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The effect of rumen protected L-carnitine on feedlot performance, carcass characteristics and blood metabolites in Iranian fat-tailed Ghezel lambs

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Abstract

The effect of dietary protected L-carnitine on feedlot performance, carcass characteristics and blood metabolites of fat-tailed Ghezel lambs were studied. Twenty four ram lambs (180±30 d) were randomly allotted to four groups. The lambs were housed in individual cages and had free access to feed and water. The animals were fed diets containing 0.0 (control), 0.5, 1.0 or 1.5 g/d rumen protected L-carnitine. Dry mater intake (DMI), average daily gain (ADG), feed conversion ratio (FCR), and blood cholesterol, glucose and urea were measured. After 80 d fattening period, the lambs were slaughtered and weight of hot and cold carcasses, tail fat, visceral fat, pelvic fat, back fat thickness, kidney, kidney fat, heart, heart fat, and lungs was determined for each group. Back fat thickness and the cross sectional area of the *Longissimus dorsi* muscle were measured at $12^{th}/13^{th}$ rib. Meat samples were taken between rib 9 to 13 for determination of meat colour and contents of protein, fat, moisture and malondialdehyde. The highest level of L-carnitine increased visceral fat percentage in carcass ($P<0.05$). Meat colour was improved ($P<0.05$) by L-carnitine feeding. Plasma cholesterol concentration on d 40 of the fattening period decreased ($P<0.05$) in animals receiving 1.5 g/d L-carnitine; however, on d 80, it increased to level recorded on d 0. Other characteristics were not significantly affected by L-carnitine feeding. We concluded that L-carnitine at the current levels had no significant effect on growth; however, meat texture was improved at the rate of 1.0 g/d L-carnitine.

Keywords: L-carnitine; finishing lamb; meat quality; carcass characteristics; blood metabolites

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Introduction

Carnitine (3-hydroxy- 4-N-trimethylaminobutyric acid) is a vitamin-like substance that mediates transport of medium and long chain fatty acids across the mitochondrial membrane, facilitating β-oxidation of fatty acids (Bremer, 1983; Rebouche and Seim, 1998). L-carnitine (LC) is synthesized from the essential amino acids lysine and methionine with the assistance of vitamin C and other secondary compounds produced in the body. This compound mainly accumulates in the liver and tissues such as skeletal muscle and heart in which fatty acids are the main source of energy. In this regard, LC plays an important role in energy production by chaperoning activated fatty acids (acyl-CoA) into the matrix for and accompanying intermediate compounds out of the mitochondrial matrix to prevent their accumulation (Harpaz, 2005). White et al. (2002) reported that 1 g/d LC improved the growth rate of grazing calves. White et al. (2002) reported that LC at 100 ppm level increased the growth rate of finishing lambs; however, ruminally protected LC was more effective than unprotected LC in improving the growth rate and feed efficiency. Although carnitine is not considered to be an essential nutrient for mammals, studies in swine (Owen et al., 1996; Musser et al., 1999) have shown that the addition of LC into the diets may be beneficial for production.

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In studies with typical production diets, supplemental LC did not affect milk production (LaCount et al., 1995) or growth performance (Hill et al., 1994) of ruminants. Limited research has been conducted on the effect of carnitine in growing cattle; however, results for cattle fed high-grain diets are not conclusive. Heifers fed a high-grain diet had lower quality grade when they received 1 g/d carnitine (Hill et al., 1995a). Steers and heifers receiving 100 mg/kg carnitine in a high-grain diet had higher carcass quality grade (Hill et al., 1995b). There is indication that metabolism of fat-tailed sheep may differ from thin-tailed sheep (Zamiri and Izadifard, 1995). Therefore, the aim of this experiment was to determine the effect of feeding rumen protected LC on feedlot performance, carcass characteristics and blood metabolites in Iranian fat-tailed sheep breed under feedlot conditions.

Materials and Methods

Animal, diets and treatments

Twenty four lambs (5 to 7 months old) fat-tailed Ghezel sheep were used in a completely randomized design to study the effect of dietary LC supplementation. The lambs were kept in the individual cages and had free access to feed and water. The animals were randomly allotted to four groups and received diets (14 d adaptation and 80 d sampling period), containing zero (control), 0.5, 1.0 and 1.5 g/d rumen protected LC. The fattening diet consisted (dry matter basis) of 70% concentrate mix and 30% fodder (Table 1). The initial live weight, slaughter (final) weight, dry mater intake (DMI), average daily gain (ADG), and feed conversion ratio (FCR) were measured during the 80 d sampling period.

Table 1: Composition of diet for finishing lambs

Ingredients	% DM
Corn silage	20
Alfalfa hay	10
Barley grain	58.78
Cotton seed meal	9.84
Calcium carbonate	0.36
Di-calcium phosphate	0.02
Salt	0.5
Vitamin premix (A, D, E)	0.5
Chemical composition*	
DM (% as fed)	75.47
CP (% DM)	12.85
ME (Mcal/kg DM)	2.63
Ca (% DM)	0.45
P (% DM)	0.32

* Based on NRC (2007) calculations

Blood samples were collected from the jugular vein on d 0, 40 and 80 of the experiment for determination of plasma glucose, cholesterol and urea, using photometric methods (Biochorom, Libra S22, England) as described in the commercial kits (Pars Azemoon Co., Iran). At the end of experiment, the lambs were slaughtered and hot carcasses, internal organs (heart, kidneys, lung, liver) and internal fat (visceral, pelvic, renal, and cardiac fat) were weighed. Cold carcass weight, and the cross sectional area of the *Longissimus dorsi* muscle and back fat depth at 12th/13th ribs were determined after 12 h chilling at 5°C. The cross section of the *Longissimus dorsi* muscle was traced on a transparent paper, and the area was determined using a planimeter. Back fat depth was measured using calipers.

A portion of cold carcass meat was taken between the 9th and 13th ribs. Meat pH was measured in fresh samples. The samples were then kept frozen at -20°C for analysis of moisture, fat and protein contents (AOAC, 1995), and malondialdehyde (MDA) concentration as a measure of lipid oxidation (Botsoglou et al., 1994). Meat colour parameters (L*a*b*) were also determined (Leon et al., 2006).

Statistics analysis

All data were normally distributed. Data on feedlot performance, carcass characteristics and meat characteristics were analyzed as a completely randomized design using the GLM procedure. Blood metabolites were analyzed as repeated measure data using the MIXED procedure of SAS (2002). The initial live weight and age of lambs were included in models as covariates. The means were compared by the least squares means procedure after adjustment by Tukey-Kramer's test. The level of significance was set at $P<0.05$.

Results

Dietary LC supplementation did not significantly affect ($P>0.05$) the feedlot performance (Table 2), carcass characteristics (Table 3), meat composition (Table 4) and plasma glucose, cholesterol and urea concentrations (Table 6). Although not significant, average daily gain and feed conversion ratio were improved by LC supplementation compared with the control diet.

The highest percentage of visceral fat was recorded in the lambs consuming 1.5 g/d and the lowest percentage in those consuming the control or 0.5 g/d LC (Table 3). No significant differences ($P>0.05$) were found between 1.0 and 1.5 g/d LC. Meat colour parameters L* (lightness) and b* (blue to green) were increased due to LC supplementation, being highest at 1.0 g/d LC supplementation and lowest for the control lambs (Table 5). Conversely, the values for a* (green to red) and R* (red index) were smaller ($P<0.05$) in LC supplemented lambs, with the smallest values in 1.0 g/d LC supplemented lambs.

On d 40 of fattening period, plasma cholesterol concentration was the highest ($P<0.05$) in control lambs and lowest with 1.0 g/d LC diet with no significant

Table 2: Effect of L-carnitine on feedlot performance in fat-tailed Ghezel rams

Characteristics	L-carnitine (g/d)				Treatment effect
	0.0	0.5	1.0	1.5	
Initial weight (kg)	28.3 (2.63)	28.3 (2.63)	33.8 (2.63)	33.1 (2.63)	NS
Final weight (kg)	42.9 (2.58)	47.4 (2.58)	51.2 (2.35)	51.6 (2.58)	NS
ADG (g)	172 (16.7)	215 (17.2)	226 (16.6)	208 (17.9)	NS
DMI (kg)	1.14 (0.019)	1.15 (0.02)	1.13 (0.019)	1.16 (0.021)	NS
FCR	7.17 (0.49)	5.76 (0.51)	5.32 (0.49)	6.00 (0.53)	NS

NS: P>0.05, ADG: average daily gain, DMI: dry mater intake, FCR: feed conversion ratio

Table 3: Effect of L-carnitine on carcass characteristics in fat-tailed Ghezel rams

Carcass characteristics	L-carnitine (g/d)				Treatment effect
	0.0	0.5	1.0	1.5	
Hot carcass, including the tail (kg)	25.5 ±0.69	27.2 ±0.71	27.7 ±0.69	27.1 ±0.74	NS
Cold carcass, including the tail (kg)	25.1 ±0.65	26.6 ±0.66	27.1 ±0.64	26.2 ±0.69	NS
Kidney weight (%)	0.28 ±0.01	0.27 ±0.01	0.28 ±0.01	0.25± 0.01	NS
Renal fat weight (%)	0.38 ±0.05	0.30 ±0.05	0.30 ±0.05	0.38 ±0.05	NS
Heart weight (%)	0.39 ±0.009	0.37 ±0.010	0.38 ±0.009	0.36 ±0.010	NS
Cardiac fat weight (%)	0.20 ±0.02	0.25±0.02	0.22 ±0.02	0.27 ±0.02	NS
Liver weight (%)	1.36 ±0.03	1.35 0.03	1.29±0.03	1.28 ±0.03	NS
Lung weight (%)	1.19 ±0.05	1.10 ±0.05	1.11 ±0.05	1.07 ±0.05	NS
Pelvic fat weight (%)	0.72 ±0.16	0.60 ±0.16	0.39 ±0.16	0.66 ±0.17	NS
Visceral fat weight (%)	0.64 ±0.14^{b}	0.49 ±0.14^{b}	0.72 ±0.14^{ab}	1.08 ±0.15^{a}	*
Tail weight (%)	8.25 ±0.90	7.44 ±0.93	7.06 ±0.90	8.04 ±0.97	NS
Back fat thickness (cm)	0.37 ±0.038	0.43 ±0.039	0.34 ±0.038	0.45 ±0.041	NS
LD muscle area (cm^2)	33.3 ±1.35	35.6 ±1.35	33.8 ±1.34	33.6 ±1.45	NS

*P<0.05, NS: P>0.05, ^{a,b}Means with similar superscripts do not differ significantly (P>0.05), LD: *Longissimus dorsi*

Table 4: Effect of L-carnitine on meat composition in fat-tailed Ghezel rams

Meat composition	L-carnitine (g/d)				Treatment effect
	0.0	0.5	1.0	1.5	
Protein (%)	21.6 ±0.17	22.1 ±0.18	22.3± 0.17	22.0 ±0.18	NS
Fat (%)	2.37 ±0.10	2.53 ±0.11	2.81 ±0.10	2.65 ±0.11	NS
Moisture (%)	74.7 ±0.18	74.4 ±0.18	74.2 ±0.18	74.5 ±0.19	NS
MDA (mg/kg)	1.39 ±0.20	1.36 ±0.21	1.25 ±0.20	1.38 ±0.21	NS
pH	6.95 ±0.08	6.80 ±0.09	6.94 ±0.08	7.09 ±0.09	NS

NS: P>0.05

differences amongst diets supplemented with LC (Table 6). In control lambs, plasma cholesterol concentration increased (P<0.05) from d 0 to 80 of the fattening period. LC supplementation at 1.5 g/d resulted in a considerable decrease in plasma cholesterol level on d 40, however, the values increased on d 80 to levels recorded on d 0.

Discussion

Production and metabolic responses to supplemental LC have been variable in ruminants. In the present experiment, DMI, ADG and FCR were not affected by the addition of LC to the diet. Similar findings were previously reported in steers (Hill et al., 1994; Greenwood et al., 2001). White et al. (1998a) reported that LC improved ADG in grazing weaning calves and DeRouen et al. (1998) reported that weaning beef calves fed broiler litter-corn diets containing LC had higher DMI and tended to have higher ADG. Lambs fed LC tended to have a higher DMI and ADG, improved FCR and carcass compared with control non-supplemented lambs (White et al., 2002). Decreased ADG in weaning calves supplemented with LC and various protein sources (White et al., 1998b) and decreased DMI and FCR in Holstein calves fed broiler litter and LC were also reported (Yavuz et al., 1997). In finishing experiments, carnitine had no effect on ADG (Hill et al., 1995a).

Plasma urea concentration was not affected by LC supplementation in experiments reported by DeRouen et al. (1998), Morris et al. (1998) and Chapa et al. (2001). Reduced plasma urea concentration following LC supplementation was reported by others (White et al., 1997; Yavuz et al., 1997; Citil et al., 2009). Plasma urea and glucose levels were not affected by LC supplementation in the present experiment, as also reported by LaCount et al. (1995, 1996a), Erfel et al. (1974) and Staples et al. (1975). White et al. (2001) reported that LC did not affect plasma urea nitrogen or plasma glucose levels of grazing calves when fed in liquid supplement. Also, Hill et al. (1995b) reported that LC had no effect on plasma urea nitrogen levels in cattle fed hay and supplemented with corn and soybean meal. In

Table 5: Effect of L-carnitine on meat colour parameters in fat-tailed Ghezel rams

Parameter	L-carnitine (g/d)			
	0.0	0.5	1.0	1.5
L*	22.7 ±0.56^{d}	28.0 ±0.58^{b}	30.3 ±0.56^{a}	25.5 ±0.60^{c}
A*	9.0 ±0.02^{a}	7.6 ±0.02^{c}	7.0 ±0.02^{d}	8.4 ±0.02^{b}
B*	2.7 ±0.01^{d}	3.3 ±0.01^{b}	3.7 ±0.01^{a}	3.0 ±0.01^{c}
R	110.1 ±0.50^{a}	96.1 ±0.52^{c}	85.0 ±0.50^{d}	99.1 ±0.54^{b}

^{a,b}Within rows, mans with similar superscript do not differ significantly (P>0.05)

Table 6: Effect of L-carnitine on plasma glucose, cholesterol and urea concentration (mg/dl) in fat-tailed Ghezel rams

	L-carnitine (g/d)			
	0.0	0.5	1.0	1.5
Glucose concentration (mg/dl)				
D 0	79.8 ±2.92	72.2 ±3.09	75.1 ±2.91	75.0 ± 3.16
D 40	79.0 ±2.92	76.1± 3.09	78.6± 2.91	79.1± 3.16
D 80	70.0 ±2.92	78.1± 3.09	81.0± 3.17	81.2 ± 3.16
Cholesterol concentration (mg/dl)				
D 0	49.0 ±5.56^{aB}	48.2 ±5.96^{aB}	43.0 ±5.56^{aB}	61.2 ±6.05^{aB}
D 40	67.8 ±5.56^{aA}	43.0 ±5.96^{bB}	29.8 ±5.56^{bB}	35.1 ±6.05^{bC}
D 80	74.6 ±5.56^{aA}	77.6 ±5.96^{aA}	82.4 ±6.11^{aA}	85.4 ±6.05^{aA}
Urea concentration (mg/dl)				
D 0	15.5 ±0.50	16.1 ±0.51	16.5 ±0.48	16.7 ±0.52
D 40	16.5 ±0.49	15.7 ±0.51	16.1 ±0.48	16.5 ±0.52
D 80	16.6 ±0.49	15.4 ±0.51	15.9 ±0.50	16.2 ±0.52

^{a,b}Within each row, means with similar superscript do not differ significantly (P>0.05); A, B: Within each column, means with similar superscript do not differ significantly (P>0.05)

experiments conducted by White et al. (2001), when calves were dosed intra-ruminally with LC solution, plasma urea nitrogen was reduced in one experiment and increased in another experiment with no effect on plasma glucose levels. On the other hand, increased plasma glucose levels in sheep were reported by Chapa et al. (1998) following intravenous administration of LC. The increase in blood glucose in response to LC supplementation was attributed to increased fatty acid oxidation and subsequent reduction in the oxidation of gluconeogenic precursors (Greenwood et al., 2001).

On d 40 of the experiment, plasma cholesterol concentration was lower in LC supplemented lambs. The lowest cholesterol level was recorded in 1.5 g/d LC group on d 40 but it increased subsequently reaching values recorded on d 0. Therefore, on d 80, plasma cholesterol concentration was not significantly different between the control and LC-supplemented animals. Greenwood et al. (2001) reported that plasma cholesterol level of growing steers was not affected by supplemental LC. Inconsistent response in plasma cholesterol concentration at different sampling times was also reported by Cetin et al. (2003), whereas LaCount et al. (1996b) reported a non-significant decrease in plasma cholesterol in dairy cows.

Percentage of renal, cardiac and pelvic fat not being affected by LC supplementation suggests that the effects of LC may be specific to certain fat depots (Greenwood et al., 2001). Visceral fat percentage being highest in lambs receiving 1.5 g/d LC in the current experiment is in contrast with Hill et al. (1995a) who observed decreased fat deposition in heifers in an experiment. However, in another experiment with steers Hills et al. (1995b) reported the increased fat deposition with LC supplementation. In experiment with finishing lambs, *Longissimus dorsi* area was decreased and percentage of lean meat was not improved by supplemental rumen protected LC (White et al., 2002). In the present experiment, chemical composition of the *Longissimus dorsi* muscle was not affected by LC supplementation which is in agreement with the findings of Owen et al. (2001).

Improvement in meat colour at 1.0 g/d LC supplementation is consistent with findings Greenwood et al. (2001). However, Hill et al. (1995b) reported that dietary LC reduced the marbling score in heifers, but little or no consistent effects were reported in steers by Hill et al. (1994).

Data on the effect of LC supplementation in ruminants are inconsistent, even in the same species. It resulted in improved growth rate and changes in lipid utilization in some studies, with no effect in other studies. Such discrepancies may be due to differences in breeds, levels of LC supplementation, duration of experiments, diet composition and other factors.

Conclusions

The results of current study suggested that 1.0 g/d LC tended to improve the growth rate and marbling score of fat-tailed ram lambs. However, more research is needed to determine the conditions under which LC can effectively improve the performance of fat-tailed Ghezel sheep.

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