et Biophysica Acta 1201, 321–327.

تأثير إضافة إل-كارنيتين إلى العلائق على معدلات النمو و الاستجابة المناعية في بدارى الأرانب النيوزيلاند

أسامه بهجت الجزار ، إسماعيل إسماعيل أبوغنيمة ، زياد عوض قلبة

*قسم الكيمياء الحيوية.** وقسم الفسيولوجيا بكلية طب بيطري البستان- فرع دمنهور- جامعة الإسكندرية،

*** قسم الإنتاج الحيواني-شعبة دواجن- كلية الزراعة- جامعة المنصورة

أجريت هذه التجربة لدراسة تأثير إضافة الكارنيتين إلى علائق بدارى الأرانب النيوزيلاندى على معدلات النمو و الاستجابة المناعية. أستخدم في هذه الدراسة عدد عشرين من بدارى الأرانب النيوزيلاندى سن أربعة أسابيع وقسمت إلى أربع مجموعات تحتوى كل مجموعة على خمس أرانب. المجموعة الأولى استخدمت كمجموعة ضابطة، المجموعة الثانية والثالثة والرابعة تم إضافة الكارنيتين بنسبة 25، 50، 100 ملليجرام/كجم عليقه على التوالي. تم تغذية الأرانب على تلك العلائق لمدة أربعة أسابيع وتم تسجيل الأوزان الحية للأرانب يوميا على مدى فترة اتجربة وهى من أربعة إلى ثمانية أسابيع من عمر الأرانب وذلك لحساب معدل النمو و بعد سن ستة أسابيع تم حقن اثنين من كل مجموعة بواحد ملليليتر بمعلق يحتوى على كريات دم حمراء لأغنام محملة بالأنتيجين 25% للحث على إنتاج الأجسام المضادة عن طريق الوريد وبعد سبعة أيام تم سحب عينات الدم من تلك الأرانب المستحثة لقياس نسبة الأجسام المضادة في المصل. وبعد ثمانية أسابيع و بعد انتهاء التجربة ذبحت الأرانب وأخذت عينات الدم من الوريد الوداجى و ذلك لمعرفة التأثير على صورة الدم وكذلك المكونات البيوكيميائية لمصل الدم. وقد أظهرت النتائج المتحصل عليها نتيجة إضافة الكارنيتين إلى العلائق حدوث زيادة معنوية فى معدلات النمو وكذلك نسبة البروتين الكلى و الجلوبيولين بالإضافة إلى نقص فى نسبة اللألبيومين إلى الجلوبيولين. على الجانب الأخر كانت هناك زيادة معنوية فى نسبة الأجسام المضادة والعدد الكلى لكرات الدم .وقد خلصت هذه الدراسة إلى أن إضافة الكارنيتين إلى علائق الأرانب له تأثير ملحوظ ومفيد في زيادة معدلات النمو وكذلك الاستجابة المناعية لجسم الحيوان.