Feed Intake, Ruminal Fermentation, Blood Metabolites and Growth Performance of Lambs Fed on Camelthorn (*Alhagi camelorum* Fisch.) Based Diets

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Summary

In order to investigate the effect of camelthorn in replacement of alfalfa and wheat straw on intake, digestibility, ruminal fermentation, blood metabolites and feedlot performance, twenty one Baluchi male lambs with an average body weight (BW) of 19.8 ± 1.1 kg were randomly assigned to three dietary treatments for 90 d. Treatments were: 1) control (without camelthorn), 2) 15% camelthorn, and 3) 30% camelthorn, based on diet dry matter (DM). There were no significant differences among treatments in case of DM intake (DMI), average daily gain (ADG) and feed conversion ratio (FCR) ($P > 0.05$). However, a trend for lower final BW was found in lambs fed 30% camelthorn compared to control group ($P < 0.1$). The digestibility coefficients of nutrients were not affected by the treatments, but neutral detergent fiber (NDF) digestibility tended to decrease linearly with increasing camelthorn level ($P < 0.1$). Increasing camelthorn linearly increased ($P < 0.05$) acetate without any changes in total volatile fatty acids (VFA) concentration. A linear decreasing trend was also observed in propionate content with increasing camelthorn ($P < 0.1$). Dietary treatments had no significant effect on blood metabolites. However, increasing camelthorn tended to decrease the serum triglyceride concentration linearly ($P < 0.1$). It can be concluded that camelthorn can be substituted with alfalfa and wheat straw up to 30% of diet DM in the fattening lambs' ration without any significant adverse effects on animal performance.

Key words

camelthorn, feedlot, halophyte, sheep

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Introduction

The main limitation in breeding and improving sheep production in countries located in arid and semi-arid zones is the lack of food resources. It is estimated that global warming would cause a loss of 25% of animal production (Seguin, 2008) in these countries, especially Africa and some regions of Asia, where ruminants are reared in extensive or pasture-based systems (Nardone et al., 2010). Ruminants in small farms are mostly dependent on grazing fodder and the crop residues for growth, reproduction and milk or meat production (Ben Salem, 2010). However, the presence of saline and alkaline soils in these areas predisposes the growth of plants tolerant to salinity and drought. Camelthorn (*Alhagi* spp) is one of the most important halophyte plants which can reduce the dependence of livestock on expensive forages such as alfalfa. It is also palatable for sheep and goats (El Shaer and Attia-Ismail, 2015). On the other hand, the presence of secondary metabolites such as (poly) phenolic compounds in camelthorn (Atta and El-Sooud, 2004; Demir et al., 2015) may retard the digestibility of nutrients because of their ability to bind with protein and carbohydrate (direct effect) or may have indirect effect on rumen microflora through interaction with the cell wall of bacteria and/or their extracellular enzymes (McSweeney et al., 2001). However, depending on the type and amount of phenolic compounds, species and physiological state of the animal and also the composition of the diet, they may have both beneficial and detrimental effects (Makkar, 2003a) and thus affect animal health and performance.

The chemical composition of different camelthorn species has been documented by El Shaer (2010) and Safaei et al. (2017). A meta-analysis of the nutritional value of camelthorn showed that the contents of organic matter (OM), crude protein (CP), ether extract (EE) and neutral detergent fiber (NDF) were 91.0, 11.0, 1.6 and 41.1% DM, respectively (Safaei et al., 2017). More recently, Kazemi and Ghasemi Bezdi (2021) evaluated the nutritional value of *Alhagi maurorum* Medik. at three growth stages *in vitro* and *in vivo*. They concluded that, except at the seeding stage, camelthorn at the vegetative or flowering stages had no adverse effect on milk production of Afshari ewes at 25% diet DM. Although camelthorn has a relatively good nutritional value, there are very few studies on the use of this food source and its possible effects on growth performance of small ruminants. Therefore, this study aimed to evaluate the effect of half or complete replacement of ration forage portion (alfalfa and wheat straw) with camelthorn on intake, ruminal fermentation, blood metabolites and fattening performance of Baluchi male lambs.

Material and Methods

Plant Collection

Alhagi camelorum Fisch. was collected from agro-lands of Sistan era with 30°50'29.4"N latitude and 61°43'12.0"E longitude in July 2019 at flowering stage. All samples were sun-dried for 48 h and then chopped at a theoretical length of 2-3 cm.

Animals, Diets and Experimental Design

Twenty one Baluchi male lambs with an average body weight (BW) of 19.8 ± 1.1 kg were randomly allocated to three dietary treatments in a completely randomized design. Before initiation of the experiment, all animals were dewormed by Albendazole 2.5% and vaccinated against enterotoxaemia (3 mL per lamb). Lambs were kept in a 2 m × 1.5 m individual concrete-floor pens where all of them were washed and disinfected before the onset of the experiment.

Dietary treatments were: 1) diet containing, as a DM basis, 20% alfalfa and 10% wheat straw, (control), 2) diet containing 10% alfalfa, 5% wheat straw, and 15% camelthorn, and 3) diet containing 30% camelthorn. The study started with a 15-day feeding adaptation period followed by a 75-day measurement period during which BW changes and dry matter intake (DMI) were recorded. The Small Ruminant Nutrition System (SRNS; version 1.9.4468; Tedeschi et al., 2010) was used to formulate experimental diets in order to meet the nutrient requirements of lambs and to have similar energy and protein contents (Table 1). Diets were fed to the animals as a total mixed ration (TMR) with forage to concentrate ratio of 30:70 twice daily ad libitum at 08:00 and 16:00 h. Fresh water was also provided all the times.

Measurements

Feed intake was recorded daily during the measurement period and the feed offered and refusals were kept frozen at -20 °C. On days 69 to 75 of the data collection period, the fecal samples of each animal were collected daily and stored at -20 °C. All lambs were weighed at the beginning and the end of the experiment at 15-d intervals before the morning feeding to calculate average daily gain (ADG) and feed conversion ratio (FCR). On 79th day, rumen fluid was collected from lambs via a stomach tube 2 h after the morning feeding, and pH was measured immediately using a portable digital pH-meter (METROHM 691, Herisau, Switzerland). About 5 mL of rumen fluid were mixed with 5 mL of 0.2 N HCl and 1 mL of 25% (w/v) meta-phosphoric acid in duplicate for analyses of NH_3-N and VFA, respectively and then kept at -20 °C. On day 81, ten mL of blood were taken from the jugular vein, 2 h after the morning feeding, centrifuged at 3000 × g for 10 min, and the serum was recovered and stored at -20 °C for later analysis.

Laboratory Analysis

The representative samples of the camelthorn, TMR, orts and feces were dried in an oven at 60 °C to constant weight and then ground (Wiley mill; Thomas Scientific, Gloucester, NJ) to pass through a 1-mm screen and analyzed for DM, OM, CP and ash-free acid detergent fiber (ADFom) (methods 930.15, 942.05, 2001.11, and 973.18, respectively). Neutral detergent fiber (NDF) was determined by the procedure described by Van Soest et al. (1991) without sodium sulfite and expressed as exclusive of residual ash (NDFom). For tannin quantification, sub-samples of camelthorn were dried in an oven at 40 °C and then ground to pass a 2 mm and 0.5 mm sieve, respectively (Makkar, 2003b). Total phenolic compounds (TP) and total tannins (TT) of camelthorn, as tannic acid (Merck GmbH, Darmstadt, Germany) equivalent, were measured by using Folin-Ciocalteu reagent (Makkar, 2003b).

Digestibility of DM and nutrients were determined by measuring acid insoluble ash (AIA) in feed and feces (Van Kuelen and Young, 1977). The concentration of ruminal NH_3-N was analyzed according to the procedure of Weatherburn (1967). Serum glucose, total protein, urea-N, cholesterol and triglycerides were measured using an autoanalyzer (Biosystems A 15; 08030 Barcelona, Spain).

Gas chromatography (YL6100 GC; Young Lin Instrument, Anyang, South Korea) was used to measure the concentration of VFA as described in our previous study (Kazemi and Mokhtarpour, 2021).

Table 1. Ingredients and chemical composition of experimental diets and camelthorn (DM basis)

Ingredients (%)	Experimental diets †			Camelthorn
	1	2	3	
Alfalfa	20	10	0	
Wheat straw	10	5	0	
Camelthorn	0	15	30	
Corn grain	20	20	20	
Barley grain	27	26	25	
Soybean meal	6.7	7.7	8.7	
Wheat bran	14.5	14.5	14.5	
Limestone	0.7	0.7	0.7	
Mineral-vitamin premix ‡	0.5	0.5	0.5	
Sodium bicarbonate	0.3	0.3	0.3	
Salt	0.3	0.3	0.3	
Chemical composition (%)				
Dry matter	91.5	91.2	91.2	41.2
Organic matter	93.7	93.2	92.7	89.4
Crude protein	13.2	13.0	12.9	8.8
Neutral detergent fiber	34.1	33.2	32.4	48.3
Acid detergent fiber	15.3	15.1	14.6	36.4
Ether extract	2.7	2.7	2.8	1.65
ME (Mcal kg^{-1} DM) §	2.44	2.44	2.44	1.74
Non-fiber carbohydrate	43.7	44.3	44.6	30.7
Calcium §	0.60	0.63	0.67	-
Phosphorous §	0.30	0.33	0.34	-
Phenolic compounds	-	-	-	4.69
Tannin	-	-	-	1.62

Note: † Treatments 1, 2, and 3 contained 0, 15, and 30% of diet DM camelthorn, respectively; ‡ Each kg of the vitamin–mineral premix contained: vitamin A (50,000 IU), vitamin D3 (10,000 IU), vitamin E (1500 IU), Calcium (155 g), Phosphorus(40 g), Sodium (71 g), Magnesium (19 g), Iron (3 g), Copper (1.3 g), Manganese (5.5 g), Zinc (12 g), Cobalt (32 mg), Iodine (55 mg), Selenium (10 mg); § ME of treatments were calculated from SRNS (2010), and camelthorn ME was estimated based on our *in vitro* gas production trial.
Non-fibre carbohydrates calculated as 100 - (NDF + CP + ether extract + ash).

Statistical Analysis

Data were analyzed as a completely randomized design using the MIXED procedure of SAS (version 9.1; SAS Institute Inc.). Initial BW of lamb was used as a covariate. A repeated measures model was employed for estimating feed intake, ADG, and FCR. The model included the effect of treatment as fixed effect, lambs within treatment as random effect and day as repeated measures.

Differences between treatments were detected by the multiple range Duncan's test, and significance was declared at $P \leq 0.05$ and trends were considered when $0.05 < P < 0.10$. All data was reported as least square means.

Results

Feed intake and growth performance of Baluchi lambs are presented in Table 2. Dry matter intake, final BW, ADG and feed conversion ratio (FCR) were not affected by dietary treatments (Table 2). However, a linear trend ($P < 0.1$) for lower final BW was detected with increasing camelthorn level in the diet. The final BW of lambs fed 30 % camelthorn was 3.9% lower than of those fed alfalfa based diet (34.7 vs 36.1 kg) ($P < 0.1$).

Inclusion of camelthorn had no significant effect on digestibility coefficients of treatments either linearly or quadratically. However, a tendency to linear reduction in NDF digestibility was observed with increasing camelthorn in the ration (Table 3).

The pH values, NH_3-N and total VFA concentrations were similar among treatments (Table 4). Increasing camelthorn linearly increased ruminal acetate concentration and also the acetate to propionate ratio ($P < 0.05$), but the propionate content tended to decrease linearly ($P < 0.1$).

As shown in Table 5, the concentrations of blood glucose, total protein and blood urea nitrogen (BUN) were not affected by dietary treatments, but a linear tendency for lower triglyceride ($P = 0.07$) and cholesterol ($P = 0.1$) was observed with increasing camelthorn.

Discussion

Feed Intake and Nutrient Digestibility

Similar energy and protein contents among treatments (Table 1) could reflect similar DMI. Voluntary feed intake of dried and ensiled camelthorn with or without supplementing with molasses in adult Baluchi male sheep showed that the animals fed alfalfa, as a control diet, had higher DM intake compared to those fed camelthorn diets (2054 vs 1201 g d^{-1}) (Bashtini et al., 2005). In contrast to our findings, Bashtini et al. (2013) reported that the use of camelthorn at the level of 80% compared to 40% DM in milking ewes ration significantly increased feed intake. Karamshahi Amjazi et al. (2017) also found higher DM intake in Kermani sheep fed diets containing 21% camelthorn silage supplemented with waste dates compared to those consumed 0, 7 and 14% camelthorn, which could be due to higher palatability and lower content of NDF. Recently, Kazemi and Ghasemi Bezdi, (2021) reported that feeding milking ewes with 25% camelthorn (*A. maurorum*) at different growth stages had no effect on feed intake compared to the control group.

Table 2. Least square means comparisons of experimental diets for intake, performance and apparent total tract digestibility in Baluchi male lambs

Item ‡	Experimental diets †			SEM	*P* value §		
	1	2	3		TRT	L	Q
Body weight (kg)							
Initial	19.7	19.5	20.1	0.29	0.71	-	-
Final	36.1	35.5	34.7	0.55	0.23	0.099	0.89
DMI (g d^{-1})	1112	1078	1052	19.61	0.34	0.16	0.83
ADG (g d^{-1})	188	180	172	3.93	0.25	0.11	0.93
FCR	5.99	6.04	6.05	0.097	0.95	0.84	0.90

Note: † Treatments 1, 2, and 3 contained 0, 15, and 30% of diet DM camelthorn, respectively; ‡ BUN - Blood urea nitrogen; § TRT - effect of treatment; L - linear effect; Q - quadratic effect; SEM - standard error of the means

Table 3. Least square means comparisons of experimental diets for apparent total tract digestibility in Baluchi male lambs

Item ‡	Experimental diets †			SEM	*P* value §		
	1	2	3		TRT	L	Q
Digestibility (%)							
DM	65.7	66.5	64.1	0.75	0.46	0.43	0.34
OM	68.5	67.8	67.3	0.78	0.85	0.58	0.94
CP	69.2	68.8	68.0	0.80	0.84	0.57	0.91
NDF	40.5	39.9	38.7	0.64	0.21	0.09	0.88

Note: † Treatments 1, 2, and 3 contained 0, 15, and 30% of diet DM camelthorn, respectively; ‡ BUN - Blood urea nitrogen; § TRT - effect of treatment; L - linear effect; Q - quadratic effect; SEM - standard error of the means

Table 4. Least square means comparisons of experimental diets for ruminal fermentation parameters in Baluchi male lambs

Item ‡	Experimental diets †			SEM	*P* value ‡		
	1	2	3		TRT	L	Q
pH	6.31	6.28	6.22	0.023	0.23	0.29	0.82
Ammonia-N (mg dL^{-1})	16.4	17.2	18.1	1.35	0.67	0.39	0.97
Total VFA (mM)	92.5	93.8	89.3	2.05	0.81	0.69	0.62
Individual VFA (mol 100 mol^{-1})							
Acetate	58.4^{b}	59.3^{b}	61.7^{a}	0.61	0.04	0.02	0.35
Propionate	21.0	19.8	18.4	0.56	0.17	0.07	0.94
Butyrate	17.4	18.1	17.8	0.49	0.87	0.75	0.68
Valerate	1.7	1.9	1.9	0.10	0.71	0.49	0.69
Acetate: Propionate	2.80	3.01	3.39	0.11	0.06	0.03	0.65

Note: † Treatments 1, 2, and 3 contained 0, 15, and 30% of diet DM camelthorn, respectively; ‡ BUN - Blood urea nitrogen; § TRT - effect of treatment; L - linear effect; Q - quadratic effect; SEM - standard error of the means; a,b Least square means within a row with different superscripts differ significantly ($P < 0.05$).

Table 5. Least square means comparisons of experimental diets for blood metabolites parameters in Baluchi male lambs (mg dL^{-1})

Item	Experimental diets †			SEM	*P* value §		
	1	2	3		TRT	L	Q
Glucose	71.1	69.3	65.0	1.77	0.39	0.19	0.75
Total protein	6.8	6.6	6.7	0.11	0.54	0.64	0.18
BUN ‡	15.9	16.3	15.0	0.35	0.32	0.30	0.26
Triglyceride	23.7	24.6	21.9	0.39	0.18	0.07	0.79
Cholesterol	58.4	51.3	50.7	1.89	0.19	0.10	0.68

Note: † Treatments 1, 2, and 3 contained 0, 15, and 30% of diet DM camelthorn, respectively; ‡ BUN - Blood urea nitrogen; § TRT - effect of treatment; L - linear effect; Q - quadratic effect; SEM - standard error of the means

Replacing half or all of barley straw with saltbush (*Atriplex*) improved DMI of Awassi ewes (Abu-Zanat and Tabbaa, 2006), which may be due to the relatively high CP content of saltbush (*Atriplex*) (12.8 %). In general, using halophytes such as camelthorn did not have any negative effect on DMI.

Although the amount of NDF in camelthorn diets was numerically lower than the control treatment, the decreasing trend of NDF digestibility with increasing camelthorn might be attributed to the higher lignin and lignocellulose bonds resistant to microbial digestion in camelthorn compared to alfalfa. There is usually a significant negative correlation between lignin content and food intake and digestibility (Jung and Allen, 1995). Therefore, non-significant linear reduction in NDF digestibility at 30 % camelthorn diet can be partially due to the higher amount of lignin compared to the control treatment. In addition, the presence of secondary metabolites such as phenolic compounds and tannins (46.9 and 16.2 mg TAE g^{-1} DM herein) in camelthorn may lead to reduce fiber digestibility due to interrelationships with lignocelluloses (Barry and Manley, 1986) or direct interaction with cellulolytic microorganisms (Patra and Saxena 2011), and/or the activity of fibrolytic enzymes (Bae et al., 1993). Therefore, the presence of high levels of ash, lignin and plant secondary metabolites may be limiting factors in using halophytes in ruminants' rations (El Shaer, 2010). Consistent to our results, Kazemi and Ghasemi Bezdi, (2021) did not observe significant difference in DM and OM digestibility between ewes fed with or without camelthorn (*A. maurorum*), but the digestibility of CP and NDF in animals fed with camelthorn at the flowering and seeding stages were lower than the control group ($P < 0.05$).

Growth Performance

To the best of our knowledge, no scientific report has been published on the effect of camelthorn on sheep fattening, so, comparisons with other studies are limited to the effect of camelthorn on lactation performance or the effect of other salt tolerant plants on animal performance. Bashtini et al. (2013) reported that milk production of Baluchi ewes fed with 80% camelthorn was not significantly different from the control group (alfalfa and straw) but orthogonal contrasts showed that the use of 40% camelthorn compared to 80% tended to decrease ($P < 0.1$) milk yield. Similarly, substitution of alfalfa with camelthorn (25% of diet DM) at vegetative or flowering stages did not have any effect on ewes' milk production, but when camelthorn (*A. maurorum*) at seeding stage significantly decreased milk production compared to vegetative stage or control fed groups ($P < 0.05$) (Kazemi and Ghasemi Bezdi, 2021) it could be ascribed by reduced digestibility of CP, and NDF, as well as the lower total amount of VFA in sheep fed camelthorn. Although the use of saltbush (*Atriplex*) instead of barley straw in the diets of Awassi lactating ewes increased feed intake, it had no effect on milk production, which may be due to the negative effects of plant secondary compounds such as oxalate and tannins (Abu-Zanat and Tabbaa, 2006). Feeding 75 and 150 g day^{-1} saltbush instead of wheat straw had no effect on feed intake, final BW and ADG of Awassi male lamb (Obeidat et al., 2016). Ben Salem et al. (2005) and Stringi et al. (2009) reported that lambs fed saltbush (*Atriplex*) had lesser BW due to lower DMI and digestibility. Based on literature, it can be concluded that feeding saltbush more than 25 % of diet DM will reduce lambs performance parameters (Abu-Zanat, 2005; Obeidat et al., 2016). In our study, a tendency to decrease final BW of lambs by feeding about 300 g d^{-1} camelthorn compared to a mixture of alfalfa and straw could be due to a decrease of 77 g d^{-1} OM ($P = 0.11$) and also a linear decrease in the percentage of propionate ($P < 0.1$) (Table 4), since reduction in fermentable OM leads to a decrease in microbial protein synthesis (Oba and Allen, 2003).

Rumen Fermentation Parameters

Rumen pH and NH_3-N were not affected by inclusion of camelthorn in the diet, which could be due to similar digestibility of nutrients among treatments. These results are consistent with Karamshahi Amjazi et al. (2014) who used different levels of camelthorn silage with waste dates in the diet of male sheep. Also, Kazemi and Ghasemi Bezdi (2021) did not observe any changes in ruminal pH and NH_3-N concentrations, either *in vitro* or *in vivo*. Rumen ammonia nitrogen concentration of lambs fed with saltbush (*Atriplex nummularia* Lindl.) and coojong (*Acacia saligna (*Labill.) H. L. Wendl.) was not significantly different compared to the clover (Ahmed et al., 2015).

In spite of a decreasing trend for NDF digestibility ($P < 0.1$), the acetate concentration significantly increased with increasing camelthorn in the ration, which may be ascribed by hydrolysis of glycosides and decomposition of heterocyclic rings of phenolic compounds by rumen microorganisms to acetate and butyrate (Patra and Saxna, 2011) as Aboagye et al. (2019) state that the gallic acid metabolites produced in the rumen including pyrogallol, resorcinol, and phloroglucinol have been hydrolyzed to acetate and butyrate.

Volatile fatty acids provide up to 80% of the energy required by the animal (Bergman, 1990). The concentration of total VFA depends mostly on DMI and also the effective degradability of the nutrients (Ferkins et al., 1986). Therefore, the lack of changes in the total amount of VFA between the treatments herein may be due to the same digestibility of OM.

Feeding lambs with a mixture of saltbush (*A. nummularia*) and coojong (*A. saligna*) at 30% DM reduced the total concentration of VFA compared to the group fed 30% clover or those fed 15% clover plus 15% coojong (*A. saligna*) (Ahmed et al., 2015). They reported that increasing in dilution rate due to increased water consumption may reduce the total VFA. Similarly, Kazemi and Ghasemi Bezdi (2021) found lower ruminal VFA in ewes fed camelthorn at the seeding stage compared to vegetative stage and control group.

Blood Metabolites

Any significant changes among treatments in case of serum blood glucose and urea nitrogen could represent proper nutritional status as these variables are used to assess the nutritional status of ruminants (Hammond et al., 1994). In contrast to our results, Karamshahi Amjazi et al. (2017) observed that blood glucose concentration of sheep increased linearly with increasing camelthorn ensiled with waste date palm, which was due to the increase in DMI and also high level of easily fermentable carbohydrates in waste dates which are likely to be converted to propionate in the rumen. On the other hand, Kazemi and Ghasemi Bezdi (2021) found a decrease in blood glucose of ewes by feeding camelthorn (*A. maurorum*) at the seeding stage. However, blood glucose remained unchanged at vegetative or flowering stages. Shaker et al. (2014) also reported that sheep fed salt-tolerant plants had lower blood glucose concentrations because of high amount of tannins in desert plants.

Our results on BUN concentration were within the normal range of 10 to 25 mg dL^{-1} reported by Frandson et al. (2009). Consistent with our results, feeding ewes with camelthorn (*A. maurorum*) at vegetative or flowering stages had no effect on BUN concentration (Kazemi and Ghasemi Bezdi, 2021). The concentration of BUN is affected by various factors such as the chemical composition of the feed, the secretion of endogenous urea nitrogen, and the function of the liver and kidneys (Ndlovu et al., 2009). In addition, BUN reflects the percentage of CP in the diet, the ratio of CP to rumen fermentable OM, and post-ruminal protein metabolism, so blood urea nitrogen can be an indicator of protein metabolism (Roseler et al., 1993). Therefore, similar ruminal ammonia nitrogen as a result of protein degradation would result in similar BUN in lambs fed the control diet and camelthorn based diets.

The tendency to reduce blood triglyceride concentration in the present study is consistent with the results of Karamshahi Amjazi et al. (2017). They reported that acetic and butyric acids were decreased by feeding camelthorn ensiled with waste date palm as an easily fermentable carbohydrate. Since acetic acid is precursor of fat in ruminants, reduction in acetic acid would lead to decrease in blood triglyceride level. However, substituting alfalfa and straw by camelthorn (*A. maurorum*) at 25% of dietary DM did not affect blood triglyceride concentration of ewes (Kazemi and Ghasemi Bezdi, 2021). In our experiment, incorporation of camelthorn resulted in an increase in the percentage and acetate to propionate ratio, therefore, a decrease in blood triglyceride could not be attributed to acetate concentration. This reduction may be due to the effect of phenolic compounds on fat digestion. Bravo et al. (1993) stated that tannins could reduce cholesterol absorption and increase fat excretion by interfering with lipid digestion through forming complexes with fatty acids. In addition, tannins can be effective in inhibiting pancreatic lipase, thereby indirectly reducing triglyceride uptake. Overall, Velayutham et al. (2012) reported that tannins could reduce triglyceride or cholesterol levels in many species under physiological and pathophysiological conditions.

Conclusion

Inclusion of elevated levels of camelthorn in sheep diet had no effect on feed intake, digestibility of nutrients, ADG and FCR. However, final BW of lambs tended to decrease linearly. Although camelthorn has traditionally been used in small ruminant feeding, our results reveal that, for optimal growth, it is not recommended to be used as a sole forage source. However, based on economical point of view and availability of camelthorn and also the lack of significant adverse effect on lambs' growth performance, it is suggested to incorporate up to 30% of diet DM in fattening lambs' ration. This study will provide bases for future studies in this area. It is recommended that other levels of camelthorn be examined for lambs' growth performance.

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Ethical Approval Statement

This article does not contain any studies with human participants performed by any of the authors. Animal handling and experimental procedures were performed according to the Iranian Council of Animal Care (1995).

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