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Effect of dietary *Conocarpus erectus* leaves and branches on milk yield, quality, antioxidant activity and fatty acid profile, and blood parameters of Najdi dairy goats

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ABSTRACT

To investigate the effect of *Conocarpus erectus* tree leaves and branches as a partial replacement of forage on milk yield and components, blood and rumen parameters of goats, 16 Najdi goats were used in a completely randomized design with 2 treatments (CON, without *C. erectus*; CE, contains *C. erectus*). The basic ratio consisted of 60% concentrate and 40% forage. In treatment CE, 22.5% of the forage (alfalfa hay and wheat straw) was replaced with *C. erectus* leaves and branches. The lowest amount of dry matter intake and digestibility were observed in the treatment CE ($P < 0.05$). The amount of milk production significantly increased ($P = 0.01$) in the treatment CE. The total count did not differ between treatments, but the highest amount of *Lactobacillus* spp. ($P = 0.01$) and the lowest amount of mold ($P = 0.01$) were observed in the treatment CE. The 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity decreased on days 15 ($P = 0.02$) and 31 ($P = 0.01$) of the experiment in treatment CE. The highest amount of short-, medium-, and long-chain fatty acids and also conjugated fatty acids were observed in the treatment CE ($P < 0.05$). Also, the concentration of fatty acids C16:0 and C18:0 was lower in the treatment CE ($P < 0.05$). The lowest amount of triglycerides, blood urea nitrogen, cholesterol, low-density lipoprotein, high-density lipoproteins, serum glutamic pyruvic transaminase, and serum glutamic oxaloacetic transaminase were observed in the treatment CE ($P < 0.05$). Ruminal pH and ammonia-N concentration were not affected by experimental treatment ($P > 0.05$). According to the results, the use of *C. erectus* leads to improved milk production and fatty acid profile, antioxidant activity, and microbial load.

Key words: antioxidant activity, *Conocarpus erectus*, dairy goat, microbial load, milk composition

INTRODUCTION

In arid and semi-arid regions, which usually face the issue of drought every once in a while, paying attention to the available resources that are not edible for humans can play a significant role in compensating for the shortage and reducing the costs of animal husbandry (Chaji et al., 2020). One of these things that can be considered in these areas is the use of multipurpose trees foliage, which is usually used to create green spaces. *Conocarpus erectus* is one of these trees that have the potential to be used as feed and provide nutrients needed by ruminants. *C. erectus* have great potential to adapt to their ecosystems' challenges and provide suitable animal feed sources. Rapid growth is one of the essential advantages of *C. erectus* (Ayoub, 2010). *C. erectus* is a cheap fodder source that can be used as a nutrient and a suitable substitute for fodder in ruminant diets (Suleiman et al., 2005). Although studies about the use of *C. erectus* fodder in animal nutrition are limited. Still, Direkvandi et al. (2020) in vitro reported that the residues from the pruning of *C. erectus* could be used in livestock industries as ideal feed in the form of silage. They also said the amount of dry matter (DM), ash, crude protein (CP), ash-free neutral detergent fiber (NDF), and ash-free acid detergent fiber (ADF) of *C. erectus* leaves and branches as 293, 170, 105, 519, and 296 g/kg of DM, respectively (Direkvandi et al., 2020). On the other hand, these plants have secondary metabolites mostly known as nutritional factors (phenol, tannin, flavonoids, nitrate, saponin, and oxalate) (Bashir et al., 2015). Plants containing secondary metabolites have been used to manipulate rumen fermentation and improve nutrient utilization in ruminants. The efficiency of intraruminal metabolism can have significant effects on animal productivity. As modifiers of rumen fermentation, plant secondary metabolites may improve the efficiency of energy use in the rumen by reducing ammonia-N concentration and reducing methane production (Busquet et al., 2005).

So, this experiment was conducted for two reasons: 1) In the southern provinces of Iran, such as Khuzestan, the *C. erectus* shrub is widely used for creative landscaping. A large volume of residues from the pruning of *C. erectus* is produced annually, and using them in feeding livestock can be a solution for removing the residues from the pruning. 2) Moreover, the use of *C. erectus* leaves and branches as silage in feeding ruminants has been investigated in several experiments (in vitro). Still, there needs to be more information about the use of *C. erectus* in feeding dairy animals, especially goats. Therefore, this experiment aimed to replace part of the forage with *C. erectus* in dairy Najdi goats to investigate feed intake, nutrient digestibility, milk yield and components, and blood and rumen parameters.

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MATERIALS AND METHODS

Animal Care

All animal management and sampling procedures are conducted according to The Care and Use of Agricultural Animals in Research and Teaching guidelines (FASS, 2010). All procedures and guidelines involving animals were approved by the Animal Experiment Committee at Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran.

Forage Preparation

The *C. erectus* leaves and branches were prepared from *C. erectus* trees available in Mollasani city (Iran, Khuzestan). Sampling was performed by plot method from 10 trees. Leaves and branches were then chopped into approximately 20-mm particle length. Then an equal amount of samples were mixed, air-dried in the shadow and grounded, and chemical composition was evaluated. The concentrations of DM, organic matter (OM), CP, NDF, ADF, ether extract (EE), and total tannin (TT) for the *C. erectus* leaves and branches were 492 g/kg fresh weight, 980, 96, 502, 292, 52, and 41 g/kg DM, respectively. In this experiment, 22.5% of the forage (alfalfa hay and wheat straw) was replaced with *C. erectus* leaves and branches.

Animals and Experimental Diets

Sixteen Najdi goats in their third and fifth lactation were selected from the herd according to kidding date, body weight (BW), milk yield, and enrolled in the study and were used in a completely randomized design with two treatments and eight replicates. This study was conducted during 45 d (May to June 2022), with 14 d for adaptation and 31 d for sampling. Before the start of the experiment, goats presented BW 42 ± 6 kg, days in milk (DIM) 35 ± 7, and daily milk yield 0.5 ± 0.2 kg. All goats were housed in individual pens (1.5 m × 1.3 m). Goats were milked once daily at 1600 hours and were fed total mix ration (TMR) diet two times a day at 0700 and 1900 hours. The TMR was formulated according to NRC (2007; Table 1) to meet the requirements of energy, protein, vitamins, and minerals. The goats were daily fed with the TMR that was prepared based on the previous day average intake plus 5%. The goats also had free access to water and salt licks during the experiment.

Table 1. Ingredients and chemical composition of the diets fed to lactating goats

Ingredients, g/kg DM	Treatments*	
	CON	CE
Alfalfa hay	120	80.0
Wheat straw	280	230
Conocarpus erectus	0.00	90.0
Wheat bran	240	240
Barley grain, ground	100	100
Corn grain, ground	200	200
Soybean meal	50.0	50.0
Calcium carbonate	2.00	2.00
Salt	3.00	3.00
Mineral–vitamin premix†	5.00	5.00
Chemical composition, g/kg DM		
DM	894	856
OM	942	948
Ash	58.2	51.6
CP	131	129
EE	26.4	30.0
NDF	407	401
ADF	234	222
Lignin	43.7	39.9
ME, Mcal/kg	2.35	2.37

*CON, without *Conocarpus erectus*; CE, *Conocarpus erectus*.
†Contained: Vitamin A = 1,000,000 IU/mg; vitamin D_3 = 100,000 IU/mg; vitamin E = 3,000 IU/mg; Ca = 150,000 mg/kg; P = 30,000 mg/kg; Zn = 5,000 mg/kg; Fe = 5,000 mg/kg; Mn = 4,000 mg/kg; Mg = 152 mg/kg; Cu = 600 mg/kg; Co = 20 mg/kg; Se = 30 mg/kg; I = 50 mg/kg.

Data and Sample Collection

Goats were weighed before morning feeding on days 1 and 31 of the experiment. During the experiment period, samples of offered TMR were collected twice a week. For estimating the voluntary feed intake, feed offered and orts were recorded daily before morning feeding. Digestibility coefficients of DM, CP, NDF, and ADF were estimated using the total fecal collection method (Givens et al., 2000). For this purpose, on day 25 of the experiment, goats were transferred to a metabolism crate equipped with feces and urine collectors. During the collection period, the amount of feed offered, orts, and feces of each goat was recorded within 24 h. Each day 10% of samples (feed, orts, and feces) were collected and frozen at –20 °C, and at the end of the collection period, daily samples were pooled of each goat and thoroughly mixed and then frozen at –20 °C for subsequent analysis.

The amount of milk produced by each goat was measured via a portable milking machine, and the milk yield was recorded. For analyses of milk fat, protein, and lactose, milk was sampled (50 mL milk) once per week at each milking time with a preservative (2-bromo-2-nitropropane-1,3-diol). On days 15 and 31, in order to investigate antioxidant activity, milk sample (50 mL unpreserved milk) was collected from all goats. Also, on day 31, milk were sampled (2 samples of 50 mL unpreserved milk) to analysis microbial load and the concentration of fatty acids in milk, that one of them was immediately transferred to the laboratory for analysis, and another part was stored at –20 °C until analysis.

To investigate blood biochemical parameters, on days 15 and 31, 4 h after morning feeding, blood sample (approximately 10 mL) was collected from jugular veins using tubes (Becton Dickinson, Rutherford, NJ, USA) containing an anticoagulant (heparin). The blood samples were centrifuged (3,000 × *g* for 15 min at 4 °C) and the plasma was separated and frozen at –20 °C until measuring biochemical parameters. To investigate ruminal pH and ammonia-N, the rumen fluid obtained 3 h after morning feeding on day 31 was strained through two layers of cheesecloth. Ruminal pH was determined immediately by a portable pH meter (Metrohm model, Swiss), and rumen fluid (25 mL) was immediately submitted for the evaluation of ammonia-N with 5 mL of HCl 0.2 N and stored at –20 °C.

Chemical Analysis

Before the chemical analysis, feed, orts, and feces samples were oven-dried at 55 °C for 48 h and then ground using a

mill equipped with a 1-mm sieve (Wiley mill, Swedesboro, USA). According to the AOAC International (1998), procedure samples were analyzed for CP (Number. 988.05), EE (Number. 920.39), ash (Number. 924.05), and ADF (Number. 973.18). Also, NDF was analyzed according to Van Soest et al. (1991).

Weekly milk samples of each goat were pooled and milk fat, protein, and lactose were analyzed by infrared spectrophotometry (Foss Electric, Hillerod, Denmark). The fatty acid profile of extracted lipids was assessed by gas chromatography as previously described by Cruz-Hernandez et al. (2007). Method of Çam et al. (2009) was used to evaluate antioxidant activity through 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging system. Percentage of DPPH scavenging activity was calculated as follows: DPPH scavenging activity (%) = [(A blank − A sample)/A blank] × 100, where A is the absorbance.

To investigate the microbial load of milk, 9 mL of physiological serum was poured into seven tubes and autoclaved in order to prepare the appropriate culture dilution. After cooling, serial dilutions up to 10^{-7} for all treatments were prepared. To determine the total count and *Lactobacillus* spp., 1 mL of each dilution was taken separately and cultured in a plate (1 mL with a sterile pipette poured into a sterile container of the culture medium of Kant agar and MRS agar plate, which is close to coagulation at a temperature of about 40 °C to 50 °C) and incubated at 31 °C for 3 d for a total count and 37 °C for 48 h for *Lactobacillus* spp. The number of colonies was counted, and the counted average was calculated in different dilutions and was considered the total count and *Lactobacillus* spp. of milk. The number of molds through the surface culture in PDA medium at 25 °C for 48 h, measurement and results reported to the number of colonies obtained from each milliliter of milk (colony count per mL).

Glucose, triglycerides, blood urea nitrogen (BUN), cholesterol, low-density lipoprotein (LDL), high-density lipoproteins (HDL), serum glutamic pyruvic transaminase (SGPT), and serum glutamic oxaloacetic transaminase (SGOT) were determined by using enzymatic methods and spectrophotometer (model S Bio-Rad Libra, England) and using kits of the ZiestChem Company (Tehran, Iran). The rumen ammonia-N concentration was measured by phenol-hypochlorite assay (Broderick and Kang, 1980).

Statistical Analysis

The results (feed intake, nutrient digestibility, milk production and composition, microbial load, and antioxidant activity) were analyzed as a completely randomized design using the General Linear Model (GLM) procedure of the SAS statistical software (SAS, 2008). The model of this design is a completely randomized design with two treatments (CON, without *C. erectus*; CE, contains *C. erectus*), and each treatment includes eight replications based on the statistical model: $Y_{ij} = \mu + T_i + e_{ij}$, where Y_{ij} is the observation, μ is the general mean, T_i is the effect of treatments, and e_{ij} is the standard error of term. Repeated data per time (blood metabolites) were analyzed as repeated measurements using the MIXED procedures of SAS statistical software (SAS, 2008) based on the statistical model: $Y_{ijk} = \mu + T_i + H_j + (T \times H)_{ij} + e_{ijk}$, where Y_{ijk} is the observation, μ is the mean of observations, T_i is the effect of treatments, H_j is the effect of sampling day, $(T \times H)_{ij}$ is interactions between the effect of treatments and sampling day, and e_{ij} is the standard error of term. The differences between treatments were analyzed using an independent *t*-test. Differences between treatment means were considered significant at $P < 0.05$.

RESULTS

Feed Intake and Nutrient Digestibility

The intake of DM (DMI) was affected by the experimental treatment and the lowest amount of DMI was observed in the treatment CE ($P = 0.02$). On the other hand, more digestibility of DM, CP, NDF, and ADF was observed in CON ($P < 0.05$; Table 2).

Milk Production and Composition, Microbial Load, and Antioxidant Activity

In the treatment CE, the amount of milk production increased ($P = 0.01$). But the composition of milk (fat, protein, and lactose) was not affected by the experimental treatment ($P > 0.05$). As a result of investigating the effect of experimental treatments on the microbial load of milk, the amount of total count did not differ between treatments ($P = 0.66$), but the highest amount of *Lactobacillus* spp. ($P = 0.01$) and the lowest amount of mold ($P = 0.01$) were observed in the treatment CE (Table 3). The antioxidant activity of milk was improved after using *Conocarpus* in the diet. As can be seen in Table 3, DPPH scavenging activity decreased on days 15 ($P = 0.02$) and 31 ($P = 0.01$) of the experiment in treatment CE.

Milk Fatty Acids Composition

The pattern of fatty acids in the milk of goats fed with experimental diet is shown in Table 4. The results showed that the use of the *Conocarpus* in the diet of goats increased the concentration of short-chain fatty acids (C4:0 to C6:0) and medium-chain (C8:0 to C10:0), long-chain fatty acids (C14:1 *c9*, C16:1 *c9*, ΣC18:1 *c*, C18:2 *c (n-6)* and C18:3 *c (n-3)*), and conjugated fatty acids (CLAs) ($P < 0.05$). Also, the concentration of fatty acids C16:0 and C18:0 was lower in the treatment CE ($P < 0.05$), and the concentration of fatty acid C15:0 was not affected by the experimental treatment ($P > 0.05$).

Blood Metabolites and Ruminal Fermentation Parameters

Blood glucose concentration of goats was not affected by experimental treatment ($P = 0.28$). The results of the present study showed that the use of *Conocarpus* in the diet of dairy goats decreased BUN concentration ($P = 0.01$). The amount of triglyceride ($P = 0.04$), cholesterol ($P = 0.03$), HDL ($P = 0.01$), and LDL ($P = 0.01$) decreased in the treatment CE. Also, the results showed that the concentration of SGPT and SGOT was lower in the treatment CE ($P = 0.01$; Table 5). Ruminal pH ($P = 0.11$) and ammonia-N ($P = 0.08$) concentration were not affected by experimental treatments (Table 5).

DISCUSSION

Feed Intake and Nutrient Digestibility

Active compounds and tannins can have beneficial or harmful effects on ruminants (Mueller-Harvey, 2006). In this study, the DMI of goats was lower in the treatment CE. Similarly, Mohammadabadi (2020) reported that adding *C. erectus* pruning residues to the diet of sheep caused a

Table 2. Feed intake and apparent digestibility of goats fed with experimental diet

Item	Treatments*		SEM	*P*-value
	CON	CE		
Intake, g/d				
DM	1,431[a]	1,245[b]	40.1	0.02
Apparent digestibility, %				
DM	73.4[a]	65.7[b]	1.51	0.01
CP	52.3[a]	48.4[b]	0.20	0.03
NDF	66.8[a]	54.7[b]	5.90	0.01
ADF	63.2[a]	42.8[b]	0.20	0.02

SEM, standard error of means.
*CON, without *Conocarpus erectus*; CE, *Conocarpus erectus*.
[a,b]Means in the same row with different superscript letters are different ($P < 0.05$).

Table 3. Milk production and composition, microbial load, and antioxidant activity of goats

Item	Treatments*		SEM	*P*-value
	CON	CE		
Milk production and composition				
Milk, kg/d	0.344[b]	0.548[a]	0.04	0.01
Milk protein, %	3.28	3.26	0.30	0.40
Milk fat, %	3.34	3.27	0.21	0.30
Milk lactose, %	4.21	4.30	0.27	0.10
Microbial load, log CFU per mL				
Total count	8.82	8.40	0.58	0.66
Lactobacillus spp.	6.75[b]	8.75[a]	0.08	0.01
Mold	6.99[a]	5.33[b]	0.03	0.01
Milk antioxidant activity				
DPPH scavenging activity, %				
DPPH d15	26.6[a]	18.2[b]	1.02	0.02
DPPH d31	67.0[a]	56.8[b]	0.60	0.01

SEM, standard error of means.
*CON, without *Conocarpus erectus*; CE, *Conocarpus erectus*.
[a,b]Means in the same row with different superscript letters are different ($P < 0.05$).

significant decrease in DMI. Also, it seems that consumption of plant species that have more than 50 g/kg DM condensed tannins cause a reduction in the amount of feed intake, and consumption of plant species that have less than 50 g/kg DM condensed tannins do not affect the amount of feed intake (Addisu, 2016). In our experiment, the TT concentration was less than 50 g/kg DM. It has been reported that salivary enzymes and mucoproteins may be precipitated by tannins and lead to a decrease in feed intake at high levels (Carulla et al., 2005). Moreover, the reduction in palatability can be one of the reasons for reducing the amount of feed intake in the treatment CE, which can be the result of its bitter and astringent taste. The decrease in digestibility of the *Conocarpus* diet can be attributed to the presence of tannins and phenolic compounds. Condensed tannins form complexes with carbohydrates and nutrients and prevent digestion by inhibiting enzymes (Bashir, 2015). McSweeney et al. (2001) also reported that tannins could reduce digestion by binding with proteins and carbohydrates through hydrophobic and hydrogen bonds and affecting ruminal microorganisms. In agreement with our results, Mohammadabadi (2020) also reported that using *C. erectus* in sheep's diet (15% of corn silage) decreased the digestibility of nutrients compared to the control. Eidipour (2020) also reported that replacing 12.5% of corn silage with *C. erectus* decreased nutrient digestibility compared to the control. However,

Table 4. Milk fatty acid profile of goats fed with experimental diets (g/100 g of total fatty acids)

Item	Treatments*		SEM	*P*-value
	CON	CE		
C4:0	1.47[b]	4.16[a]	0.08	0.01
C6:0	2.03[b]	3.45[a]	0.31	0.02
C8:0	2.01[b]	5.36[a]	0.13	0.01
C10:0	9.50[b]	20.5[a]	0.25	0.01
C14:1 *c9*	0.42[b]	0.52[a]	0.007	0.01
C15:0	0.56	0.54	0.03	0.35
C16:0	23.4[a]	19.0[b]	0.38	0.01
C16:1 *c9*	0.86[b]	1.12[a]	0.36	0.03
C18:0	5.30[a]	2.70[b]	0.36	0.03
ΣC18:1 *c*	7.01[b]	17.1[a]	0.14	0.01
C18:2 *c (n-6)*	1.04[b]	3.44[a]	0.04	0.01
C18:3 *c (n-3)*	0.13[b]	0.64[a]	0.01	0.01
CLA:9	0.04[b]	0.06[a]	0.007	0.10
CLA:12	0.07[b]	0.08[a]	0.002	0.20

SEM, standard error of means.
*CON, without *Conocarpus erectus*; CE, *Conocarpus erectus*.
[a,b]Means in the same row with different superscript letters are different ($P < 0.05$).

Table 5. Blood chemistry parameters and ruminal fermentation parameters of goats fed with experimental diets

Item	Treatments*		SEM	*P*-value
	CON	CE		
Blood metabolites†				
Glucose, md/dL	48.5	46.2	1.05	0.28
BUN, md/dL	20.2[a]	15.7[b]	0.33	0.01
Triglycerides, md/dL	38.5[a]	32.2[b]	0.75	0.04
Cholesterol, md/dL	61.1[a]	49.9[b]	0.65	0.03
LDL, md/dL	23.2[a]	17.9[b]	0.46	0.01
HDL, md/dL	34.3[a]	27.8[b]	1.12	0.01
SGPT, U/L	24.5[a]	19.2[b]	0.20	0.01
SGOT, U/L	93.5[a]	68.7[b]	0.40	0.01
Ruminal parameters				
Ammonia-N, mg/dL	7.79	6.62	0.58	0.08
pH	6.31	5.95	0.08	0.11

SEM, standard error of means.
*CON, without *Conocarpus erectus*; CE, *Conocarpus erectus*.
†Data obtained from blood metabolites were analyzed as repeated measurements and, in this table, only the main effects (treatments) were used.
[a,b]Means in the same row with different superscript letters are different ($P < 0.05$).

in experiments, the use of phenolic compounds in the diet leads to an increase in the digestibility of DM in dairy cows (Jami et al., 2012). Although high consumption of plant active compounds can hurt feed intake and digestibility of nutrients in ruminants, the extent of this effect can differ with the source type.

Milk Production and Composition, Microbial Load, and Antioxidant Activity

Although there have been no studies on the use of *Conocarpus* on milk production and composition, Abarghuei et al. (2013) reported using phenolic compounds (pomegranate peel extract; 400, 800, and 1,200 mL/d) in dairy cows increased milk production. The increase in milk production in the treatment CE can be because the active compounds can prevent energy loss by changing the rumen fermentation pattern toward propionate production and reducing methane production. As a result, more energy is available to the milk-secreting cells, and milk production increases (Aschenbach et al., 2010). Using *Conocarpus* leaves and branches in the current study did not affect milk protein. Positive effects of moderate phenolic compounds on milk production have been reported (Waghorn et al., 2008; Vasta et al., 2009). These researchers said that the positive effects of increasing milk and protein production in feeds containing low or moderate tannin are due to low protein degradation in the rumen and increased protein flow and absorption of amino acids in the small intestine. It has also been reported that phenolic compounds reduce the incidence of subclinical helminth infections in ruminants, thereby increasing milk production and protein utilization (O'Connell and Fox, 2001). On the other hand, the amount of milk fat in the treatment CE was numerically lower, which is probably due to the less fiber in the diet in this treatment. Since lactose is a regulator of the osmotic pressure of milk, its concentration is almost constant and is less affected by diet (Palmquist and Jenkins, 1980).

The microbial load of milk in treatment CE was numerically reduced compared to the control. In general, flavonoids and flavonols have antimicrobial effects, probably caused by the combination of extracellular proteins, the formation of a complex with the cell wall, or by disrupting the cell membrane of microorganisms. Phenolic compounds can show antimicrobial effects by directly inhibiting microorganisms and binding to their extracellular enzymes (Hervás et al., 2003). Medicinal plants and their extracts have antimicrobial properties (Lee et al., 2004). However, Cross et al. (2007) reported that medicinal plants had no significant effect on the population of coliforms, lactic acid-producing bacteria, total anaerobic bacteria, and *Clostridium perfringens*. The better antioxidant activity of the treatment containing *Conocarpus* can be due to the high antioxidant activity of the extract of *Conocarpus* due to the presence of phenolic compounds, tannins, and flavonoids. Free plant polyphenols are easily absorbed and have a better effect on antioxidant activity (Fartashvand and Hajisadeghi, 2016). The antioxidant effects of compounds in medicinal plants lead to the neutralization of free radicals as well as carboxylic acid compounds (which bind to metals) and prevent oxidation (Shabani and Alimoradi, 2020), for instance in replacing *Moringa oleifera* leaves with alfalfa, the antioxidant activity of rabbit meat increased (Sun et al., 2018).

Milk Fatty Acids Composition

There needs to be more information about the effect of active compounds in changing the rumen biohydrogenation pattern and manipulating the fatty acid profile of ruminant products (milk and meat) (Benchaar et al., 2009). Tannins from Acacia or *Quebracho* leaves in ruminal cultures lead to the reduction of stearic acid (Vasta and Luciano, 2011). According to studies, the content of C18:1 was higher in the milk of goats fed with Ziziphus leaves (Sampelayo et al., 2007). In studies conducted on dairy cattle grazing on legumes, tannins are responsible for reducing the biohydrogenation of dietary polyunsaturated fatty acid to C18:0. Benchaar and Chouinard (2009) stated that the diet supplemented with 6.7 g/kg DM of *Quebracho* condensed tannin extract did not affect milk fatty acid composition in dairy cows. The increase in the concentration of fatty acids, especially polyunsaturated fatty acid, is probably due to the effect of active compounds and tannins of *Conocarpus*, which protect fats from biohydrogenation, or it is due to inhibiting the growth of bacteria responsible for biohydrogenation (Mapiye et al., 2011). However, some studies have reported the need for more effect of tannin and active compounds on rumen biohydrogenation and milk fatty acid profile (Benchaar and Chouinard, 2009; Cabiddu et al., 2009).

Blood Metabolites and Ruminal Fermentation Parameters

The saponins in *Conocarpus* may lead to blood glucose reduction due to inhibiting the suppression of glucose transport from the small intestine. Also, flavonoids are specific inhibitors of Glucose 6-phosphatase and inhibit glucose production in the liver and reduce blood glucose (Li et al., 2000). Similarly, Hosseini and Chaji (2021) also stated that using *Conocarpus* silage had no significant effect on serum glucose concentration. However, Mohammadabadi (2020) reported that feeding *Conocarpus* to sheep caused a substantial decrease in blood glucose. The decline in BUN concentration in the treatment containing *Conocarpus* can be because of tannins, by reducing the degradation of protein in the rumen, leading to a decrease in ammonia-N production and, as a result, a reduction in its absorption into the blood. Because the increase of ammonia-N in the rumen increases its transfer from the rumen to the liver, and in the liver, this nitrogen enters the bloodstream after being converted into urea. Agreeing with our results, Mohammadabadi (2020) reported that feeding *Conocarpus* to sheep caused a significant decrease in the concentration of BUN. Regarding the effects of tannin on the number of lipoproteins, Kim et al. (2007) reported that using these sources causes a significant change in the number of lipoproteins and reduces LDL by reducing triglycerides. It has been reported that the concentration of plasma cholesterol decreases under the influence of saponin (one of the secondary compounds found in *Conocarpus*). Saponin plays a role in reducing cholesterol absorption through direct binding with cholesterol as well as binding with bile acids (Brogna et al., 2011).

Although there was no significant difference in pH between the treatments, it was numerically lower in the treatment containing *Conocarpus*. Some studies have mentioned that active compounds reduce ruminal pH (Yanez Ruiz et al., 2004; Bhatta et al., 2007). However, the pH was in the ideal range for the activity of microorganisms. Similarly, using *Conocarpus* in sheep ration did not affect rumen pH and ammonia-N (Mohammadabadi, 2020). Also, the numerical

decrease of ammonia can be due to the negative effect of tannin and saponin on the rumen protozoa population (Yanez Ruiz et al., 2004; Calsamiglia et al., 2007) because protozoa have proteolytic and de-amination activity that leads to the production of ammonia-N in the rumen (Williams and Coleman, 1992).

CONCLUSION

The results of this experiment showed that the use of *C. erectus* leaves and branches in the diet of dairy goats, although did not have a positive effect on feed intake and digestibility, but significantly lead to improve milk fatty acids profile, especially conjugated fatty acids, antioxidant activity, and also the microbial load.

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Conflict of interest statement

None declared.

Author contributions

T.M. supervised the research work, conducted the statistical analysis, drafted the manuscript, and revised the manuscript. H.N.N. and S.H. carried out the experimental work. E.D. drafted the manuscript, revised the manuscript, and prepared the manuscript to the journal submission.

LITERATURE CITED

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