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Effect of conjugated linoleic acid addition on growth performance, digestion and metabolism of stabling Tan sheep

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Conjugated linoleic acid (CLA) is a group of geometric and positional isomers of linoleic acid which have benefits to body composition, immune system and atherosclerosis (Ferkay *et al.* 2017). It also have beneficial anticarcinogenic, antiatherogenix, antidiabetic and cholesterol reduction properties (Badee and Hidaka 2014). Thus, there is a considerable interest in including CLA in animal feed to both improve the lean production efficiency as well as provide functional foods to human. Although high oil diets (CLA-promoting diets) are effective in modifying the fatty acid composition of ruminant products, they often depress dry matter intake with occasional reduction in animal performance (Bessa *et al.* 2008). Most researches studies focused on how the supply of CLA affect the fatty acid composition of tissues, but little information is availble on the digestion and metabolism of nutrients. Therefore, the objective of the present study was to investigate the effects of CLA addition on growth performance, digestion and metabolism of stabling Tan sheep.

The experimental procedures used in this study were in accordance with the University's Guidelines for Animal Research. The experiment was performed at sheep breeding farm in Ningxia Province of China. Fattening Tan sheep (16) were assigned to two groups with 8 sheep (16) (3 rams and 5 ewes) in each. The control group was fed a basal diet and the treatment group was fed basal diet + 2% CLA. Basal diet was formulated to meet the nutrient requirement for meat-producing sheep (Table 1; NY/T816-2004). The composition of CLA is shown in Table 2. In all groups, feed was given twice a day at 06:30 and 17:30. The sheep had free access to drinking water.

Feed offered and refused, and body weights were recorded once every two weeks during the feeding trial. Each measurement was recorded for two consecutive days. Tape was used to measure the height, length and bust at the beginning and end of feed trial.

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After the feeding trial, 3 rams in each group were selected for digestion and metabolism test. The test lasted for 15 days with 10 days for adaptation. Faecal weights were recorded daily for 5 test days and sub-samples were dried at 60°C for 72 h and ground through a 1-mm screen (Wiley mill) for analysis of DM, OM, CP, EE, NDF, ADF and N. Urine volumes were recorded daily for 5 test days. A sub-sample was acidified immediately after collection by diluting 1 volume of urine with 4 volumes of 0.072 N H_2SO_4 and analyzed for urinary urea N (Rahmatullah and Boyde 1980).

A general linear model procedure (SAS Inst. Inc., Cary, NC) was used to analyze the data. The data were analyzed by one-way ANOVA. The degree of significance was defined as follows: $P>0.10$, not significant; P = 0.05 to 0.10, trends; $P\leq0.05$, significant.

Addition of CLA increased the feed intake, final weight and daily gain ($P<0.05$) (Table 3). Neither the initial height, length, and bust nor the final height, length, and bust were affected by the CLA addition (Table 4, $P>0.05$). However, addition of CLA increased the absolute value of bust ($P<0.05$). Granados-Rivera *et al.* (2017) found that there were no significant effects of feeding CLA supplement on forage intake of grazing dairy cows. Shi *et al.* (2017) also reported that CLA supplementation had no influence on dry matter intake, milk yield, and milk protein and lactose contents. However, several studies found that feeding CLA to monogastric animals promotes a decrease in fat content and an increase in lean content. Most studies in mice have reported that feeding CLA reduced the body fat content (Yeganeh *et al.* 2017), but effects of CLA in other species were more variable (Ostrowska *et al.* 2003). The variability in response may relate to dose or isomer composition of CLA supplement or age or strain of animal studied (Wynn *et al.* 2006). Commercial CLA supplements are isomeric mixture (c9, t11 and t10, c12), and various isoforms could have different biological actions. Yeganeh *et al.* (2017) confirmed that of the two most metabolically active isomers of CLA, the t10–c12 CLA is the isomer responsible for weight loss, and its effect was independent of feed intake.

Addition of CLA had no effect on the apparent

Table 1. Composition and nutrient levels of the basal diet (DM basis)

Item	
Ingredient (%)	
Corn	33.57
Wheat bran	4.09
Soybean meal	2.44
Cottonseed meal	2.31
Corn silage	53.98
NaCl	0.35
Limestone	0.26
Premix[1]	3.00
Chemical composition[2]	
ME (MJ/kg)	8.75
CP (%)	10.39
Ca (%)	0.35
P (%)	0.22

[1]Premix provided the following per kg of the diet: Vitamin A, 1000,000 IU, biotin 40 mg, nicotinic acid 1,000 mg, vitamin D_3 400,000 IU, vitamin E 5,000 IU, Fe (as ferrous sulfate) 1,500 mg, Cu (as copper sulfate) 2,000 mg, Zn (as zinc sulfate) 600 mg, Mn (as manganese sulfate) 4,000 mg, I (as potassium iodide) 90 mg, Se (as sodium selenite) 3.0 mg. [2]ME is a calculated value while others are measured values.

Table 2. Composition of conjugated linoleic acid

Items	Standard request	Testing results
Palmitic acid (%)	< 9	5.4
Stearic acid (%)	< 4	2.0
Oleic acid (%)	8-20	10.8
Linoleic acid (%)	< 3	1.2
Conjugated linoleic acid (%)	78–84	80.4
Total bacterial count (cfu/g)	< 1000	< 10
Coliform bacterial (MPN/100g)	< 40	< 30

digestibility of dry matter, organic matter, and crude protein (Table 5, P>0.05). The apparent digestibility of EE was increased by CLA addition, but the NDF and ADF apparent digestibility decreased. These results were in accordance with Zheng *et al.* (1999), who found that addition of fatty acid had no effect on rumen pH or digestibility of dry matter and organic matter, but could reduce the digestibility of fibre. The effects of CLA on body composition appear to be due in part to reduced fat deposition and increased lipolysis in adipocytes, possibly coupled with enhanced fatty acid oxidation in both muscle cells and adipocytes (Ferlay *et al.* 2017). Leaver *et al.* (2006) also reported that the effect of dietary CLA was to increase β-oxidation in liver, to reduce levels of total body lipid and liver triacylglycerol, and to affect liver fatty acid composition, with increased elongase expression and HUFA biosynthetic capacity. On the other hand, rumen fibre digestibility will be inhibited by increasing degree of unsaturation and inclusion level of feed lipids. Therefore, the addition level of CLA should be controlled to avoid making depression in fibre digestibility.

Effect of CLA addition on nitrogen metabolism of stabling Tan sheep are presented in Table 6. Addition of CLA decreased the urinary nitrogen (P<0.05), while the apparent digestibility of nitrogen was enhanced by CLA. This result was in line with Schauff and Clark (1992), who reported that absorption of N increased linearly when fat was fed to cows.

In conclusion, the results of the present experiment showed that addition of CLA improved the growth performance, increase the apparent digestibility of EE and nitrogen of stabling Tan sheep. However, the decrease in fibre apparent digestibility imply that the addition level of CLA should be controlled.

Table 3. Effect of conjugated linoleic acid addition on the productive performance of stabling Tan sheep

Parameter	Diet	
	Control	CLA
Feed intake (g/d)	832±21.2[b]	900±19.2[a]
Initial weight (kg)	36.2±2.47	36.7±1.33
Final weight (kg)	40.9±1.91[b]	43.4±1.55[a]
Daily gain (g/d)	78.1±21.67[b]	114±29.00[a]

[a, b]Means in the same row with different superscripts differ significantly (P<0.05).

Table 4. Effect of conjugated linoleic acid addition on the height, length and bust of stabling Tan sheep

Parameter	Diet			
	Control		CLA	
	Male (3)	Female (5)	Male (3)	Female (5)
Initial				
Height	64.1±1.63	60.5±1.76	65.3±1.62	59.5±1.03
Length	70.0±1.83	67.4±1.76	71.2±1.50	68.4±2.23
Bust	82.8±1.25	74.9±2.12	83.1±1.04	75.5±2.47
Final				
Height	65.0±1.78	61.4±1.83	66.5±1.72	66.5±1.72
Length	71.8±1.86	68.9±1.92	72.8±1.18	72.8±1.18
Bust	86.3±1.61	78.5±1.99	88.2±0.98	88.2±0.98
Absolute value				
Height	0.97±0.15	1.02±0.24	1.20±0.17	1.10±0.16
Length	1.77±0.06	1.46±0.25	2.00±0.35	1.62±0.33
Bust	3.53±0.50[b]	3.64±0.29[b]	5.10±0.17[a]	4.66±0.43[a]

[a, b]Means in the same row with different superscripts differ significantly (P<0.05).

Table 5. Effect of conjugated linoleic acid addition on apparent digestibility of feed nutrients

Parameter	Diet	
	Control	CLA
Dry matter (%)	74.3±2.62	73.6±2.28
Organic matter (%)	76.5±1.03	76.0±1.18
Crude protein (%)	67.0±1.80	66.3±2.07
EE (%)	72.1±0.82[b]	77.4±0.96[a]
Neutral detergent fibre (%)	57.3±1.28[a]	49.2±2.36[b]
Acid detergent fibre (%)	49.9±0.83[a]	40.6±1.48[b]

[a,b]Means in the same row with different superscripts differ significantly (P<0.01).

Table 5. Effect of conjugated linoleic acid addition on apparent digestibility of feed nutrients

Item	Diet	
	Control	CLA
Nitrogen intake (g/d)	9.76±0.19	9.83±0.15
Feed nitrogent (g/d)	3.25±0.08	3.30±0.13
Urinary nitrogen (g/d)	2.82±0.21[a]	2.44±0.16[a]
Nitrogen deposition (g/d)	3.69±0.29	4.09±0.32[a]
Apparent digestibility of digestibility (%)	38.1±1.66[b]	41.0±1.23[b]

[a, b]Means in the same row with different superscripts differ significantly (P<0.05).

SUMMARY

This study was conducted to determine the effect of addition of conjugated linoleic acid (CLA) on growth performance, digestion and metabolism of stabling and Tan sheep. Fattening Tan sheep (16) were assigned to two groups, viz. control group (fed a basal diet) and treatment group (fed basal diet + 2% CLA). After the feeding trial, 3 rams in each group were selected for digestion and metabolism test. Average daily gain and the apparent digestibility of EE were significantly increased by CLA addition, but the NDF and ADF apparent digestibility were decreased. Addition of CLA decreased the urinary nitrogen, while it enhanced the apparent digestibility of nitrogen. Addition of CLA could improve production performance and enhance feed efficiency in Tan sheep. It may be the optimal additive for efficient breeding and production of high-grade mutton.

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