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EFFECT OF FEEDING RUMEN-PROTECTED METHIONINE WITH CALCIUM SALTS AND YEAST ON PRODUCTIVE PERFORMANCE OF LACTATING EWES WHEN FED BARLEY STRAW

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KEYWORDS

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Rumen-protected methionine

Yeast

ABSTRACT

A comparative study was conducted to examine the capacity of rumen-protected methionine and calcium-salts to enhance milking performance of Awassi ewes when fed barley straw to be comparable with those ewes fed Alfalfa hay. Aqueous ammonia and yeast culture were also tested for their further ability to promote animals performance when fed straw. Forty-four Awassi ewes were randomly assigned into four dietary treatment groups in a completely randomized design. Ewes were fed with 1 kg/head/day concentrate ration supplemented with alfalfa hay (CON) or either ammonia treated (ASTRW) or untreated barley straw (STRW) supplemented with calcium-salts and rumen protected methionine at a level of 50 g and 5 g/head/day respectively. In the fourth diet, 30 g/head/day of yeast culture was added to ammonia treated supplemented straw (AYSTRW). The experiment started after weaning and lasted for 70 days thereafter. Milk yield, milk composition, body weights, feed intake, milk fatty acids and some blood parameters were studied as production variables. There were no significant differences ($p>0.05$) between ewes in milk and energy corrected milk production, feed consumption, weight increase, feed efficiency, milk fat, milk fatty acid composition, milk and blood urea and blood Serum triglycerides. The current results indicated that supplementing barley straw with rumen-protected methionine and calcium salts was sufficient for Awassi ewes produced modest milk production to maintain milk yield and quality without any detrimental effects on animal performance comparable with ewes fed alfalfa hay as a source of forage.

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1 Introduction

Awassi sheep breed is fat-tailed breed found extensively in southern Turkey, Iraq, Syria, Jordan and other countries in the Mediterranean area (Haile et al., 2017). It is used mainly for meat and milk production and, in fewer manors, for wool. It is well adapted to hot and dry conditions. Awassi sheep production is based on a semi-intensive system characterized by low prolificacy but high milk production (Haile et al., 2017).

Ruminants including sheep have the unique capacity to utilize forages of various qualities. They can make use of forages nutrients and digesting their relatively high contents of fibers with the assistance of the microorganisms that are endemic to the digestive system, mainly the rumen (Huws et al., 2018). Therefore, these animals can transform relatively low quality dietary nitrogen into high quality animal protein (i.e. meat and milk). Due to that, forages make up half or more of the diet of sheep profoundly affect energy and carbohydrate intake (Kendall et al., 2009).

Cereal straws are carbohydrate-rich residues representing a large potential source of dietary energy for ruminants. It has been well recognized that wheat and barley straws have poor nutritional value because of their low nitrogen and high fiber content (Tang et al., 2008).

Low quality straws are widely used for ruminant feeding, especially in regions of highly cereal production, because of high cost and limited availability of good quality forages. However, the nutritive value of straws is relatively low due to its high ligno-cellulosic content, low crude protein (CP) content, poor palatability, and low organic matter (OM) digestibility (López et al., 2005). Increasing the nutrient availability for better utilization of crop residues has been a primary focus of research in ruminant livestock nutrition. In this direction, various methods have been tested such as physical processing, physicochemical processing, biological treatment, and use of feed additives (Sundstøl & Owen, 1984).

The objective of the present study was to examine the capacity of rumen-protected methionine and calcium-salts to enhance milking performance of Awassi ewes when fed barley straw as sole forage source in feeding dairy Awassi ewes post-weaning to be comparable with those ewes fed Alfalfa hay. Using aqueous ammonia and yeast culture were also tested for their further ability to promote ewes performance when fed barley straw.

2 Materials and Methods

2.1 *Location and Animals*

The experiments were conducted in the Agricultural Research Station that belong to the University of Jordan in Jordan Valley, which located at 32° 10’ N latitude and 35° 37’ E longitudes with an elevation of –244 m below sea level. Forty-four dairy Awassi ewes were used in the experiments with an average body weight of 61 ± 9 kg (M ± SD) and aged between 46-50 months. Ewes care and handling complied with the EU legislation for the protection of animals used for scientific purposes (Directive number 2010/63/EU). The Scientific Research Council of the University of Jordan also approved the experimental protocols.

Ewes were randomly assigned to one of four dietary treatment groups and each ewe in the treatments were housed in individual pen (1.5 m x 1 m) to get accurate individual data per single ewe and to minimize the experimental error.

2.2 *Feedstuffs*

All animals in the four treatment groups (11 ewes /group) were-fed concentrate mixture at a level of about 1.0 kg dry matter/head/day (Table 1). Type of roughage was the treatment of each group. Animals, which were fed alfalfa, was given about 1.0

Table 1 Chemical composition of concentrated ration used in feeding Awassi ewes during the experiment with its ingredients composition

Ingredients	DM ($g.kg^{-1}$)
Barley grains	700
Soybean meal	150
Wheat bran	130
Limestone	5.0
Di-calcium phosphate [a]	10
Salt	2.0
Sodium bicarbonate	2.0
Vitamins & minerals mix [b]	1.0
Chemical composition	
DM	930
CP	162
Ether extract	17
NFE	588
CF	37
NDF	229
ADF	154
Ash	126
GE (Mcal/kg)	3.66
ME (Mcal/kg)	2.9 [c]

[a] Dicalcium phosphate (28 % Ca, 19 % P);
[b] The composition of each gram of mineral and vitamin premix were as follows: vitamin A 3000 I.U.; vitamin D_3 500 I.U.; vitamin E 2 mg; Potassium iodine 500 µg; Cobalt sulphate 50 µg; Sodium selenite 75 µg; Copper sulphate 3 mg; Ferrous sulphate 20 mg; Magnesium sulphate 20 mg; Manganese oxide 20 mg; Zinc sulphate 5 mg and Dicalcium phosphate (24 % Ca, 18 % P) 20 mg;
[c] Calculated according to NRC (2007)

kg dry mater/head/day, whereas the other animals who fed barley straws, were given lower amount at a level of 0.6 kg dry mater/head/day due to the difference in density between alfalfa hay and straw (barley straw have lower density and larger size than alfalfa). Control group of ewes was fed alfalfa hay (CON) while the second group was fed barley straw. Straw was supplemented with rumen protected fat (calcium salts of palm fatty acids) and rumen protected methionine (48% of DL-methionine MetiPEARL from KEMIN) at a level of 50 g/head/day (Manso et al., 2006) and 5 g/head/day (Yang et al., 2010) respectively (STRW). In the third group, ewes were fed as those ewes in-group two with the difference that the barley straw was previously treated with aqueous ammonia (ASTRW). In group four, ewes were fed as those ewes in group three but with the addition of yeast culture (*Saccharomyces cerevisiae* 1.5 x 10^9 CFU) at a level of 30 g /ewe/day (Degirmencioglu et al., 2013) (AYSTRW). All feed additives (protected fat, protected methionine and yeast culture) were added directly to the feeders of ewes.

The amounts of concentrate and roughages, which were offered to the animals, were calculated to provide them with the nutritional requirements according to the NRC recommendations for sheep (National Research Council, 2007). Rations were mixed twice weekly and were offered for all animals twice a day at 7:00 a.m. and 2:00 p.m. Clean drinking water was continuously provided for all animal. The experiment was conducted after weaning (at 2 months post-lambing) and lasted for 70 days. Individual feeding was the style of feeding for each pen, and each ewe was individually milked by hand.

2.3 *Measurements of milk production and feed consumption*

Animals were weighted individually three times during the experiment to estimate body weight change. Weight gain were examined for once, while daily milk production, daily dry matter intake and feed efficiency (kg milk produced/kg feed consumed) were measured twice a week during the experiment. During estimating daily feed consumption, excess feed was applied to the feeders and the residual feeds were measured to estimate exactly the correct daily feed intake of the animal. Energy corrected milk (ECM) (a milk with 3.5% fat and 3.2 % protein) was determined following the equation of Flores et al. (2009) as follows:

ECM (kg/d) = [milk (kg/d) × 0.327] + [fat (kg/d) × 12.86] + [protein (kg/d) × 7.65]

2.4 *Feed, milk and blood sampling*

Composite feed samples were taken every week after feed preparation and kept frozen (–20°C) for chemical analysis. Milk samples were randomly taken from different ewes in each treatment group (at the middle and the end of the experiment). Milk samples were collected and preserved in sealed plastic jars with adding 10 drops of potassium permanganate (0.01N) and stored at −4 C° for further analysis. Samples were analyzed for composition of crude protein (Kjeldahl), fat (Gerber), casein, total solids contents and milk urea using the standard procedure of AOAC (2006). Blood samples were randomly taken from different ewes in each treatment group (only at the end of the experiment). Blood samples were collected three hours after morning feeding from the jugular vein (Bassert et al., 2017) into heparinized vacuum tubes and centrifuged at 3000 xg for 15 min. The obtained plasma was stored at -20 C° until further analysis. Three blood samples were analyzed for ammonia, urea, serum cholesterol and triglycerides using enzymatic colorimetric methods (Biolabo/ AMMONIA enzymatic method, Linear/ UREA Berthelot, Linear/ CHOLESTEROL MR and Linear/ TRIGLYCERIDES MR respectively).

2.5 *Chemical analysis*

Frozen feed sample were collected and ground through a 1 mm screen and analyzed for crude protein, ether extract, ash and nitrogen free extract according to AOAC (2006) procedures. In addition, neutral detergent fibers (NDF) and acid detergent fibers (ADF) were analyzed according to Goering & Van Soest (1970) using Ankom fiber analyzer (Ankom220, Ankom Technology, Macedon, NY, USA). Gross energy was analyzed using bomb calorimeter (IKA C200), whereas, metabolizable energy were calculated according to NRC (2007). For milk fatty acid analysis, fat was separated following the Roese-Gottlib method (AOAC, 2006), trans esterified into fatty acid methyl esters by methylation at room temperature with KOH (2M) in Methanol, and analyzed by gas chromatography (Třinacty et al., 2006) using a Shimadzu 2010 (Shimadzu Corp., Kyoto, Japan) equipped with flame ionization detector. The GC conditions were column oven temperature was 70 °C for 1 min, increased to 165 °C at 20 °C/min and kept at 165 °C for 8 min, then increased to 180 °C 1 °C/min and then increased to 220 °C at 3 °C/min and kept at this temperature for 10 min. The carrier gas was Helium. Injector and detector temperatures were 250 °C and helium flow rate was 1.1 ml/min.

2.6 ***Aqueous ammonia treatment***

Barley straw that used in the third and fourth dietary treatments of the experiment were treated with aqueous ammonia, in which a rate of 120 L of aqueous ammonia (25 % w/w) was sprayed on one ton air-dry (91 %) straw (Hadjipanayiotou et al., 1993). The aqueous ammonia solution was sprayed onto a stack of whole straw bales (mechanically baled straw; each bale weighing approximately 20 kg). Plastic sheet was used underneath weighted straw bales. The treated stack was then covered tightly to prevent leaking of ammonia gas for almost twenty days. Straw was air ventilated one week before used in feeding animals.

2.7 ***Statistical analysis***

The effect of different sources of roughage on studied variables were analysed using general linear model (GLM) procedure of SAS v. 9.4 (SAS Institute Inc., 2013) in a completely randomized design. The analysis model includes treatment as independent variables. Dry matter intake, milk yield, and its composition were analysed in a repeated measures design. Initial body weight of ewes was taken as covariates for final body weight while Initial milk production and age of ewes was used as covariates for average daily milk production. Least square means were separated for significances ($P<0.05$) using Fisher protected LSD test.

3 Results

3.1 ***Chemical composition of roughages used***

The data illustrated in Table 2 shows that there is a quite difference between alfalfa hay and barely straw in crude protein content (186 and 43 $g.kg^{-1}$ respectively), neutral detergent fiber (464 and 789 $g.kg^{-1}$ respectively) and acid detergent fiber (433 and 695 $g.kg^{-1}$ respectively). This was reflected on metabolizable energy, which was also high for alfalfa hay compared with straw of barley (2.1 and 1.6 Mcal/kg respectively). Treating straw with aqueous ammonia improved the crude protein content from 43 to 72 $g.kg^{-1}$ and decreased the ADF percentage from 695 to 670 $g.kg^{-1}$. Subsequently, ME was increased about 50 kcal/kg of treated straw (calculated by equation of Donker, 1989).

3.1 ***Milk Production, composition and Blood parameters***

Animal performance were evaluated depending on amount of milk production, body weigh change, composition of milk and some blood parameters including blood ammonia, urea, serum cholesterol and triglycerides.

Average daily milk production, energy corrected milk production, weigh change, daily feed consumption and feed efficiency data for ewes consumed alfalfa hay showed no significant differences compared to that produced by others ewes (Table 3). Figure 1 illustrate the average daily milk

Table 2 Chemical composition of Alfalfa hay and barley straw that used as roughage for feeding Awassi ewes during the experiment

Item ($g.kg^{-1}$)	Alfalfa hay (CON)	Barley straw (STRW)	Ammonia treated straw (ASTRW)
DM	922	914	912
CP	186	43	72
Ether extract	19	8.0	8.0
NFE	317	336	328
CF	294	399	401
NDF	464	789	766
ADF	433	695	670
Ash	107	127	103
GE (Mcal/kg)	3.86	3.56	3.69
ME (Mcal/kg)	2.1 [a]	1.6 [a]	1.65 [b]

[a] Calculated according to NRC (2007);
[b] Calculated according to equations of Donker (1989)

Table 3 Average daily milk yield, energy corrected milk, weight change during the experiment, daily feed consumption and feed efficiency for Awassi ewes that fed four different roughage sources

Forage type	Alfalfa hay (CON)	Barley straw (STRW)	Ammonia treated straw (ASTRW)	Ammonia treated straw + Yeast (AYSTRW)	Significance
Average Daily milk yield (kg)	0.75 ± 0.1	0.53 ± 0.1	0.55 ± 0.08	0.69 ± 0.08	ns
Energy corrected milk (kg/day)[1]	1.2 ± 0.2	0.9 ± 0.2	0.94 ± 0.13	1.2 ± 0.14	ns
Weight change (kg)	9.5 ± 4.1	5.0 ± 6.8	5.0 ± 0.9	7.8 ± 1.8	ns
Daily feed consumption (kg)	2.0 ± 0.09	1.8 ± 0.05	1.8 ± 0.08	1.9 ± 0.02	ns
Feed efficiency (%)[2]	0.6 ± 0.1	0.4 ± 0.1	0.5 ± 0.07	0.6 ± 0.06	ns

Mean ±Std. Error
Means in the same row with different superscripts differ significantly (P<0.05)
ns: not significant
[1] Energy corrected milk (kg/d) = [milk (kg/d) × 0.327] + [fat (kg/d) × 12.86] + [protein (kg/d) × 7.65]
[2] feed efficiency =kg milk produced/kg feed consumed

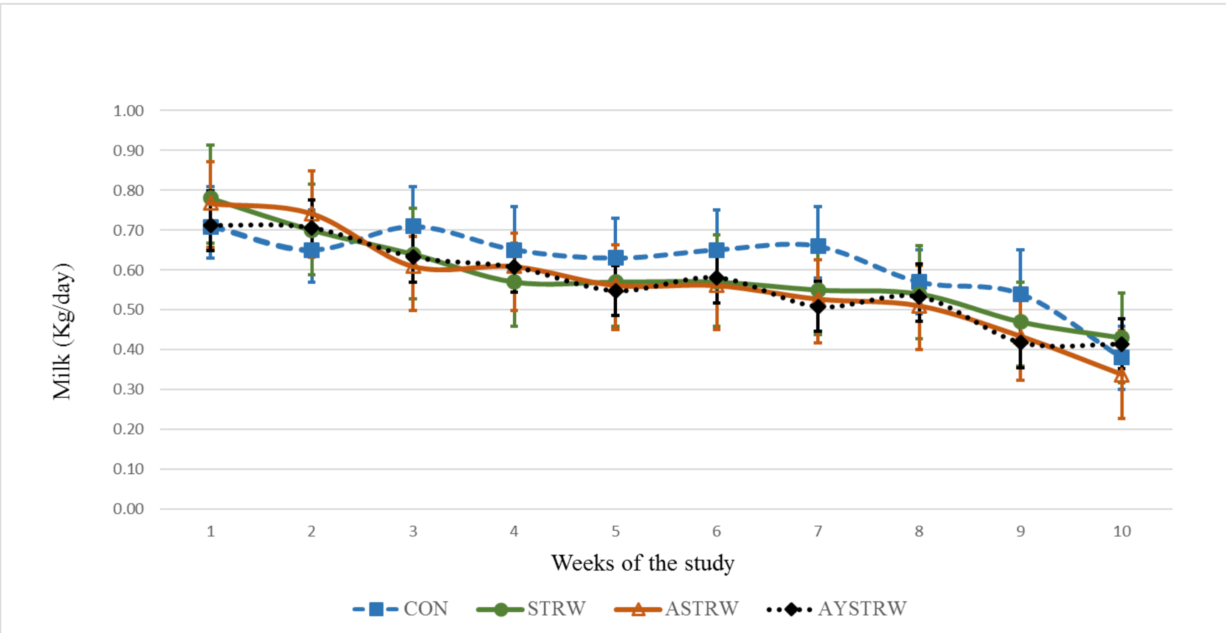

Figure 1 Average daily milk production of ewes fed four different roughage sources during the whole experiment interval.

production of ewes fed the four different forage sources during the whole experiment.

Results of milk chemical analysis is illustrated in Table 4. Milk total solids of ewes fed STRW and ASTRW was significantly the highest ($p < 0.05$) value (17.4 %) while milk protein for ewes fed AYSTRW was significantly the highest value (6.0 %). However, Milk fat and urea values exhibited no significant differences between treatments.

Blood ammonia concentration (Table 5) showed significant differences between ewes fed AYSTRW and other ewes fed either STRW or ASTRW but not CON while blood urea illustrated no significant differences between treatments. Despite serum cholesterol of ewes fed AYSTRW is significantly higher than ewes fed CON (71.0 and 57.7 mg/100 ml respectively; $p<0.05$) serum triglycerides showed no differences between treatments (p>0.05).

Table 4 Milk composition of Awassi ewes fed the four different roughage sources

(%)	Alfalfa hay (CON)	Barley straw (STRW)	Ammonia treated straw (ASTRW)	Ammonia treated straw +Yeast (AYSTRW)	Significance
Milk Fat	6.7 ± 0.09	7.2 ± 0.3	7.3 ± 0.17	7.5 ± 0.5	ns
Milk protein	5.7 ± 0.04 [b]	5.9 ± 0.07 [a]	5.5 ± 0.06 [c]	6.0 ± 0.06 [a]	*
Milk Casein	4.7 ± 0.04 [ab]	4.8 ± 0.05 [a]	4.5 ± 0.07 [b]	4.8 ± 0.07 [a]	*
Milk total solids	16.4 ± 0.1 [b]	17.4 ± 0.2 [a]	17.4 ± 0.24 [ab]	17.0 ± 0.41 [b]	*
Milk Urea (mg/100ml)	32.0 ± 0.7	28.5 ± 1.6	30.8 ± 1.4	28.6 ± 1.2	ns

Mean ±Std. Error
Means in the same row with different superscripts differ significantly (P<0.05)
* P < 0.05, ns – not significant

Table 5 Blood sample composition of Awassi ewes fed the four different roughage sources

Concentration (mg/100ml)	Alfalfa hay (CON)	Barley straw (STRW)	Ammonia treated straw (ASTRW)	Ammonia treated straw + Yeast (AYSTRW)	Significance
Blood Ammonia	24.7 ± 1.9 [ab]	32.7 ± 3.9 [a]	26.7 ± 3.3 [a]	16.5 ± 1.8 [b]	*
Blood Urea	13.8 ± 1.0	16.3 ± 1.2	14.3 ± 1.3	20.5 ± 3.0	ns
Serum cholesterol	57.7 ± 5.2 [b]	70.3 ± 4.1 [ab]	68.0 ± 3.2 [ab]	71.0 ± 1.5 [a]	*
Serum triglycerides	54.7 ± 7.2	55.7 ± 6.2	61.0 ± 1.5	61.3 ± 4.4	ns

Mean ±Std. Error
Means in the same row with different superscripts differ significantly (P<0.05)
* P < 0.05, ns – not significant

Regarding to Milk fatty acid composition, no changes were found either in the concentration of short chain fatty acids (C4-C10), or in that of medium chain fatty acids (C12-C14) or long chain fatty acids (C16-C20) by different sources of roughage (Table 6). Fatty acids used to synthesize the milk triglycerides arise from two sources included plasma lipids and de novo synthesis in the mammary gland. De novo synthesis generally involves short-chain fatty acids (C4:0–C14:0) and some C16:0 (Alichanidis et al., 2016). The plasma lipids are derived from diet and from storage in body tissue. For ruminants, biohydrogenation in rumen results in reduced impact on the diet on the final fatty acid profile (Alichanidis et al., 2016).

4. Discussion

4.1 *Milk production of Awassi ewes*

The Local Awassi is a hardy, low-prolific, and low milk-producing breed that is well adapted to the extensive and harsh production conditions of the Middle East (Gootwine, 2011), where environmental constraints, such as food availability and climate, are the rate-limiting factors for production. Awassi ewes raised at experimental station, where the experiment was conducted, produced milk from as low as 0.3 kg/ day up to 1.3 kg/day in their med lactation period (week 8 to 18) and for single lamb production. According to Talafha & Ababneh (2011), these levels classified flock of present study as traditional and improved breed of milk producers. They reviewed that the amount of suckling milk in traditional production system ranged between 68 and 90 kg during a period of 81–93 days, while the improved Awassi milk yield ranging from 97.5 to 360 kg over 95 to 222 days lactation period. However, at government research stations (at different locations in Jordan), Awassi ewe produces 40–60 kg of milk per 150-day lactation period under traditional (extensive) production system and 70–80 kg under improved (intensive) production system (Talafha & Ababneh, 2011) These levels do not include the suckling period when milk is left for lambs. These levels of milk production are attached with results of present study and further conclusions. On the other hand, the improved Awassi is probably equal to or somewhat superior to the East Friesian in milk yield. Average milk was reached up to 524 kg in 214 days (Thomas & Haenlein, 2017). In that level of production, it is supposed that results and conclusions of present study will not be convenient.

4.2 *Calcium salts, methionine and yeast*

Feeding ruminants with rumen protected fat as calcium salts were examined in many experiments. Most of results are in agreement with the results of current study, where using protected fat in combined with methionine increased the nutritive value of straw and it was able to supply animal with its needs compared with alfalfa hay.

Table 6 Milk fatty acid composition (% of milk fat) of Awassi ewes fed different roughage sources

Fatty Acid (% of milk fat)	Alfalfa hay (CON)	Barley straw (STRW)	Ammonia treated straw (ASTRW)	Ammonia treated straw + Yeast (AYSTRW)	Significance
C4	2.40 ± 0.25	2.33 ± 0.1	2.49 ± 0.29	2.48 ± 0.21	ns
C6	2.24 ± 0.15	2.21 ± 0.06	2.22 ± 0.21	2.42 ± 0.21	ns
C8	2.19 ± 0.11	2.28 ± 0.09	2.67 ± 0.26	2.43 ± 0.26	ns
C10	7.93 ± 0.3	8.17 ± 0.44	9.83 ± 0.83	8.94 ± 0.55	ns
C12	4.45 ± 0.16	4.65 ± 0.29	5.41 ± 0.38	4.96 ± 0.23	ns
C14	12.81 ± 0.28	12.55 ± 0.27	13.08 ± 0.38	12.70 ± 0.36	ns
C16	36.72 ± 1.1	35.04 ± 1.17	33.94 ± 1.01	35.16 ± 0.96	ns
C16:1	1.64 ± 0.12	1.61 ± 0.07	1.47 ± 0.09	1.66 ± 0.37	ns
C17	0.61 ± 0.1	0.60 ± 0.03	0.67 ± 0.06	0.74 ± 0.16	ns
C17:1	0.47 ± 0.1	0.43 ± 0.03	0.40 ± 0.02	0.40 ± 0.03	ns
C18	7.50 ± 0.38	8.07 ± 0.12	7.32 ± 0.33	7.86 ± 0.65	ns
C18:1	17.63 ± 0.68	19.26 ± 0.46	17.09 ± 1.07	17.13 ± 0.41	ns
C18:2	2.08 ± 0.16	2.06 ± 0.05	2.26 ± 0.22	1.92 ± 0.07	ns
C18:3	0.21 ± 0.04	0.15 ± 0.02	0.22 ± 0.04	0.30 ± 0.15	ns
C20	0.26 ± 0.06	0.22 ± 0.02	0.21 ± 0.03	0.21 ± 0.02	ns
C20:1	0.37 ± 0.05	0.30 ± 0.03	0.34 ± 0.03	0.28 ± 0.03	ns
C22	0.07 ± 0.01	0.06 ± 0.01	0.22 ± 0.11	0.10 ± 0.04	ns
C24	0.11 ± 0.03	0.10 ± 0.03	0.13 ± 0.03	0.11 ± 0.03	ns
SFA[1]	77.29 ± 0.93	76.26 ± 0.51	78.19 ± 1.34	78.12 ± 0.48	ns
USFA[2]	22.39 ± 0.81	23.81 ± 0.47	21.77 ± 1.31	21.67 ± 0.56	ns

Mean ±Std. Error
Means in the same row with different superscripts differ significantly (P<0.05)
* P < 0.05, ns – not significant
[1] Saturated fatty acid
[2] Unsaturated fatty acid

Ganjkhanlou et al. (2009) evaluated the production response of early lactating cows fed alfalfa hay (as forage) to rumen-protected fat (Ca-PFA). They found that supplementation of early lactating diet with decreased feed intake but without altering milk production, milk composition and body weight, thus improved milk efficiency. Other studies indicated that cows that were fed corn and alfalfa silage with Ca-PFA produced more milk than cows fed control diet or diets with hydrogenated triacylglycerides from palm oil (HPO) due to higher digestibility of long chain fatty acids from Ca-PFA, which increases the concentration of digestible energy in diets, compared to HPO (Weiss & Wyatt, 2004). Adding 200–300g supplemental Ca-PFA in wheat straw based diets fed to buffaloes to increase its energy density without adversely affecting DM intake and digestibility was proposed by Naik et al. (2009).

Regarding feeding of ewes and does with Ca-PFA, a study was carried out to evaluate the effect of feeding a dry fat source with alfalfa hay and cereal straw as roughage to seasonal ewes and does on their postpartum reproductive performance. It was reported that supplemental fat to ewes at 3% during their postpartum period could improve their milk production and affect live weight change during that period with no effect on weaning weight or litter weight of lambs (Titi et al., 2008). Moreover, Ca salt supplementation can improve milk production of lactating ewes, growth rate of their lambs, and produce healthy quality value milk (Titi & Obeidat, 2008). Furthermore, addition of Ca-PFA to the diet of dairy ewes fed alfalfa hay, rice hulls and soybean hulls as roughages increased milk fat content over the entire lactation period, and milk fat yield in the first half of lactation. The relative milk fat yield response from dietary

Ca-PFA to milk varied by feeding level and stage of lactation (Casals et al., 2006). Adding of Ca-PFA in the concentrate fraction of diets for lactating goats fed alfalfa hay as roughage gives rise to a good digestive utilization of the diet together with improved N and metabolizable energy utilization for milk production (Sanz et al., 2002).

Reddy et al. (2003) examined the effect of using protected fat as a supplement source of energy in straw-based diets for small ruminants. It was found that inclusion of Ca-PFA at 0.10 level in the diet of sheep improves the nutrient utilization without affecting the dry matter intake from straw-based diets in Deccani sheep.

Supplementation of rumen-protected methionine improved dairy performance and promoted amino acid utilization in lactating cows. The optimal level of rumen-protected methionine (RPMet) in the diet was 42 g /cow/ day (Yang et al., 2010). Furthermore, RPM addition to diets increased production of total milk protein, whereas, dry matter intake and milk fat percentage were slightly decreased, whereas milk production was slightly increased (Patton, 2010). In another research, it was reported that methionine improved metabolic protein utilization, followed by the lowest plasma, urine and milk urea levels in the supplemented low protein diet. Supplementation of methionine may nevertheless be useful in rations with particularly low protein content fed to early lactating cows in order to prevent negative long-term effects (Kröber et al., 2000). However, other investigators found that high producing dairy cows fed a diet that was adequate in CP responded to rumen protected lysine and methionine primarily with increased production of milk protein and fat throughout the full lactation (Robinson et al., 1994).

Related to usage of a combination of two types of feed additives (Ca-PFA and RPMet), a study assessed their adding effects on dry matter intake, milk yield and composition and on selected reproductive parameters starting two weeks post-partum through week seventeen of lactation. Overall results suggest that the use of 700 g of calcium salts of CA-PFA/cow/day in the concentrate supplement improves major reproductive indices and milk yield of high producing dairy cows during early lactation, and that adding rumen protected methionine (40 g/cow/day) to Ca-PFA not only helps alleviate the milk protein depression commonly observed with added fat, but further improves the performances of cows (Ben Salem & Bouraoui, 2008).

Effect of yeast culture (*Saccharomyces cerevisiae)* inclusion in ruminant rations (dairy cattle, sheep, goats, lambs and calve) on their performance was studied by many researchers (Callaway & Martin, 1997; Ahmed & Salah, 2002; Guedes et al., 2008; Marden et al., 2008; Lascano & Heinrichs, 2009). The three main effects that have been identified are; improvement of rumen maturity by favoring microbial establishment (Callaway & Martin, 1997), stabilization of ruminal pH and interactions with lactate-metabolizing bacteria (Guedes et al., 2008; Marden et al., 2008), and increase of fiber degradation and interactions with plant–cell wall degrading microorganisms (Chaucheyras-Durand et al., 2008; Guedes et al., 2008). Some studies suggested that yeast culture provides soluble growth factors (i.e., organic acids, B vitamins, and amino acids) that stimulate growth of ruminal bacteria that utilize lactate and digest cellulose (Callaway & Martin, 1997). The positive effect of adding yeast was obvious in present study in reducing significantly blood ammonia of ewes fed AYSTRW, which may be related to improving rumen culture and ecology. However, additional cost of adding yeast as feed additive was not covered by convenient increase in milk production and or weight increase.

4.3 ***Aqueous ammonia for enhance barley straw***

Many attempts have been conducted to improve the nutritive value of cereal straw using aqueous ammonia. Kiangi et al. (1981) investigated the effectiveness of aqueous ammonia (NH_4OH) for treating maize stover, rice and wheat straws. They found that NH_4OH had a similar effect as anhydrous NH_3 in improving dry mater and organic matter in-vitro digestibility of maize stover, rice and wheat straws. In another study, chopped cereal straw was treated with NH_4OH (12 liters of 25% NH_3 by weight/100 kg straw) and that increased significantly the in vitro organic matter digestibility (53.9% versus 40.2% of the control) and the content of N x 6.25 (104 versus 37 $g.kg^{-1}$ dry matter (DM) of the control) (Hadjipanayiotou et al., 1993). Oji et al. (2007) investigated changes in chemical composition and nutritive value of maize residues treated with urea and aqueous ammonia. They found that treatment improved ($P < 0.05$) intake and digestion coefficients for N, DM, NDF, ADF and OM but there were no differences ($P > 0.05$) between aqueous NH_3 and urea treatments.

Conclusion

The current results indicated that feeding barely straw as roughage supplemented with calcium salts and protected methionine is sufficient for Awassi ewes produced modest milk level, without any detrimental effects on animal performance and with maintain milk production and quality. The application of these results will contribute to sustainable sheep farming in hot dry areas by decreasing feeding cost and increasing overall profit in case of lack of alfalfa hay availability. Further studies are needed to examine the effect of the complementary method of enhancing straw in feeding highly milk producer ewes with average daily milk exceed 1.5 kg per day including improved Awassi ewes.

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Conflict of interest

The authors declare that they have no conflict of interest.

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