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Feeding corn silage improves nursing performance of Awassi ewes when used as a source of forage compared to wheat hay

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ABSTRACT

The objective of this study was to evaluate the effect of using corn silage (SILAGE) or wheat hay (HAY) as a source of forage on nursing performance of Awassi ewes. Forty ewes (body weight; BW = 43.5 ± 1.58 kg) and their single lambs (BW = 6.3 ± 0.28 kg) were randomly assigned to two diets; SILAGE *vs.* HAY (four pens/diet; five ewes/pen). Concentrate feeding was restricted to 1.1 kg dry matter (DM)/ewe/d, whereas forage was offered *ad libitum*. The study lasted for 56 d (7 d of adaptation and 49 d of data collection). Ewes and lambs were weighed after the adaptation period and at the end of the study. Milk yield and blood samples were collected on days 9, 16, 23, 30, 37, 44 and 51. Intakes of forage and total DM were greater (P<0.05) in SILAGE-fed ewes compared to those fed HAY. Additionally, intakes of crude protein, ether extract and net energy were also greater (P≤0.002) in the SILAGE group. However, neutral and acid detergent fiber intakes were greater (P=0.022) in the HAY than in the SILAGE group. Average daily gain was greater (P=0.032) in the SILAGE than the HAY group. Circulating glucose concentration was greater (P=0.023) in the SILAGE treatment compared to the HAY group, while serum urea nitrogen was similar (P=0.914) in both groups. Milk, total milk solids, protein and fat yields were greater (P<0.05) in the SILAGE than in the HAY group. Dietary replacement of wheat hay with corn silage to early lactating Awassi ewes improved feed intake, yields of milk and milk components, ewe body weight, and lamb average daily gain.

1. Introduction

Awassi sheep, the predominant breed in the Middle East, are raised to supply both milk and meat. Jordan is a semi-arid country in that region with an average rainfall of merely 200 mm/year (El-Shatnawi and Ereifej, 2001). The greatest rainfall occurs in December and January; followed by emergence of spring grasses, such that maximum pasture mass is obtained

Abbreviations: ADF, acid detergent fiber; ADG, average daily gaina; NDF, neutral detergent fiber; BW, body weight; CP, crude protein; DM, dry matter; EE, ether extract; NFC, non-fiber carbohydrates; TS, total solids.

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in late winter and early spring (February and March). However, erratic rainfall and overgrazing, reduces the availability of high quality forage.

The main forages utilized by livestock in the Middle East are wheat and barley hay, which are available at reasonable costs but have a low nutritive value (energy and crude protein concentration) and digestibility. To overcome negative nutritive attributes of hay for milk production, local producers use corn silage during the winter months. Corn silage contains moderate levels of crude protein (88 g/kg dry matter (DM) and net energy (6.07 MJ/kg DM) which makes it a good forage source for lactating ewes compared to wheat hay (NRC, 2001). Our hypothesis states that using corn silage rather than wheat hay as a source of forage would improve milk production and composition as well as ewe body weights and growth of their lambs. Therefore, the objective of this study was to evaluate nursing performance of ewes and pre-weaning growth of their lambs when corn silage was used as the main forage source.

2. Materials and methods

2.1. Experimental design and diets

The study was conducted at the Agriculture Center for Research and Production at Jordan University of Science and Technology (JUST), which is classified as a semi-arid region with an average annual rainfall of 240 mL, at latitude 32° 30′ N and 35° 57′ E and elevation of 510 m above sea level. August is the warmest month with an average temperature of 32.6 °C while February is the coldest month with an average temperature of 3.5 °C.

All animal-related procedures used in the current study were pre-approved by the Institutional Animal Care and Use Committee at JUST. Forty nursing Awassi ewes (body weight; BW = 43.5 ± 1.58 kg) and their single lambs (BW = 6.3 ± 0.28 kg) were randomly assigned to one of two forage treatments: wheat hay (HAY; $n = 20$) or corn silage (SILAGE; $n = 20$). Ewes were penned in groups of fives in eight adjacent open-sided pens (4 m × 4 m; four pens per diet).

Concentrates (barley-based) were fed per pen with an allowance of 1.1 kg/ewe/d on DM basis. Ingredient and chemical composition of the concentrate mixture, wheat hay and corn silage are presented in Table 1. Concentrates were mixed every 2–3 weeks, and sampled for laboratory analysis to ensure consistency of chemical composition. In addition, samples of wheat hay and corn silage were frozen at −20 °C every 2 weeks for chemical analysis. Forage and water were offered *ad libitum* throughout the study duration. Concentrates and forages were offered once daily at 09:00 h. Forage refusal was collected, weighed and sampled daily before feeding. Lambs had access to the diets of the ewes and, thus, the lambs' intake was not exclusively from nursing. The study lasted for 56 d, comprised of a 7-d adaptation period and a 49-d period for data collection. Ewe and lamb BW was recorded after the adaptation period and at the end of the study.

2.2. Laboratory procedures

At the end of the experiment, samples of wheat hay, corn silage and refusals were composited for each pen. The samples were then dried at 55 °C in a forced-air oven to constant weight (dry matter 1) and ground to pass a 1 mm sieve (Brabender, Duisburg, Germany). These samples were analyzed for DM (100 °C in air-forced oven for 24 h; dry matter 2), N (Kjeldahl procedure; # 976.06), and ether extract (EE; Soxtec procedure, Soxtec System HT 1043 Extraction Unit, Tecator, Hoganäs, Sweden; # 920.29) using AOAC (1990) procedures. The actual DM content was then calculated by multiplying dry matter 1 by dry matter 2. Neutral detergent fiber (aNDF) and acid detergent fiber (ADF) analysis was performed according to procedures described by Van Soest et al. (1991) using the Ankom^{2000} fiber analyzer apparatus (Ankom Technology Corporation, Macedon,

Table 1
Ingredients of the concentrate and chemical composition of the concentrate mixture, wheat hay (HAY) and corn silage (SILAGE) fed to nursing Awassi ewes.

Item	Concentrate	HAY	SILAGE
Ingredient			
Barley grain	650		
Wheat bran	80		
Corn grain	160		
Soybean meal (440 g/kg CP; solvent)	80		
Salt	12		
Limestone	15		
Vitamin/mineral premix[a]	3		
Chemical composition			
DM (g/kg)	911	901	389
CP (g/kg DM)	162	36	91
aNDF (g/kg DM)	199	761	477
ADF (g/kg DM)	58	515	314
EE (g/kg)	40	20	37
NE_l (MJ/kg)[b]	7.74	4.23	6.07

[a] The composition per kg of the vitamin/mineral premix was: vitamin A, 2,000,000 IU; vitamin D3, 40,000 IU; vitamin E, 400 mg, Mn, 12.80 g; Zn, 9.00 g; I, 1.56 g; Fe, 6.42 g; Cu, 1.60 g; Co, 50 mg; Se, 32 mg.
[b] Net energy for lactation was calculated based on NE values presented for each feed ingredient in the standard tables from NRC (2001).

NY, USA). The aNDF analysis used sodium sulfite in the neutral detergent solution and a heat stable alpha amylase. Both aNDF and ADF are expressed with residual ash. The estimated net energy for lactation (NE_l; MJ/kg) of the forage and the concentrate mixture was calculated based on NE values presented for each feed ingredient according NRC (2001).

2.3. Blood and milk measurements

On days 9, 16, 23, 30, 37, 44 and 51, a 10 mL blood sample was collected from each ewe by jugular venipuncture, and allowed to clot prior to centrifugation at 1200 × *g* for 20 min at 4 °C. Serum was stored at −20 °C until analyzed. Serum glucose and urea N concentration was analyzed using colorimetric assay (QuantiChromTM Glucose Assay Kit DIGL-100 and QuantiChromTM Urea Assay Kit DIUR-500, BioAssay System).

Milk yield was measured on the same days of blood sampling. To estimate daily milk yields, lambs were separated from their dams for 12 h before milking. Before feeding, ewes were hand-milked at 08:00 to evaluate milk yield per 12 h and individual milk weights were recorded. Ten ewes from each treatment group were randomly chosen for milk composition analysis. A 125 ml milk sample was collected from each ewe and analyzed immediately for total solids, fat and protein ($N \times 6.38$) contents. The same ewes were used at each data collection point throughout the study. Total solids were determined using a forced-air oven at 50 °C to a constant weight, then at 100 °C for 24 h (AOAC, 1990; #967.03). Total N was determined using a Kjeldahl procedure (AOAC, 1990; # 976.06) and fat was analyzed according to the Gerber method (Gerber Instruments, K. Schnider and Co. AG, 8307 Langhag, Effretikon, Switzerland). Yields of total solids, fat and protein were calculated by multiplying the daily milk yield by the content of these components.

2.4. Statistical analysis

Intake data were analyzed based on the average of all ewes in each pen. The effect of forage type on intake was analyzed using pen per group as the experimental unit and ewe within pen as a random effect. However, ewe and lamb body weight changes were analyzed with the forage effect only. Milk and blood data were analyzed by ANOVA for a completely randomized design as repeated measures using Mixed procedure of SAS (SAS version 9.0). Model effects included forage, week, and forage × week, where week was the repeated effect. The appropriate covariance structure of the data was chosen for each analysis from the structures of compound symmetric, autoregressive order one, and unstructured (based upon the Schwarz Bayesian criterion). Means were subsequently separated using the sliced time effects for forage × week interaction, and the PDIFF function associated with generation of least squares mean (±SEM). The rest of the data were analyzed with the treatment effect and ewe within pen was used as a random effect. Significant differences were considered if $P \leq 0.05$.

3. Results

The amount of the concentrate offered was allocated per pen and restricted to 1.1 kg DM/d per ewe. No concentrate refusals were observed throughout the study (Table 2). Intakes of forage, total DM (*i.e.*, concentrate and forage), CP and EE were all greater (P<0.05) for the SILAGE than the HAY diet. However, the HAY group had greater (P=0.022) aNDF and ADF intakes than the SILAGE ewes.

Average daily gain (ADG) was greater (P=0.032) for the SILAGE than the HAY group (Table 2). No forage × week interaction (P>0.05) was detected for either glucose or serum urea nitrogen concentration between groups throughout the study. However, overall serum glucose concentration was greater (P=0.023) in the SILAGE group compared to the HAY group.

Least square means of the milk production and composition are shown in Table 3. SILAGE group had greater (P<0.05) milk yield than the HAY group during weeks 6, 7, and 8. A forage × week interaction (P<0.05) was observed for milk total solids content being greater in the HAY than in the SILAGE group during weeks 7 and 8. No forage × week interaction (P>0.05) was detected for the total solids yield. However, sliced effects showed that total solids yield was greater (P<0.05) in the SILAGE group than in the HAY group during weeks 6 and 8.

No forage × week interaction (P>0.05) was observed for milk protein content. Overall milk protein content was lower (P<0.05) in the SILAGE (51.0 g/kg) compared to the HAY (55.6 g/kg) group. However, a sliced effect was observed between groups for milk protein content being greater (P<0.05) during weeks 6 and 8 and tending (P<0.10) to be greater during weeks 5 and 7 in the HAY group than in the SILAGE group. Despite this fact, the SILAGE group had greater (P<0.05) milk protein yield than the HAY group during weeks 6, 7, and 8.

No forage × week interaction (P>0.05; Table 3) was observed for milk fat content between the two groups. However, overall milk fat content was lower (P<0.05) in the SILAGE compared to the HAY group. A sliced effect was detected for milk fat content being greater in the HAY than in the SILAGE group during weeks 7 and 8. Neither forage × week interaction (P>0.05) nor diet affected the overall milk fat yield between the two groups. However, milk fat yield was lower in the HAY group compared to the SILAGE group during week 8.

4. Discussion

Milk production and performance of nursing ewes is highly dependent on feed composition and intake. Nutrition during early lactation is critical for most dairy ewes to supply enough nutrients for maintaining milk production and improving or

Table 2
Effects of feeding wheat hay (HAY) or corn silage (SILAGE) on intake, performance and blood metabolites of nursing Awassi ewes and their lambs ($n = 20$ per dietary treatment).

Item	Diets		SE	P-value
	HAY	SILAGE		
Feed intake[a] (DM kg/d)				
Concentrate	1.1	1.1	–	–
Forage	0.71	0.88	0.045	0.037
Nutrient intake (DM kg/d)				
DM (DM kg/d)	1.80	1.97	0.044	0.033
CP (DM kg/d)	0.19	0.25	0.005	0.001
aNDF (DM kg/d)	0.76	0.64	0.028	0.022
ADF (DM kg/d)	0.43	0.34	0.017	0.012
EE (DM kg/d)	0.06	0.08	0.002	0.002
NE (MJ/d)	10.99	13.30	0.245	0.001
Ewes				
Initial BW (kg)	43.8	43.2	1.58	0.799
Final BW (kg)	45.6	47.7	1.30	0.271
BW change (kg)	1.85	4.48	0.907	0.048
Lambs				
Initial BW (kg)	6.3	6.3	0.28	0.900
Weaning BW (kg)	18.5	20.9	0.90	0.068
Average daily gain[b] (g)	251	299	15.3	0.032
Blood metabolites of Ewes (mg/dL)				
Glucose	74.2	79.9	1.64	0.023
Urea N	11.8	11.4	2.79	0.914

[a] Intake was measured for each pen containing 5 ewes and their lambs. The average intake per ewe was established by obtaining the intake per pen and dividing by five (*i.e.*, $n = 4$ for intake).
[b] Average daily gain = (weaning BW − initial BW)/49 d.

maintaining body condition. As a result of better feeding during the early lactation period, ewes would be better prepared for the subsequent breeding season and may return earlier to estrus (Kridli et al., 2001). Therefore, the present study was conducted to evaluate the effect of replacing wheat hay, a forage source, with corn silage on milk production of Awassi ewes and growth of their lambs.

The greater DM and forage intakes in silage-fed ewes *versus* HAY-fed ewes observed in the present study were inconsistent with Sormunen-Cristian and Jauhiainen (2001) who reported greater intake in Finnish Landrace ewes fed timothy/meadow fescue as hay compared to silage. Oelker et al. (2009) reported that DM intakes were not different when dairy cows were fed either alfalfa hay or corn silage. Similarly, Petit and Flipot (1992) found that forage and total DM intake was not different when beef steers were fed grass hay or silage. It is well established that NDF level in the diet regulates feed intake such that the higher the dietary NDF content, the lower feed intake is (Van Soest, 1965). In the current study, NDF and ADF concentrations were greater in the HAY compared to SILAGE diets, which may explain the reduction in forage and total DM intake in the HAY group. Another possible explanation for the greater DM intake in the SILAGE group could be related to the lower NDF content in the SILAGE diet, which should improve digestibility and, therefore, allowed a higher feed intake. Nutrient digestibility was not measured in the current study; therefore, more studies are required to further evaluate the effect of corn silage feeding on nutrient digestibility and nitrogen balance during the lactating period of sheep. The higher serum glucose concentration for SILAGE ewes compared to HAY ewes is most likely due to greater starch consumption in the SILAGE group or simply due to the greater SILAGE intake *per se*.

In the current study, ewe BW and lamb growth were improved by SILAGE over HAY. This finding is consistent with results obtained by Leto et al. (2002) when ewes were fed Sulla silage compared to Sulla hay, and likewise was attributed to greater

Table 3
Milk production and composition of Awassi ewes fed either wheat hay (HAY) or corn silage (SILAGE) as a forage source.

Item	Diets		P-value			
	HAY $n = 10$	SILAGE $n = 10$	SE	Forage	Week	Forage × week
Production (g/12 h)						
Milk	243	317	18.2	0.081	0.082	0.024
Total solids	34.3	42.0	5.20	0.167	0.199	0.137
Crude protein	13.1	16.0	1.75	0.120	0.085	0.042
Fat	11.5	13.3	2.24	0.419	0.001	0.276
Milk composition (g/kg)						
Total solids	144.9	132.1	3.15	0.010	0.025	0.022
Crude protein	55.6	51.0	1.51	0.043	0.036	0.801
Fat	51.0	40.7	3.49	0.047	<0.001	0.511

intakes of DM, CP, EE and net energy. The improvement of ADG that was observed in the SILAGE group would potentially benefit ewe lambs allowing them to reach the puberty and thus enter the breeding season earlier.

Leto et al. (2002) did not find differences in milk yield or milk components when lactating ewes were fed either Sulla hay or Sulla silage. In the current study, the differences in milk yield could be attributed to the greater nutrient intake in the SILAGE diet compared to the HAY diet as milk yield is closely related to intake. However, feeding SILAGE negatively impacted milk components. The reduction in milk protein content could be related to increased milk yield (dilution effect) rather than decreased milk protein synthesis. However, the reduction in milk fat may be explained by differences in the microbial population in the rumen due the differences in the fiber intake, as observed in the HAY group. Further studies are needed to investigate how the nutritive value of wheat hay *vs.* corn silage may affect microbial population in the rumen.

5. Conclusion

What hay was replaced by the corn silage in the present trial as a source of forage to nursing Awassi ewes. Results indicate that the greater feed intake in the SILAGE group was the major reason for improving the milk yield and composition compared to the HAY group. Therefore, it is recommended to substitute wheat hay with corn silage (when available) in the diet of lactating Awassi ewes. This substitution can improve ewe body weight and milk yield and improve pre-weaning growth rate of the lambs. The most noticeable negative effect observed was the reduction in milk components in ewes fed corn silage. However, the overall milk yield increased in corn silage-fed ewes, which is economical advantage.

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