Effect of oilseed sources and L-carnitine administration on growth, feed intake, feed digestibility, and blood metabolites of Afshari lambs

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The experiment was conducted to evaluate the effects of oilseed sources and L-carnitine supplementation on growth, feed digestibility, and blood metabolites in Afshari lambs. Twenty male lambs of 2-month old and weighing 22.5 ± 2.58 kg were used in a completely randomized design with a 2×2 factorial arrangement (n=5) of oilseed sources with and without supplemental carnitine in an 84-day feeding period. Diets were isoenergetic and isonitrogenous. Soybean or canola seeds were included at 15% of the dry matter (DM) of the diet, each with or without 0.11 g/day L-carnitine applied to each lamb. Initial weight was stratified across dietary treatments. At the end of the experiment, serum glucose, ammonia, total protein, triglyceride, total cholesterol, HDL, and LDL were determined. There was no interaction between oilseed sources and L-carnitine level on feed intake, digestibility, or blood metabolites. Replacing soybean seed with canola seed and carnitine administration had no effects on feed intake, body weight gain, or feed conversion ratio. L-carnitine administration decreased (P≤0.05) NDF digestibility from 63.0 to 41.5% and tended to decrease (P=0.13) organic matter digestibility. Oilseed sources had no effects (P>0.05) on blood profile, but triglycerides and cholesterol tended (P=0.13) to be increased when soybean seeds were replaced with canola seeds. Although L-carnitine administration increased blood ammonia and tended to increase HDL (P=0.13), other blood metabolites were not affected. The results indicate that soybean seed could be substituted by canola seed in the diets of growing lambs. Supplementing with L-carnitine had no effect on responses of lambs fed diets of soybean seed and canola seed.

Keywords: *L-carnitine, canola seed, soybean seed, Afshari lamb, digestion, growth*

Oilseeds have been integrated in livestock feeding to improve the nutritive value of diets, thus to increase animal production. Canola seeds, which are low in glucosinolate and erucic acid, can be grown in conditions not suitable for soybeans and maize. Although canola is produced mainly for the extraction of edible oil, it is also used in livestock feeding (Brand *et al.* 2001 and Beauchemin *et al.* 2009). Canola contains approximately 40% of ether extract and 20% of CP (Khorasani *et al.* 1991). The oil is primarily composed by oleic acid (52.8%; Khorasani *et al.* 1991), which can decrease palmitic acid and improve fatty acid composition of meat (Rule *et al.* 1989, Solomon *et al.* 1991 and Karami *et al.* 2013). Therefore, full-fat canola seed is an excellent source of protein and highly digestible energy for diets of growing lambs (Brand *et al.* 2001). Data from cattle fed whole canola indicated that the seeds are relatively resistant to digestion in the rumen and intestine unless processed (Khorasani *et al.* 1992 and Hussein *et al.* 1995). However, increasing full-fat canola to 18 % of the diet had no negative influence on growth of lambs (Brand *et al.* 2001).

Carnitine facilitates transport of medium and long chain fatty acids (LCFA) across the mitochondrial membrane for β-oxidation (White *et al.* 2002 and Kathirvel *et al.* 2013) and appears to be involved in nitrogen metabolism. Carnitine is essential for mitochondrial β-oxidation of LCFA. L-carnitine has several other functions such as altering the acetyl-CoA:CoA ratio, transporting medium and short chain fatty acids from peroxisomes to mitochondria, and modulating flow of intermediates through pathways associated with fatty acid, glucose, and nitrogen metabolism (Chapa *et al.* 2000, Greenwood *et al.* 2001 and Carlson *et al.* 2007). The growth rates of weaned calves and growing cattle have been improved by including carnitine in the diet (Hill *et al.* 1995 and White *et al.* 2001 and Foroozandeh *et al.* 2014).

Supplementation of the diet with carnitine may change the responses to feeding soybean seeds and canola seeds. According to an existing hypothesis, replacing dietary canola seed with soybean seed would have no effect on the growth of lambs, but including L-carnitine on the diet would improve fat and protein digestion and metabolism, and, consequently, feed intake and blood metabolites. Therefore, the objective was to determine the effects of oilseed sources and carnitine administration on growth, feed digestibility, and blood metabolites of Afshari lambs.

Materials and Methods

Twenty male lambs of 2-month old and weighing 22.5 ± 2.58 kg were used in a completely randomized design with a 2×2 factorial arrangement of diets for an 84-day feeding period. Lambs were assigned randomly to either soybean seeds or canola seeds at 15% of the

dietary DM with or without 0.11 g/d of L-carnitine. Initial body weight was stratified across diets. Diets were formulated to be isoenergetic (11.2 MJ metabolizable energy/kg of DM diet) and isonitrogenous (14.6 % crude protein). Ingredients and chemical compositions of the diets are presented in table 1.

During the experiment, lambs were housed in individual pens (1.2 × 0.9 m) in a well-ventilated barn. The duration of this experiment was 84 days, with 14 days for adaptation and 70 days for data collection. Lambs were gradually switched from the basal diet to the experimental diets. Week 1 was for adaptation of lambs to pens and high concentrate diets and for estimation of feed intake. Week 2 was for adaptation to experimental diets. Lambs received water and diets *ad libitum* twice daily in equal proportions, at 0800 and 1500 h.

Samples of each diet were analyzed for dry matter, crude protein, ash, ether extract, calcium, and phosphorus (AOAC 2002). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were measured by the method of Van Soest *et al.* (1991).

Dry matter intake (DMI), average daily gain (ADG), and feed conversion ratio were calculated for each lamb. Lambs were weighed biweekly in the morning before feeding, to determine ADG and feed to gain ratios.

At the end of experiment, blood samples (10 mL) were taken from the jugular vein of all lambs and concentrations of glucose, ammonia, total protein, triglyceride, total cholesterol, HDL and LDL in serum were measured using Pars Azmoon kits and associated procedures (Pars Azmoon Co., Tehran, Iran).

All results were analyzed using the GLM procedure of the SAS (2002). The model of analysis of variance included the effect of oilseed sources and level of L-carnitine as main effects, and the interaction with lamb as the experimental unit. For data with more than one time measuring the average of times was analyzed. Differences among means of variables with significant interactions were assessed by least squares mean separation. Significance was declared $P < 0.05$ and trends at $P \leq 0.15$ unless noted otherwise.

Results

Final body weight, ADG, feed intake, and feed conversion ratio are shown in table 2. There was no effect of oilseed sources or L-carinitine on lamb growth or feed intake. Lambs had a mean final weight of 37.2 kg, 226 g of ADG, 1129 g of daily DMI, and 5.2 units of DM per unit of gain.

Digestibility of dietary components was not affected by the source of oilseed (table 2). Feeding L-carnitine decreased ($P \leq 0.05$) NDF digestibility and tended to decrease organic matter digestibility ($P=0.13$).

Data for blood metabolites are shown in table 3. There was a tendency to interaction ($P=0.08$) for LDL concentration. L-carnitine increased LDL in lambs fed diets containing canola seed and decreased LDL in lambs fed diets containing soybean seed. The concentrations of cholesterol ($P=0.09$) and triglycerides ($P=0.13$) tended to increase when soybean seed was replaced by canola seed. Feeding L-carnitine increased ($P<0.05$) blood ammonia to 6 µg/dL, but other blood characteristics were not affected.

Table 1. Ingredient and chemical composition of completely mixed diets fed to lambs.

Item	Soybean seeds		Canola seeds	
L-carnitine:	0.0 g/d	0.11 g/d	0.0 g/d	0.11 g/d
Ingredient, g/kg of DM				
Whole canola seed	0.0	0.0	150.0	150.0
Soybean seed	150.0	150.0	0.0	0.0
Lucerne hay	188.0	188.0	231.0	231.0
Wheat bran	0.0	0.0	39.0	39.0
Barley	645.4	645.4	496.7	496.7
Soybean meal	2.3	2.3	68.7	68.7
$CaCO_3$	11.3	11.3	11.6	11.6
Salt	3.0	3.0	3.0	3.0
L-carnitine (g/day)	0.0	0.11	0.0	0.11
Chemical composition[1]				
ME, MJ/kg	11.53	11.53	11.53	11.53
CP, %	14.61	14.61	14.61	14.61
NDF, %	31.59	31.59	26.05	26.05
ADF, %	12.09	12.09	15.78	15.78
EE, %	3.95	3.95	7.59	7.59

[1]ME = metabolisable energy; CP = crude protein; NDF = neutral detergent fibre; ADF = acid detergent fibre; EE = ether extract.

Table 2. The effect of oilseed source and L-carnitine on feed intake, nutrient digestibility, and growth of lambs.

Item[1]	Soybean seeds		Canola seeds		SEM	P values		
L-carnitine:	0.0 g/d	0.11 g/d	0.0 g/d	0.11 g/d		Seed	L-carnitine	Inter
DMI, g/day	1045.0	1113.0	1191.0	1168.0	100.0	0.33	0.82	0.65
Digestibility %								
NDF	61.9	32.6	64.1	50.3	9.67	0.33	0.05	0.44
CP	74.0	64.2	76.4	72.4	4.51	0.27	0.16	0.53
OM	76.2	65.8	79.1	75.9	4.13	0.15	0.13	0.40
Final BW, kg	36.6	37.0	37.7	37.5	2.37	0.73	0.95	0.90
ADG, g/day	229.0	206.0	216.0	255.0	26.8	0.45	0.71	0.22
Feed conversion ratio	4.7	5.7	5.6	5.7	0.59	0.51	0.38	0.46

[1]DMI = dry matter intake; NDF = neutral detergent fiber; CP = crude protein; OM= organic matter; BW = Body Weight; ADG = average daily gain.

Table 3. The effect of oilseed sources and L-carnitine administration on blood metabolites of finishing lambs.

Item	Soybean seeds		Canola seeds		SEM	P values		
L-carnitine:	0.0 g/d	0.11 g/d	0.0 g/d	0.11 g/d		Seed	L-carnitine	Inter
Glucose, mg/dL	89.0	91.2	91.4	90.0	3.12	0.85	0.89	0.57
Triglyceride, mg/dL	23.4	24.4	25.4	32.4	2.81	0.09	0.17	0.30
Cholesterol, mg/dL	58.6	57.8	59.6	70.0	4.19	0.13	0.26	0.20
Ammonia, µg/dL	36.2	42.2	39.6	46.0	2.99	0.24	0.05	0.94
LDL, mg/dL	25.4	21.2	23.8	30.4	2.88	0.20	0.68	0.08
HDL, mg/dL	28.4	31.8	30.8	33.4	1.88	0.30	0.13	0.83
Total protein, g/dL	6.9	7.3	7.1	7.0	0.19	0.79	0.44	0.24

Discussion

There was no interaction between oilseed sources and L-carnitine feeding for growth, feed intake, digestibility, and blood metabolites. No report could be found in the literature about whether L-carnitine effects depend upon oilseed sources. Body synthesis of L-carnitine might be enough to prevent any interactions.

The similar effect of soybean and canola seeds on growth and feed intake was expected. This was supported by lack of an effect on digestibility. Few reports on the effects of different oil seeds on growth and feed intake of lambs have been reported in the literature. In agreement to the results of this study, Rule *et al.* (1994) observed similar feed intakes and ADG when feeding canola and soybean seed diets to bulls. Rizzi *et al.* (2002) indicated that feed intake, live weight gain, and feed conversion ratio were not affected by feeding soybean or sunflower seed diets to growing lambs. However, Petit *et al.* (1997) reported that, compared to canola seed, soybean seed increased DM intake. There was no effect on ADG or feed conversion ratio. The discrepancy between the results of this study and those of Petit *et al.* (1997) could be ascribed to differences in proportions of soybean seed and canola seed (7 vs. 28% of DM) and the high level of dietary oilseed (~35 % of DM diet).

Unexpectedly, feed intake and ADG were not affected by including L-carnitine in the diet. It is possible that de novo synthesis of carnitine or its concentration in the basal diet fulfilled the requirements of the lambs. Growth and metabolic responses to supplemental L-carnitine have been variable in ruminants. Hill *et al.* (1994) and Chapa *et al.* (2001) reported that supplementation with L-carnitine had no effect on feed intake, gain and efficiency in lambs and steers, respectively. In contrast, White *et al.* (1998) showed an improvement in gain when grazing calves were supplemented with L-carnitine. Also, White *et al.* (2002) indicated that adding 100 ppm L-carnitine to the diet led to faster and more efficient gains.

The decrease in NDF digestibility and the trend to decrease OM digestibility were not expected from supplementation of the diet with L-carnitine. However, LaCount *et al.* (1996) found that adding 1.75 g/d of L-carnitine to mid-lactation dairy cow diets decreased NDF and tended to decrease the digestibility of DM and OM. In contrast, LaCount *et al.* (1995) demonstrated that supplementing early lactation dairy cows with 6 g/d of L-carnitine improved fatty acid digestibility and tended to improve the digestibility of DM and OM.

The trends observed for increasing triglyceride and cholesterol concentrations in the blood of lambs fed canola seed diet compared to soybean seed diet were expected because canola seeds contain a higher concentration of dietary fat. This agrees with the

increased plasma cholesterol concentrations in dairy cows (Khorasani *et al.* 1992) and lambs (Lough *et al.* 1994) fed higher levels of fat. Petit *et al.* (1997) also observed that plasma LDL, HDL, cholesterol, and triglyceride levels increased with a high level of supplementation of canola seed compared to soybean seed. Also, a study with dairy cows that were offered diets with incremental levels of canola seed revealed a trend to increased plasma concentrations of triglyceride (Khorasani *et al.* 1998).

The increase of ammonia concentration in the blood of lambs supplemented with L-carnitine was not expected and contrasts literature data showing no effect of L-carnitine on blood ammonia in lactating ewes (El-Shahat and Abo-El maaty 2010), dairy cows (Carlson *et al.* 2007), Holstein calves (Bunting *et al.* 2002), and growing lambs (Chapa *et al.* 2001). However, Yavuz *et al.* (1997) reported that Holstein calves fed diets containing broiler litter and L-carnitine had higher ruminal ammonia N compared to calves fed a similar diet containing broiler litter without supplemental L-carnitine. Chapa *et al.* (2001) explained that the influence of L-carnitine on circulating ammonia N levels could depend on the route and level of administration, the adaptation of the rumen microbial population to L-carnitine, or even to the severity experienced for hyperammonemia. Under the conditions of the current study, the load of ammonia produced during fermentation of basal diet may have added the effects of L-carnitine and led to hyperammonemia.

Replacing canola seed with soybean seed and including L-carnitine in the diets of lambs did not affect feed intake, nutrient digestibility, or growth. These diets had minimal effects on lipid-related metabolites such as triglyceride, total cholesterol, LDL, HDL, cholesterol, total protein, glucose, and ammonia concentrations in the serum of growing lambs. The lack of response in blood metabolites supports the absence of a response in growth and feed intake and indicates that canola seed could be substituted by soybean seed in diets for growing lambs. Supplementing with L-carnitine had no effect on responses of lambs fed soybean seed and canola seed diets.

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