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The effect of feeding low quality date palm (*Phoenix dactylifera* L.) on the performance, antioxidant status and ruminal fermentation of mid-lactating Saanen dairy goats

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ABSTRACT

This study was conducted to evaluate the effect of feeding low quality date palm (*Phoenix dactylifera* L.) (LDP) on the performance, antioxidant status, and ruminal fermentation in Saanen dairy goats. Eight multiparous Saanen dairy goats averaging 92 ± 9 DIM and 2050 ± 280 g of milk production were used in a replicated 4 × 4 Latin square design. Each experimental period lasted 21 days: 14 for adaptation, and 7 for measurements. Experimental treatments were as follows: (1) diet without LDP (control), (2) diet containing 6% of LDP (LDP6), (3) diet containing 12% of LDP (LDP12), and (4) diet containing 18% of LDP (LDP18) (DM basis). The dry matter intake (DMI) and apparent digestibility were not affected by the treatments. In addition, there was no difference in milk yield, and milk composition. Inclusion of LDP in the diet increased total antioxidant capacity (TAC) as LDP18 had the highest and control had the lowest concentration of TAC in milk and blood, respectively. No significant difference was seen in malondialdehyde (MDA) content in milk and blood. Superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) activity had no significant effect across treatment in blood. There was significant difference in ruminal pH among treatments, yet goats fed LDP12 and LDP18 had the highest ruminal propionate concentration and the lowest acetate concentration. With increasing of LDP to diet, the acetate: propionate ratio decreased while concentration of valerate increased. The results of this study indicate that LDP can be substituted with partial replacement of diet in dairy goats ration without negative effects on animal performance. In addition, inclusion of LDP in ration improved the antioxidant capacity of dairy goats.

1. Introduction

The date palm *(Phoenix dactylifera* L.) has always played an important role in the economy and social life of the people of arid and semiarid regions of the world. The global production of date fruits was about 7 million tons in 2010 (FAO, 2010) with Egypt, Iran, and Kingdom of Saudi Arabia, being the main producing countries, with a production of 1.13 million ton, 1 million ton and 983.000 ton, respectively.

In Iran, about 20–30% of date palm production (approximately 200–300 thousands tones) is considered as a waste product (no edible for human) either discarded or used in animal feed, because of inadequate texture (too soft or too hard), or simply due to their low quality (MAJ, 2011). This by-product is rich in nutrients and bioactive compounds (such as carotenoids, polyphenols especially phenolic acids isoflavons, lignans, and flavonoids, tannins, and sterols), which can be extracted and used as value added materials (Cheikh-Rouhou et al., 2006a,b). It can also be used to feed animals with high-energy supplements (Al Yousef et al., 1994).

Typically dates contain carbohydrate (total sugars, 44–88%), fat (0.2–0.5%), protein (2.3–5.6%), dietary fiber (6.4–11.5%), minerals (the percentage of each mineral in dried dates varies from 0.1 to 916 mg/100 g date) and vitamins (such as vitamin C, B1, B2, A, riboflavin and niacin) (Sawaya et al., 1982; Al-Hooti et al., 1997; Al-Shahib and Marshall, 2003). In recent years, the price of energy supplements has been increased dramatically with the increase of demand of feeds for animals. The increase in feed prices encouraged nutritionists to search for cheaper high-energy feed ingredients. LDP could be used as an energy source to replace a part of the concentrates in the ration. Energy level and source in the diet affect the animal performance and feed utilization (Nunes, 1994). Rumen microorganisms are also affected by the dietary energy source and level (Sandine, 1979; Saucier et al., 1992). Al-Dobaib et al. (2009) reported that replacing 30% cereal grain with LDP had no effect

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Table 1
Feed ingredients and chemical composition of experimental diets.

Item	Treatment[1]			
	Control	LDP6	LDP12	LDP18
Ingredients, %				
Alfalfa hay	50.0	50.0	50.0	50.0
Barley grain	20.0	14.0	8.0	2.0
Whole cotton seed with lint	5.0	5.0	5.0	5.0
Soybean meal	4.5	5.5	6.5	8.5
Wheat bran	19.5	18.5	17.0	15.5
Date palm discard	0.0	6.0	12.0	18.0
Calcium carbonate	0.4	0.4	0.4	0.4
Vitamin-mineral Mix[2]	0.5	0.5	0.5	0.5
Salt	0.1	0.1	0.1	0.1
Chemical composition, % of DM				
ME (Mcal/kg of DM)	2.3	2.3	2.4	2.4
CP	14.8	14.7	14.7	14.8
NDF	40.3	40.2	40.1	39.8
NFC[3]	35.0	35.6	36.2	36.9
Ether extract	3.9	3.9	3.9	3.8
Ca	0.9	0.9	0.9	0.9
P	0.6	0.6	0.6	0.6
TPC[4]	0.83	0.96	1.08	1.26

[1] Control, LDP6, LDP12 and LDP18 diets contained 0%, 6%, 12% and 18% of LDP(DM basis), respectively.
[2] Contained (/kg of premix; DM basis): 330,000 IU of vitamin A, 60,000 IU of vitamin D, 1000 IU of vitamin E, 160 g Ca, 85 g P, 63 g Na, 45 g Mg, 2,100 mg Zn, 1,500 mg Mn, 535 mg Cu, 12 mg Se, 45 mg I.
[3] NFC calculated as 100 − (CP + Ash + NDF + EE).
[4] TPC Total Phenolic Compounds.

on milk yield and composition of Aradi goats. El-Hag et al. (1993) reported that the addition of discarded dates at the levels of 15 or 25% of the whole DM of ration had no effect on performance of sheep.

The good nutritional value of dates palm is based on their dietary antioxidants. Antioxidant date palm content in showed very well (Mansouri et al., 2005; Biglari et al., 2008). Phenolic compounds of fruit mainly phenolic acids and flavonoids have been shown to possess such benefits as antioxidant (Peterson and Dwyer, 1998). However, evaluation of LDP as a feed for lactating dairy animal has been little studied, and its potential to transfer antioxidants into milk is unknown. Therefore, the present study has been carried out to evaluate the effect of replacing a part of dietary concentrate by LDP on the performance, ruminal fermentation, and antioxidant status in Saanen dairy goats.

2. Materials and methods

2.1. Animals, diets and experimental design

Eight multiparous Saanen lactating goats averaging 42 ± 3 kg of body weight (BW) and 92 ± 9 days in milk (DIM) and 2050 ± 280 g of milk yield were randomly assigned to a 4 × 4 Latin square design. Each experimental period lasted 21 days.

The animals were kept in individual metabolic cages in a barn, protected from rain and wind and equipped with individual troughs to facilitate quantitative measurement of the feed intake.

The goats were taken care of in accordance with guidelines of the Iranian Council on Animal Care (1995). Experimental treatments were as follows: (1) diet without LDP (control), (2) diet containing 6% of LDP (LDP6), (3) diet containing 12% of LDP (LDP12), and (4) diet containing 18% of LDP (LDP18) (DM basis) (Table 1).

Experimental diets were formulated to meet the requirements according to National Research Council (NRC, 2001). Diets were fed as a Total Mixed Ration (TMR) with 50:50 forage to concentrate ratio and were formulated to have similar Crude Protein (CP), Neutral Detergent Fiber (NDF) and Non Fibrous Carbohydrate (NFC) (Table 1). The diets were offered twice daily ad libitum (07:00 and 15:00 h) and the goats had free access to fresh water.

2.2. Sample collections and calculations

NDF and Acid Detergent Fiber (ADF) were determined during a 7-days measurement period. The animals were weighed at the beginning and at the end of each measurement period. For every diet, feed and apparent digestibility of DM, NDF, CP and Organic Matter (OM) were determined. Feed intakes and feed refusals were collected before the morning feeding and weighed daily during the measurement period. DMI was calculated by the difference between total amount of dry matter offered and refused.

Fecal samples of each goat were collected through the 5-day collection periods and then dried in an oven. Daily dried samples were ground and later composited for each 5-day periods. Feeds and orts were sampled daily during the collection period and were composited further. Composite samples of the TMR, feed refusal and feces were dried in an oven, then ground to pass through a 2-mm screen and stored for later analysis. Rumen fluid samples were taken from animals by stomach tube with a vacuum pump 2 h after the morning feeding on days 18 and 19. The pH values of the fluid samples were determined and recorded using a pH meter (METROHM 691). Approximately, 100 ml of ruminal content was strained through four layers of cheesecloth. A subsample of 5 ml was combined with 5 ml of HCl 0.2 N for NH_3-N analysis. Another sample was put into a plastic bottle containing 1 ml of 0.25 g/ml metaphosphoric acid and 1 ml of 0.006 g/ml 2-ethylbutyric acid (internal standard), which was for volatile fatty acid (VFA) analysis.

Ruminal subsamples were frozen at −20 °C until the conductance laboratory analyses. On day 21 of each period, 10 ml blood samples were collected from the jugular vein of each goat, just 2 h after the morning feeding. Blood samples were then centrifuged at 3000 × *g* for 10 min, followed by separation serum finally frozen at −20 °C. One whole blood sample was collected in a tube containing potassium ethylene diamine tetra-acetic acid (K-EDTA) for antioxidant activity content and stored at −20 °C for later analysis. Within 1 h of the bleeding, hemoglobin (Hb) content was determined by a commercial colorimetric kit (Sigma Diagnostic, Milan, Italy), blood samples were centrifuged at1400 g for 20 min at 48 °C and plasma was thus harvested. Goats were milked two times daily at 07:00 and 19:00 h. Milk production was recorded daily for each animal. A daily composite milk sample from the morning, and afternoon milking was taken during the collection period. Fresh subsamples were analyzed daily for chemical composition. One sample out of each sampling day without preservative was kept frozen at −20 °C to determine antioxidant concentrations (TAC and MDA).

2.3. Laboratory analysis

Ash (AOAC 2005, method 942.05) and CP (Kjeldahl N × 6.25) were determined by the block digestion method using copper catalyst and steam distillation into boric acid (method 2001.11) on 2100 Kjeltec distillation unit according to Association of Official Analytical Chemists (AOAC) (2005). NDF and ADF were determined by Van Soest et al. (1991). The sodium sulphite and α-amylase were not used and both NDF and ADF were expressed exclusive of residual ash. Total Phenolic Compound (TPC) was determined by Folin–Ciocalteu reagent using tannic acid as a standard (Makkar, 2000). Acid-insoluble ash (AIA) content was used as an internal marker to determine the apparent digestibility of DM, OM, CP and NDF as reported by Van Keulen and Young (1977). Ruminal fluid samples were thawed, centrifuged at 1200 × *g* for 10 min, where the supernatant fluid was analyzed for VFA by gas chromatography (Hewlett-Packard,model 5890, Avondale, PA). The NH3-N concentration of rumen fluid samples was analyzed by the pro-

Table 2
Effect of treatment on dry matter intake, milk yield and composition.

Item	Treatment[c] Control	LDP6	LDP12	LDP18	SEM	*P* Value
Intake of DM (g/d)	1655	1731	1662	1745	95	0.28
Milk production (kg/d)[d]	1.66	1.62	1.59	1.61	0.10	0.48
4% FCM	1.54	1.44	1.41	1.41	0.12	0.29
Milk Composition (%)						
Fat	3.39	3.24	3.18	3.12	0.19	0.28
Protein	2.96	2.98	2.95	3.00	0.03	0.57
Lactose	4.40	4.43	4.35	4.46	0.05	0.25
Solid not fat	8.07	8.16	8.06	8.23	0.08	0.34
Total solids	11.46	11.41	11.24	11.36	0.23	0.76
Milk yield (g/d)						
Fat	56.68	53.32	51.89	51.18	5.75	0.32
Protein	49.50	48.55	47.21	48.51	3.37	0.45
Lactose	73.83	72.10	70.91	72.20	5.18	0.32
Antioxidant activity of milk[e]						
TAC (mmol/lit)	1.18[b]	1.50[a]	1.66[a]	1.69[a]	0.10	0.01
MDA (nmol/ml)	2.83	2.92	2.88	2.83	0.09	0.90

[c] Control, LDP6, LDP12 and LDP18 diets contained 0%, 6%, 12% and 18% of LDP(DM basis), respectively.
[d] 4% FCM was calculated as {(0.4 kg of milk) + (15 kg of milk fat)}.
[e] TAC = total antioxidant capacity, MDA = malondialdehyde.

cedure developed by Weatherburn (1967). Serum urea N, glucose and protein were determined using an autoanalyzer (Biosystems A 15; 08030 Barcelona, Spain). Whole blood glutathione peroxidase was measured using a Randox kit (Randox Laboratories, London, UK) according to instruction of the kit.

Superoxide dismutase activity was measured using a Randox kit (Randox Laboratories,London, UK), The GP_X, catalase and SOD activity were expressed as U/g of hemoglobin. TAC in serum and milk was determined by Ferric reducing antioxidant power (FRAP) method.

The level of malondialdehyde in serum and milk was determined using thiobarbituric acid method according to Placer et al. (1966). the results were obtained in terms of nmol/ml and determined using the colorimetric method.

Milk samples were analyzed for protein, fat and lactose contents with a Milko-Scan 605 analyzer (Foss Electric, Hillerød, Denmark). Fat corrected milk (4% FCM) was defined as milk with 4% fat (National Research Council, 2001).

2.4. Statistical analysis

Mixed procedure of SAS (9.1) was used to analyze data for a Latin square design.

The data collected over the time were analyzed using repeated measures technique. Least squares means procedure (LSMEANS) was used to detect the difference between dietary treatments.

The data were analyzed using the following statistical model:

$$Y_{ijk} = \mu + T_i + P_j + C_K + \epsilon_{ijk}$$

where Y_{ijk} = dependent variable; μ = the overall mean; T_i = effect of treatment (i = 1, 2, 3 or 4); P_j = effect of period (j = 1–4); C_K = random effect of goat; and ϵ_{ijK} = random residual error.

3. Results

3.1. Animal performance

The addition of LDP to the diet of the dairy goats did not affect ($P > 0.05$) on DMI (Table 2) since DMI was similar for all treatments. The difference among the four groups for milk yields, 4% FCM and milk composition (Protein, lactose, total solids, milk fat, and solids not fat) were not significant ($P > 0.05$). The mean digestibility of DM, OM, NDF and CP is listed in Table 3. Digestibility of nutrients was similar across treatments not affected by the treatments ($P > 0.05$).

Table 3
Effect of treatment on apparent total tract digestibility of diets.

Item	Treatment[a] Control	LDP6	LDP12	LDP18	SEM	*P* Value
Diet digestibility, %						
DM	67.17	67.64	66.46	64.62	1.30	0.81
OM	64.90	66.99	65.61	67.67	1.26	0.68
NDF	51.92	50.34	50.56	51.72	0.93	0.88
CP	65.99	65.14	66.48	68.11	1.31	0.93

[a] Control, LDP6, LDP12 and LDP18 diets contained 0%, 6%, 12% and 18% of LDP(DM basis), respectively.

3.2. Antioxidant activity and blood metabolites

The effects of diets on TAC and MDA in milk are presented in Table 2. The Effect of feeding LDP on TAC was significant ($P < 0.05$) as the control had the lowest TAC compared with other treatments. In addition, increasing LDP level of TAC content was increased although the difference between LDP6, LDP12, and LDP18 was not significant ($P > 0.05$).

The feeding of LDP had no effect on the content of MDA in milk. The effect of treatments on antioxidant activity and blood metabolites are demonstrated in Table 4. Treatments showed no differences with regard to blood metabolites (serum urea N, glucose, and triglyceride) ($P > 0.05$). The concentrations of TAC of blood among treatments were significant ($P = 0.01$). The goats fed with LDP18 diet had the highest content of TAC when compared to other treatments. Also, the feeding of LDP12 and LDP6 had a higher content of TAC compare to control with a significant growth ($P = 0.01$). However, other antioxidant parameters (SOD, GSH-Px and MDA) were not affected by the treatments ($P > 0.05$).

3.3. Rumen fermentation parameters

The mean of ruminal fermentation parameters are presented in Table 5. Goats fed the LDP18 and LDP12 diets had lower ruminal pH compared with those fed the control diet ($P = 0.02$). Likewise, the difference between LDP6 and LDP18 was significant ($P = 0.02$); however, the concentration of ammonia-N did not differ between treatments.

Table 4
Effect of treatment on antioxidant activity and blood metabolites.

Item	Treatment[d] Control	LDP6	LDP12	LDP18	SEM	*P* Value
Blood metabolites (mg/dl)						
Serum urea N	17.36	17.70	17.50	17.40	0.32	0.85
golucose	64.64	63.43	63.87	63.13	1.19	0.29
triglycride	75.09	74.62	75.51	74.44	1.74	0.45
Antioxidant activity of blood[e]						
TAC (mmol/lit)	0.68[c]	0.74[b]	0.79[b]	0.85[a]	0.01	0.01
MDA (nmol/ml)	2.31	2.22	2.28	2.25	0.10	0.94
SOD (U per g Hb)	1726	1655	1628	1644	44	0.26
GSH-Px (U per g Hb)	44.13	44.46	46.59	44.57	3.04	0.93

[d] Control, LDP6, LDP12 and LDP18 diets contained 0%, 6%, 12% and 18% of LDP(DM basis), respectively.
[e] TAC = total antioxidant capacity, MDA = malondialdehyde, SOD = superoxide dismutase, GSH-Px = glutathione peroxidase.

Table 5
Effect of treatment on ruminal fermentation parameters.

Item	Treatment[d] Control	LDP6	LDP12	LDP18	SEM	*P* Value
Ruminal parameters						
Ruminal fluid pH	6.48[a]	6.35[ab]	6.24b[bc]	6.11[c]	0.05	0.02
Runinal NH_3-N, mg/dl	13.52	13.34	13.43	13.35	0.42	0.98
Total VFA (mM)	59.40	60.65	61.60	61.62	1.72	0.74
Individual VFA (proportion of total VFA)						
Acetate (%)	68.37[a]	66.02[ab]	63.43[bc]	62.88[c]	0.97	0.01
Propionate (%)	19.28[c]	20.28[bc]	23.00[ab]	23.70[a]	0.89	0.03
Butyrate (%)	10.23	11.25	10.80	10.86	0.87	0.87
Valerate (%)	0.83[b]	0.98[ab]	1.10[a]	1.13[a]	0.07	0.04
Isovalerate (%)	1.26	1.44	1.49	1.55	0.09	0.26
Acetate/propionate	3.54[a]	3.27[a]	2.78[b]	2.66[b]	0.14	001

[d] Control, LDP6, LDP12 and LDP18 diets contained 0%, 6%, 12% and 18% of LDP(DM basis), respectively.

Although total VFA concentration was not affected by the treatments ($P > 0.05$), increasing dietary LDP content raised ruminal molar proportions of propionate ($P = 0.03$) and valerate acid ($P = 0.04$), whereas it decreased the ruminal molar proportions of acetic acid and acetate/propionate ratio ($P = 0.01$).

4. Discussion

The milk yield was not affected by the treatments (Table 2) possibly due to similar DMI (Table 2). Addition of dates to the ration of ruminants can improve the productivity of lambs and positively affect Animal performance (Al-Dabeeb, 2005). The results of our study are similar to the findings of El-Hag et al. (1993) who reported that the addition of discarded dates at the levels of 15 or 25% of the whole DM of ration had no effect on feed intakes. It was contrary to the findings of Al-Dabeeb, (2005) who reported feeding low quality date palm at the levels of 10 or 20% in fattening Najdi sheep ration affected on DMI Lambs in the control group consuming more feed (1167 g/day) than the other two groups fed date-supplemented diets (1028 g/day for D10 and 877 g/day for D20). Al-Dobaib et al. (2009) reported that the addition of discarded dates at the level of 30% of ration had no effect on milk production and composition in Aradi goats, similar to our study. Apparent nutrients digestion was not affected by dietary treatments (Table 3). In agreement with our study, Hmeidan et al. (1993) observed that the addition of 33% discarded dates did not negatively affect the feed intake, digestibility and nitrogen retention of Najdi lambs. Al-Dabeeb, (2005) reported that addition of 10 or 20% ration with low quality date palm in fattening Najdi sheep ceases the reduction in digestibility of all nutrients (except EE) as dates in the diets increases. The discrepancies between the results of the two studies may have been due to the fact that the animal use in the present study was dairy goat, while the animal employed in their experiment was fattening Najdi sheep. From the producers' point of view, our results for DMI and milk yield were under a hot climate, which may be an encouraging factor for the producers in the arid and semi-arid countries to overcome the problem of high price animal food in this area using diets including LDP.

Addition of LDP to diet increased the concentration of TAC in milk (Table 2) and blood (Table 4), and as LDP concentration was elevated, so did the TAC in both milk and blood. Antioxidant activity and phenolic content of date fruit have been reported by many researchers (Al-Farsi et al., 2005; Mans05; Allaith, 2008; Biglari et al., 2008; Amorós et al., 2009). Phenolic compounds in plants have protective properties against oxidation, disease and predation. These compounds, including the large flavonoid family, are the focus of numerous studies to elucidate their role in human health (Singh et al., 2007).

Salinas-Rios et al. (2015) reported that inclusion of coffee pulp (a source of antioxidant) in the sheep diet had no effect on FRAP levels in the plasma but MDA decreased with inclusion of 12% coffee pulp in the diet compared to 6% and 0% levels. The discrepancies between the results of the two studies may have been due to the fact that in the experiment of Salinas-Rios et al. (2015) coffee pulp was substituted with alfalfa hay which is a forage with high antioxidant content (Cao et al., 1996), while in present study LDP was substituted with wheat bran (Table 1). Similar to this study, Emami et al. (2014) reported that addition of Pomegranate seed pulp (a byproduct contain high polyphenol) to kids ration at a level of 15% increased the concentration of TAC in plasma compared to the control diet. Recently, Aguiar et al. (2014) found that feeding phenolic compounds from propolis extracts to dairy cows improved the antioxidant capacity of milk compared with that in the control. Generally, a higher intake of natural antioxidants results in transfer of these molecules to animal tissues with a resultant increase of total antioxidant capacity (Descalzo and Sancho, 2008). Also, the

higher TAC in plasma of goats fed with DPS levels in the diet was probably a result of increased absorption of antioxidants from the gastrointestinal tract and transfer of these compounds into milk. As goats fed with LDP had the highest antioxidant activity in milk, they may be producing milk with the highest oxidative stability. The effects of treatments on the concentration of MDA were not significant in the milk and blood ($P > 0.05$). As an end product of lipid peroxidation, formation of malondialdehyde is accelerated by oxidative stress (Horie et al., 1997) and thus detection of MDA can reflect the level of oxygen free radicals and the extent of lipid peroxidation. Congruent with our study, Zhou et al. (2012) found that supplementation of tea saponins (Ilex kudingcha C.J. Tseng) to goat ration had no effect on MDA, SOD and GSH-Px in plasma. Habib and Ibrahim, (2011) reported that feeding 7 or 14% of date seed to rats ration increased MDA content in both serum and liver. Di Trana et al. (2006) investigated the effect of hot season and nutrition on the oxidative status in dairy goats. The concentration of SOD, GSH-Px and α-tocopherol was not affected by nutrition, but these factors were influenced by season. They concluded that in summer lactating goats may have experienced moderate oxidative stress. It seems that, seasonal rather than nutritional factors have a more pronounced effect on oxidative status markers in dairy goats. As our study was conducted from April to August, (half of the experiment was in spring, a half in summer), the goats were in barn and protected against hot stress, and the temperatures were favorable, so with regard to these factors, the goats were probably not under oxidative stress. Eventually, note that SOD, GSH-Px and MDA were not significant. Treatments had no any effect on blood metabolites (serum urea N, glucose, and triglyceride), as chemical compounds of all diet were relativity similar, so expect the difference among treatments were not significant. Date fruit consists of 70–88% carbohydrates, most of which is in the form of sugars, mainly glucose, sucrose and fructose. Because of this, the fruits are a great source of energy and it is approximated that 100 g of the flesh can provide 314 kcal of gross energy (Al-Farsi and Lee, 2008).

Due to the rapid fermentation of sugars compared to the other carbohydrate fractions, rumen pH is expected to be lower for diets containing sugars. However, many studies in the literature showed that rumen pH is not affected when dietary starch sources are partly replaced by sucrose (Sutoh et al., 1996; McCormick et al., 2001; Broderick et al., 2008) or lactose (Schingoethe et al., 1980; DeFrain et al., 2004). Furthermore, some studies reported that rumen pH increases (Chamberlain et al., 1993; Heldt et al., 1999) or tend to increase (Penner et al., 2009; Penner and Oba 2009) with the partial replacement of dietary starch sources with sugar. Recently in congruence with our results, Razzaghi et al. (2014) reported that feeding sucrose to Saanen dairy goats decreased ruminal pH in comparison to the control diet. Collectively, there is little evidence in the literature to support the concept that increasing dietary sugar concentration decreases rumen pH. Discrepancy between the current study and the mentioned previous studies may be difference in sugar type as in present study we used date palm (combination of various sugars) while in previous studies the sugar directly fed to animals, as well as the type of animal goat or cow can also affect rumen pH (Moharrery et al., 2014). The feeding of LDP decreased acetate and acetate/propionate ratio and increased propionate and valerate (Table 5).

This finding is contrary to earlier reports (Ribeiro et al., 2005; Mullins and Bradford, 2010; Martel et al., 2011) that sugars increase the ruminal concentration of butyrate and not propionate. Our result is however congruent with the finding of Razzaghi et al. (2014) who reported feeding sucrose to saanen dairy goats decreased acetate, acetate: propionate ratio while increased propionate and valerate concentrations in the rumen. These results confirmed the results related to milk fat that as LDP to ration increases, the concentration of fat drops (Table 2).

Some studies have reported that molar proportion of butyrate in rumen fluid is not affected by feeding sugars. It should be noted that butyrate production in the rumen is not the same as butyrate concentration because the concentration is a function of production, absorption, and passage of butyrate.

Because absorption of butyrate is faster than that of acetate or propionate (Leek, 1993), butyrate concentration in rumen fluid, either as molar-% or mM, may underestimates the actual butyrate production. Studies where sugar partly replaced dietary starch showed that the molar proportion of propionate declines (Heldt et al., 1999; DeFrain et al., 2004) or is not affected (Kellogg and Owen, 1969b,a; Vallimont et al., 2004). Some studies have revealed that feeding sugars can increase the concentration of valerate in the rumen, which can be formed partly from condensation and reduction of acetate and propionate. Heldt et al. (1999) noted that feeding sucrose in place of starch increased valerate concentration in the rumen, consistent with our results. The development in the proportion of propionate and reduction of proportion of acetate in diets containing LDP results in decreased rumen pH. Inconsistencies observed in this study in comparison with others, may be due to greater dietary non-fiber carbohydrate intake (Table 1) or ruminant species (cow or goat) in the present study.

5. Conclusion

The results of this study indicated that substitution part of dietary concentrate with LDP in the ration of dairy goats had no effect on DMI and nutrients digestibility. Milk yield and composition were not affected by treatments. Inclusion of LDP in the diet increased TAC in both blood and milk compare control diet. In regard to, LDP is a cheap by-product and is considered as a natural antioxidant source. Therefore, it can be used as an alternative source for small ruminants in arid and semi-arid regions particularly in the Persian Gulf region.

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