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Forage Supplementation Feeding of Lactating Merino Ewes in Dry Season at the Foothills Agro-ecological Zone in Lesotho

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Authors' contributions

This work was carried out in collaboration among all authors. Author MLR performed the feeding trial, data collection and analysis, interpretation of results and wrote the first draft of the manuscript. Author OIAO supervised the study, verified data collected and handled manuscript preparation. Author NK designed the study and feeding measurements. Author M. Mahlehla was in charge of overall field data collection. Author PM handled fodder production. Author SM was responsible for travel and logistics. Authors L. Moea, L. Mochoa, ML and M. Mantsoe were responsible for data collection and selection of participating farmers. All authors read and approved the final manuscript.

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ABSTRACT

A farmer-participatory research, which lasted for seven weeks, was carried out at Machache, in the Foothills Agro-Ecological Zone of Lesotho to examine the effect of forage based diets supplementary feeding on the performance response and milk quality of lactating ewes during dry lambing season. A total of 270 lactating merino ewes were randomly distributed among four dietary treatments: basal diet (T1) which was the range land pasture used as control, cereal forage based diet (T2), leguminous forage based diet (T3) and mixed forage based diet (T4). The feed value of the supplementary diets T2 (4.70% CP and 9.94MJ/kg ME), T3 (12.31% CP and 10.27 MJ/kg ME), T4 (11.90% CP and 10.47 MJ/kg ME)] was superior to that of the range land pasture T1 (2.80% CP and 8.61MJ/kg ME). Ewes on forage supplemented diets performed significantly (P<0.05) better than the control group in feed intake, live body weight and live weight change. The milk quality evaluation showed that solids-non-fat (SNF), protein and lactose were highly significant (P<0.05) for T3 and T4 than T1 and T2 which had high milk fat. The study revealed that diets T1 and T2 lacked the nutritional capacity to meet the nutrient requirements of lactating ewes as evidenced by slight body weight improvement. It is concluded that supplementary diets T3 (leguminous forage based diet) and T4 (mixed forage based diet) contained adequate nutrients that can meet the requirement of lactating ewes during dry lambing season. This was verified by high voluntary feed intake and good nutrients utilization as resulted by improving of body weight and high milk quality response of lactating ewes.

Keywords: Dry season; ewes; merino; milk quality; supplementary forages.

1. INTRODUCTION

The production of sheep in the Kingdom of Lesotho suffers from seasonal feed shortage either in the form of pasture or fodder during dry seasons (winter/spring) [1,2]. The use of forage-concentrate supplement strategy is not yet popular among small livestock farmers in the country. Ruminant animal feeds are in abundance during the rainy seasons of summer and autumn and tend to become increasingly scarce in supply in winter and spring, when available feeds are of very low nutritional value. Nutrient requirements of ewes vary with differences in age, body weight and stage of production [3,4]. The potentials of cultivated crops are not optimized by small livestock after harvest because, they graze heavily for some time and experience hunger as time dovetails into summer. Drought sets in country-wide mid-June up to early-December and dependence of grazing animals on the pasture as a main source of forage is adversely affected.

Nutrient requirements are lowest for ewes during maintenance, increase gradually from early to late gestation, and are highest during lactation. During the dry winter/spring seasons, forages can be provided to the flock when pastures are inadequate, and grain may be added to the diet at certain stages of production when additional nutrient supplementation is required. Ewe body weight does not remain constant throughout the year, but a change with stage of production [5,6] hence feeding management is improved significantly by knowing ewe body weight.

The lactation phase is a critical period in ewes' production cycle since most lactating ewes' exhibit a negative energy balance in early lactation [7,8]. This is due to their voluntary feed intake which is insufficient to meet the demands for increasing milk yield. Over this period, the ewe will mobilize body reserves, particularly body fat, in support of milk production [9]. Failure to supplement ewes accordingly results in excessive body weight loss, low milk production; poor mothering ability and poor lamb gains [8]. In order to encourage supplementary forage-concentrate diet among farmers, a feeding trial study was conducted in the Foothills Agro-Ecological zone in the Kingdom of Lesotho to determine the effect of supplementary forage-concentrate diets on the production performance and milk quality of lactating ewes during critical production cycle which coincides with period of feed scarcity.

2. MATERIALS AND METHODS

2.1 Study Area

An on-farm study was conducted at the Machache area in Maseru District representing the Foothills, one of the four agro-ecological zones (Lowlands, Foothills, Highlands, and

Senqu River Valley) in Lesotho. Machache is located at south east, about 40km away from Maseru, the nation's capital city. Machache and Bushman shearing sheds within the Machache area were covered. The Foothills agro-ecological zone has defined soil structure suitable for agriculture. However, the country has a temperate climate which is marginally suitable for arable crop production, as it experiences erratic and spatially variable rainfall [10-12] ranging from 500 mm to approximately 1,200 mm per year in a few locations in the northern and eastern parts of the country [13].The Foothills cover an area of 344, 660 hectares or 31%, of which only 59,365 ha is suitable for crop production, with a larger portion of the remaining 69% being occupied by range land. It lies at elevations of 1800 m to 2000 m above the sea level and, that forms a divide between the Lowlands and the Highlands [14].

2.2 Forage Production and Processing

Forage production was done at the Ha-Matela sub-centre, where improved forage seeds were cultivated. These were cereal seeds of maize and fodder sorghum and, leguminous seeds of lab-lab and vetch. The vegetative parts of the cereal seeds were harvested at maturity stage (24 weeks after planting for both maize and sorghum) together with their grains using sickles and stored in the form of haystack to be dried. The leguminous forage was harvested at seeding stage (15 weeks after planting for both lab-lab and vetch) and allowed to wilt under the sun and dried under store shade. After drying process, each of the cereal and leguminous forages was separately milled with hammer mill and stored in nylon bags before ration formulation.

2.3 Experimental Diets

There were four (4) dietary treatments consisting of the control diet (T1) which was the range land pasture (basal diet) and, three supplementary diets namely cereal forage based diet (T2), leguminous forage based diet (T3) and mixed forage based diet (T4), as shown in Table 1. Concentrate ingredients (maxiwol, sunflower seed, corn hominy chop and yellow maize) and urea molasses mineral block (UMMB) were added at 14.04 % and 8.77 %, respectively to each of experimental diets T2, T3 and T4.

Table 1. Composition of the Experimental Diets for Ewes

Ingredients (%)	Experimental Diets			
	T1	T2	T3	T4
Range land pasture	***Ad libitum***	***Ad libitum***	***Ad libitum***	***Ad libitum***
Cereal forages				
Turf	0	35.09	0	0
Corn stover	0	21.05	0	0
Sorghum hay	0	21.05	0	0
Legume forages				
Alfalfa hay	0	0	29.82	0
Lablab hay	0	0	17.55	0
Vetch hay	0	0	29.82	0
Mixed forages				
Turf	0	0	0	19.30
Corn stover	0	0	0	10.53
Sorghum hay	0	0	0	10.53
Alfalfa hay	0	0	0	19.29
Lablab hay	0	0	0	8.77
Vetch hay	0	0	0	8.77
Concentrates				
Maxiwol	0	4.21	4.21	4.21
Sunflower seed	0	3.51	3.51	3.51
Corn hominy chop	0	3.51	3.51	3.51
Yellow maize	0	2.81	2.81	2.81
UMMB	0	8.77	8.77	8.77
Total	0	100.00	100.00	100.00

Range land pasture grazed by the experimental ewes contained a combination of; Dactylotenium aegytium (L.) Wild, Eragrostis capenisis, Eragrostis curvula, Eragrostis racemosa, Fascuca ovina, Hyparrhenia hirta, Nassella trichotoma, Themeda triandra
UMMB = Urea molasses mineral block in the form of mineral lick
T1 = Basal diet of range land pasture grazed
T2 = Cereal forage + Concentrate + UMMB + Grazed pasture
T3 = Legume forage + Concentrate + UMMB + Grazed pasture
T4 = Cereal forage + Legume forage + Concentrate + UMMB + Grazed pasture

2.4 Experimental Animals, Management and Design

The experimental design was an on-farm farmer-participatory feeding trial with lactating merino sheep ewes. A total of 270 lactating merino sheep ewes contributed by 27 stratified farmers at the rate of 10 lactating ewes per farmer were used. The ewes were between two to three years old, and were selected randomly and grouped into four dietary groups T1, T2, T3 and T4. The control group fed basal diet had 54 ewes with 18 animals per replicate and, each of the supplemental diet groups had a total of 72 animals with 24 animals per replicate. The difference in the number of the experimental animals in the control group as against the supplementary dietary treatments was because farmers were reluctant to provide equal number of ewes per dietary treatment group, because of the anticipated poor performance response from animals placed on the basal diet (control).

The experiment was a Completely Randomized Design. All experimental animals were identified using plastic ear tags. The ewes on supplemented diets were each offered 600g supplementary diet per week at the rate of 200g each on Mondays, Wednesdays and Fridays between the hours of 08:00 to 09:00 before they were released to graze. The feeding trial lasted seven weeks during which the growth performance and milk yield of the ewes were evaluated and milk quality was also determined. The entire flock of ewes was used for the growth performance while, 108 ewes at the rate of nine ewes per replicate was used for milk assessment.

2.5 Experimental Data

2.5.1 Composition of experimental diets

The proximate composition of samples of the pasture and supplementary diets was determined using the standard methods [15]. Detergent fibre analysis was done to determine neutral detergent fibre (NDF) and acid detergent fibre (ADF) by refluxing method [16], crude protein (CP) by Kjeldahl method and phosphorus (P) by spectrophotometric method [16]. Dry matter digestibility (DMD), dry-matter intake (DMI) and total digestible nutrients (TDN) of forage feed samples were predicted according to [17] using the formula; DMD % = 88.9 – (ADF% x 0.779), DMI% = 120 ÷ NDF% and TDN% = 88.9 – (0.79 x ADF %). Metabolisable energy (ME) level was derived using the formula; ME (MJ/kg DM) = 0.17×DMD% - 2.0 [18].

2.5.2 Production performance

The supplemental feed intake and live body weight of the ewes were collected weekly with the use of electronic weighing scales. The supplemental feed intake was estimated as the amount of feeds offered less the unconsumed feed. Body weight gain (BWG) was calculated as the difference between final body weight (BW_f) and initial body weight (BW_i); i.e. $BWG = BW_f – Bw_i$.

2.5.3 Milk sample collection and analysis

Milk samples were collected twice; at early lactation peak (4th week of lactation) and late lactation peak (7th week of lactation) during the feeding trial by hand milking. An average of 40 ml milk was collected per ewe into labelled sample specimen bottle and kept in cooler box with ice pack. Samples were taken to the laboratory within 24h of collection for a rapid milk test analysis using automated Milkana Multi-Test Analyser which determined fat, solids-non-fat (SNF), protein and lactose contents.

2.6 Data Analysis

The data collected were subjected to one-way analysis of variance (ANOVA) using the IBM Statistical Package for Social Science version 20 [19] at 95% significant level to detect statistical significances among dietary treatments. Normality test for normal distribution and Levene test of homogeneity for equality of variances were tested. The differences among mean treatment groups were separated using Duncan test at p<0.05 [20].

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Experimental Diets

The nutrient composition of the experimental diets is presented in Table 2. The result revealed that supplemental diets T3 and T4 were significantly (p<0.05) superior than T2 and T1 in CP, DMD, TDN and ME. There was also a decline in DM and P for T1 which varied significantly (p<0.05) from T2, T3 and T4. However, T1 did not differ (p>0.05) significantly from the supplementary diets T2, T3 and T4 in ADF and DMI, while T2 was significantly (p<0.05) higher in NDF. High nutrient density in CP, DMD, TDN and ME indicated good quality of the supplemental diets, but high NDF in T2 caused a reduction in voluntary DMI. NDF is related to voluntary feed intake thus, the lower the NDF, the more an animal eats and conversely, the higher the NDF, the lower the intake [21]. The high NDF content of cereal forage diet (T2) signified that it lacked the nutritive ability to support the high nutritional needs of lactating ewes.

The minimum requirement needed for rumen microbes to function is 8% [22], while according to [23], the crude protein requirement for lactating ewes estimated between 12 and 18% CP. However, the dietary CP in T1 and T2 were lower than the minimum requirement but, the dietary CP in T3 and T4 seemed to have met the protein requirement of lactating ewes. It has been found that lactation greatly increases energy requirements, and peaks at around 25 days after lambing, whereby the energy requirements (MJ/head/day) for maintaining ewes during lactation ranged between 11.8 and 19.2 MJ ME/kgDM [24].

3.2 Performance of Ewes

The result for feed intake is shown in Table 3. There was significant (p<0.05) difference between the supplementary groups. The ewes in T1 had access only to pasture. The feed intake was significantly (p<0.05) lower in T2 (508.08g/kg), compared to T3 (600.00g/kg) and T4 (600.00g/kg), and they did not differ significantly (p>0.05). The result might be caused by the high NDF levels in T2. High NDF content in animal feeds is a feed intake inhibitor which limits the quantity of feeds consumed by the animal. It has been stated that NDF or total fibre influences level of intake and high levels limit intake, but minimum levels are necessary to maintain a healthy rumen environment in ruminants [25]. It is the fibre in the diet that stimulates rumination, chewing, and saliva production. A minimum dietary NDF content range from 25 to 28% dry matter basis for lactating ruminants has been recommended [26].

There was significant (p<0.05) difference in body weight gain among the dietary treatments. The body weight gain for T1 (0.72 kg) and T2 (1.56 kg) was significantly (p<0.05) lower than body weight gain for T3 (2.60 kg) and T4 (2.89 kg). The body weight gain in T1 and T2 was not significantly different, and similarly, body weight gain in T3 and T4 did not vary significantly (p>0.05). The low body weight gain in ewes in dietary groups T1 and T2 was possibly due to the relatively low dietary CP and energy in the basal and cereal forage based diets. This probably put the ewes in poor conditions, since CP is a necessary building block for body tissue and muscle growth, while energy is essential for body maintenance, milk production and daily activities of the animal. The small body weight changes possibly showed that the ewes were under critical challenge of using body reserves for their survival.

It has been reported [27] that supplementary feeding is important for the supply of additional feed (usually grain or hay) to the sheep grazing a pasture or stubble that is lacking in energy or protein. It has been known that the majority of animal tissues and organs need proteins and other elements as their building blocks [28]. Therefore, proteins in animal nutrition are needed for the growth and regeneration of tissues. They are usually the most expensive nutrients in animals' diets and they cannot be replaced by any other nutrient.

3.3 Milk Quality

The effect of the experimental diets on milk composition of lactating ewes is presented in Table 4. There was significant (p<0.05) difference in milk composition of the lactating ewes among the treatment groups. The results revealed that the milk quality from the ewes on the supplemental diets T2, T3 and T4 was better compared to the control group (T1) in protein, SNF and lactose. However, lactating ewes in the control group had higher milk fat content compared to the ewes fed the supplemental diets. This showed that the NDF and ADF in the basal diet were utilized effectively by lactating ewes to synthesis milk fat. The experimental ewes in T4 had low milk fat during late peak which might have been influenced by low ADF in the supplemental diet. It has been reported by [29] that fibrous sources of energy tend to increase milk fat content because cellulolytic bacteria in the rumen produce mainly acetate, which is a precursor for fatty acid synthesis in the mammary gland.

Table 2. Chemical composition and calculated values of experimental diets (Mean ± SE)

Parameters	Treatments				P - value
	T1	T2	T3	T4	
DM (%)	91.50^{b}±0.50	93.00^{a} ±0.00	93.00^{a}±0.00	93.00^{a}±0.00	0.030
CP (%)	2.80^{b} ±0.24	4.70^{b} ±0.90	12.31^{a} ±3.29	11.90^{a}±1.00	0.040
NDF (%)	58.00^{b} ±5.00	82.50^{a}±7.50	53.00^{b} ±0.00	60.50^{ab}±7.50	0.048
ADF (%)	34.00^{a} ±1.00	24.00^{a} ±11.00	21.50^{a} ±8.50	20.00^{a} ±7.00	0.622
P (%)	0.07^{d} ±0.00	0.13^{b} ±0.00	0.15^{a} ±0.00	0.12^{c} ±0.00	0.001
DMI (%)	2.08^{a} ±0.18	1.46^{a} ±0.13	2.26^{a} ±0.00	2.01^{a} ±0.25	0.102
DMD (%)	62.42^{d} ±0.00	70.21^{c} ±0.00	72.15^{b} ±0.00	73.32^{a} ±0.00	0.001
TDN (%)	62.04^{d} ±0.00	69.94^{c} ±0.00	71.92^{b} ±0.00	73.10^{a} ±0.00	0.001
ME (MJ/kg)	8.61^{d} ±0.00	9.94^{c} ±0.00	10.27^{b} ±0.00	10.47^{a} ±0.00	0.001

^{a,b,c,d} Means in the same row with different superscripts differ at p<0.05
P = Probability at 0.05%
SE = Standard error
T1 = Basal diet consisting of range land pasture
T2 = Cereal forage + Concentrate + UMMB + Grazed pasture
T3 = Legume forage + Concentrate + UMMB + Grazed pasture
T4 = Cereal forage + Legume forage + Concentrate + UMMB + Grazed pasture

Table 3. The Effect of Experimental Diets on Ewes performance (Mean ± SE)

Parameters	Treatments				P - value
	T1	T2	T3	T4	
Initial BW (kg)	33.28	33.54	34.80	30.21	
Final BW (kg)	34.00^{bc}±0.50	35.10^{b}±0.67	37.40^{a} ±0.37	33.10^{c} ±0.41	0.001
Feed intake (g/kg)	0.00^{c}±0.00	508.08^{b}±7.29	600.00^{a}±0.00	600.00^{a}±0.00	0.001
Body weight gain (kg)	0.72^{b} ±0.11	1.56^{b} ±0.17	2.60^{a} ±0.40	2.89^{a} ±0.48	0.001

^{a,b,c} Means in the same row with different superscripts differ at p<0.05
P = Probability at 0.05%
SE = Standard error
T1 = Basal diet consisting of range land pasture
T2 = Cereal forage + Concentrate + UMMB + Grazed pasture
T3 = Legume forage + Concentrate + UMMB + Grazed pasture
T4 = Cereal forage + Legume forage + Concentrate + UMMB + Grazed pasture

Table 4. The Effect of Experimental Diets on the Milk quality of Ewes (Mean ± SE)

Milk indices (%)	Treatments				P – value
	T1	T2	T3	T4	
Fat at early peak	10.71^{a} ±1.63	10.11^{a} ±0.47	7.98^{a} ±0.99	9.07^{a} ±0.39	0.256
Fat at late peak	9.63^{a} ±0.39	7.84^{ab}±1.07	7.15^{ab}±1.30	4.28^{b}±0.75	0.003
SNF at early peak	7.93^{c}±0.43	9.46^{b}±0.10	10.47^{a} ±0.16	10.19^{ab}±0.39	0.001
SNF at late peak	8.93^{b}±0.40	10.14^{ab}±0.41	11.13^{a} ±0.27	11.14^{a} ±0.19	0.001
Protein at early peak	3.25^{c}±0.33	4.46^{b}±0.07	5.25^{a} ±0.12	5.04^{ab}±0.12	0.001
Protein at late peak	4.02^{b} ±0.32	4.98^{ab}±0.32	5.78^{a} ±0.20	5.73^{a} ±0.14	0.001
Lactose at early peak	4.06^{b}±0.08	4.24^{ab}±0.22	4.39^{a} ±0.04	4.33^{a} ±0.02	0.001
Lactose at late peak	4.20^{b}±0.05	4.35^{ab}±0.06	4.45^{a} ±0.05	4.52^{a} ±0.03	0.001

^{a,b,c} Means in the same row with different superscripts differ at p<0.05
P = Probability at 0.05%
SE = Standard error
T1 = Basal diet of range land pasture grazed
T2 = Cereal forage + Concentrate + UMMB + Grazed pasture
T3 = Legume forage + Concentrate + UMMB + Grazed pasture
T4 = Cereal forage + Legume forage + Concentrate + UMMB + Grazed pasture

Milk fat content can decline significantly if the diet is too low in fibre, a condition called milk fat depression (MFD). Milk fat depression occurs by altering rumen fermentation that causes production of conjugated linoleic acid, a bioactive fatty acid, which inhibits fatty acid synthesis [30]. According to [31], lack of adequate energy in the ration can cause a fall in SNF and protein content of the milk, and the use of high energy with low fibre rations would be expected to produce milk with better-than-average SNF. It has been observed reported that the concentration of milk protein is highest in early and late lactation, and lowest during peak of lactation through mid-lactation, and found that dietary crude protein level affects milk yield but not milk protein percentage, unless the diet is deficient in crude protein [32]. It was observed in this study that the percentage lactose in milk at both early and late peak lactation increased as the dietary energy consumed by the ewes increased. This is consistent with earlier findings that the amount of energy consumed, density of energy in the diet, and the source of energy in the diet all influence milk lactose percentage and yield [33,34].

4. CONCLUSION

The result obtained in this study revealed that T1 (the basal diet) which consisted of 100% range land pasture and treatment T2 made up of 77.64% cereal forage were unable to meet the nutritional needs of lactating ewes during dry season as evidenced by nutritional indicators of low feed intake, low weight change, and low milk quality. Diets T3 and T4 were high in CP and ME, and it proved seemed adequate as supplementary diets for the lactating ewes to maintain and improve ewes' performance in terms of their production response and milk quality. Thus, supplementary diets T3 (leguminous forage based diet) and T4 (mixed forage based diet) are recommended for lactating ewes during dry periods, when dry matter yield and nutritive value in the range land and grazing pastures are low.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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