The effect of lucerne *(Medicago sativa)* hay quality on milk production and composition of Jersey cows

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Abstract

The influence of lucerne hay quality on the milk production potential and milk composition of Jersey cows was investigated. Three different grades of lucerne hay (Prime, Grade 1, Grade 2; selected according to the New Lucerne Quality Index) were included in a total mixed ration (TMR) and fed to lactating cows. The three dietary treatments consisted of the same basal diet (53% lucerne hay, 7% wheat straw and 40% concentrate), differing only with respect to the lucerne hay quality. Fifty-seven lactating Jersey cows (389 ± 39.07 kg) were selected and blocked according to production potential (milk production, days in lactation, as well as lactation number) and randomly allocated to each of the dietary treatments (n = 19 animals per treatment). After a dietary adaptation period of 14 days, each treatment received their respective diets for the remaining period of 54 days. Average dry matter intake (DMI) and individual milk production was measured on a daily basis and production parameters were calculated accordingly. Milk composition samples were collected every second week. Grade 2 lucerne hay significantly decreased the voluntary DMI of the cows. However, the Prime lucerne hay significantly increased the metabolizable energy intake (MEI), as well as both the protein and milk urea nitrogen (MUN) content of the Jersey milk, compared to the Grade 1 and Grade 2 treatments. In contrast, the efficiency with which ME is utilized for milk production was significantly decreased following Prime lucerne hay inclusion. Milk yield as such was not affected by dietary treatment. Results of the present study seem to indicate that lucerne hay quality does affect the production performance, milk composition and efficiency of energy utilized for milk production purposes of Jersey cows.

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Introduction

Roughage quality is a major challenge for lucerne hay producers. The demand for high quality lucerne hay as a primary roughage source for the dairy industry has grown significantly since the 1970's, due to the fact that the milk production potential of dairy herds has increased considerably. These high-producing cows generally have a restricted rumen capacity and require roughage of excellent nutrient content, which is often highly digestible and palatable. Lucerne hay *(Medicago sativa)* is such a typical high quality roughage source and therefore its demand has increased (Orloff & Putnam, 2007). Roughage quality can be evaluated by its palatability (voluntary intake), apparent digestibility, nutrient content and anti-nutritional factors (Lemus, 2009). Although the voluntary intake of roughage is one estimate of its quality, the chemical composition is closer related to its digestibility than voluntary intake (Van Soest, 1965). Nutritionists agree that roughages with a high digestible energy and protein content, compared to lower quality roughages, could result in an increased intake potential, with a resultant favourable animal production and milk composition (Orloff & Putnam, 2007).

Scholtz *et al*. (2009) evaluated different parameters used to assess lucerne hay quality and found large differences in the accuracy of the predictions. Assessment was performed by evaluating the milk yield of the dairy herds. It was found that within these diets, the acid detergent fibre (ADF) content of lucerne hay, as the primary roughage source, was the best parameter to predict potential milk yield. Therefore, by including ADF, ash and lignin in a multiple linear regression equation, Scholtz *et al*. (2009) found that the accuracy of milk yield prediction improved remarkably. It was further concluded that protein is a poor

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indicator of milk yield – hence the protein content of lucerne hay may not be a reliable indicator of its quality. The aim of this study was therefore to investigate the effect of lucerne hay quality on the milk production potential and characteristics of Jersey cows fed a total mixed ration (TMR).

Materials and Methods

Ethical clearance was obtained for all procedures conducted during this study (DECRA number R12/64). The research was conducted from July to September 2012 at the Outeniqua Research Farm (Longitude 22º 25.222'E, Latitude 33º 58.702'S) near George in the Western Cape, South Africa. Three treatment diets (consisting of 53% lucerne hay, 7% wheat straw and 40% concentrate; Table 1) were formulated according to NRC (2001) nutrient requirements for dairy cows. The dietary treatments differed only with respect to the grade of lucerne hay included, selected according to the New Lucerne Quality Index

Table 1 Chemical composition and particle score of treatment diets fed to Jersey cows differing in lucerne hay quality (n = 4)

	*Treatment		
Parameter (% of DM)	**Prime**	**Grade 1**	**Grade 2**
Dry matter	94.3	94.8	94.9
Crude protein	18.5	14.7	12.0
Soluble protein	6.56	5.18	4.35
Rumen degradable protein	12.6	9.90	8.234
#ADICP	1.04	1.49	1.29
#NDICP	1.49	1.85	1.77
Acid detergent fibre	19.6	28.4	35.8
Neutral detergent fibre	28.0	37.8	47.1
Lignin	4.19	6.03	7.47
Starch	19.1	17.4	15.3
Fat	3.36	2.85	2.59
Total digestible nutrients	69.9	63.9	59.8
Metabolizable energy (MJ/kg)	11.2	10.0	9.25
#PSPS score top compartment (19 mm sieve) (%)	6.7	14.6	11.7
#PSPS score middle compartment (8 mm sieve) (%)	25.2	27.2	38.0
#PSPS score bottom compartment (%)	68.2	58.2	50.4
Ash	8.43	8.24	6.94
Calcium	0.81	0.89	0.67
Phosphorus	0.35	0.33	0.27
Magnesium	0.28	0.26	0.26
Potassium	2.14	1.98	1.53
Sulphur	0.22	0.16	0.14
Sodium	0.29	0.20	0.21
Chlorine	0.66	0.62	0.62
Iron	485	515	268
Manganese	68.0	47.5	38.3
Zinc	65.5	61.5	55.8
Copper	14.8	13.3	11.8

* Presented as a total mixed ration (TMR) and lucerne hay quality evaluated according to the New Lucerne Quality Index (NLQI).
# ADICP = Acid detergent insoluble crude protein, NDICP = Neutral detergent insoluble crude protein, PSPS = Penn State Particle Size Separator.

(NLQI) (Van der Merwe & Scholtz, 2011), i.e. Prime, Grade 1 and Grade 2. The nutrient composition of the three lucerne hay grades used, as analysed by near infrared spectroscopy (NIRS), is set out in Table 2. The concentrate was composed of maize meal, hominy chop, wheat bran, salt and a mineral premix. The concentrate included in the Grade 2 treatment contained additional urea to ensure that the crude protein (CP) requirement of the cows was met. Each diet's particle size was evaluated by using the Penn State Particle Size Separator (PSPS; Nasco, Fort Atkinson, Wisconsin, USA), as described by Lammers *et al*. (1996) (Table 1).

Fifty-seven multiparous Jersey cows, with an average body weight of 389 ± 39.07 kg, were selected and blocked into groups, according to similar production potential: milk production, days in lactation, as well as the lactation number. Thereafter, animals within each group were randomly allocated to each of the three treatment diets (n = 19 cows per treatment). Each treatment was then further randomly subdivided into four replicates consisting of five animals each (one replicate within each treatment containing four animals) and allocated to 12 pasture camps set aside for the study. Each individual cow's body condition score (BCS) was determined according to the five-point system as described by Wildman *et al*. (1982), at the onset and end of the trial period.

Table 2 Chemical composition and quality index (NLQI) of lucerne hay as measured by near infrared spectroscopy (NIRS)

	***Treatment**		
Nutrient (% of DM)	**Prime**	**Grade 1**	**Grade 2**
Dry matter	89.5	88.8	93.0
Crude protein	26.7	22.9	19.9
Ash	8.89	11.7	6.22
Acid detergent fibre	24.8	32.7	37.9
Neutral detergent fibre	29.1	40.8	49.3
Lignin	4.86	6.69	8.31
New Lucerne Quality Index	115	103	98.5

*Lucerne hay quality evaluated according to the New Lucerne Quality Index (NLQI).

Following a dietary adaptation period of 14 days, each replicate received their respective treatment diets for the remaining period of 54 days. All the animals were fed a predetermined quantity of feed, calculated according to a 15% refusal rate of the average intake of the preceding three days. The average dry matter intake (DMI) of each replicate, as well as the individual milk production was measured on a daily basis. Production parameters were calculated accordingly. Composite milk samples were collected every second week and stored pending chemical analysis. All cows also had free access to clean drinking water.

The data was subjected to a PROC MIXED analysis of the SAS program, version 9.2 (SAS, 2008). Treatment was treated as a fixed effect, block as a random effect and week as a repeated measurement. Tukey's honest significant difference (HSD) test was used to identify significant differences (P <0.05) between treatments.

Results and Discussion

The effect of lucerne hay quality on the production performance and milk composition of the Jersey cows fed diets containing alternate grades of lucerne hay are set out in Table 3. From the results it can be seen that the Grade 2 lucerne hay quality significantly decreased (P <0.05) the voluntary DMI of the cows. This decrease in DMI could probably be explained as owing to the high NDF content of the Grade 2 lucerne hay included (Tables 1 and 2), compared to the other two treatments. Beauchemin (1991) reported that when the NDF content of a diet increased, the time spent ruminating would increase, and negatively affect DMI. Other factors, such as palatability and digestible energy intake, may play an even greater role in the inhibition of intake when including lucerne hay in the diet of ruminants (Van Soest, 1965). However, Van Soest (1965) further stated that lucerne hay generally contains less fibre than other roughages, and this could result in increased intake levels due to its limited filling effect. In contrast, the significantly (P <0.0001) higher average metabolizable energy intake (MEI) of the cows fed the Prime lucerne treatment, compared to

Grades 1 and 2, was expected due to the higher ME and total digestible nutrient (TDN) content of this same treatment (Table 1).

The significant (P <0.0001) lower MEI, as affected by the Grade 2 treatment, may be associated with the decreased DMI, as well as the low ME content (Table 1) of the same diet. Lucerne hay quality did not have any significant effect (P >0.05) on any of the performance parameters measured (Table 3). This was despite the significant (P <0.05) effect of the Prime and Grade 2 treatments on the total amount of energy consumed (MEI), as well as DMI, respectively. Mertens (1997) explained that, apart from the lower energy density of the diet, milk production generally decreases as a result of a decreased feed intake – which may be a result of the dietary fibre content. This was, however, not the case in the present study. Nelson & Satter (1990) recorded a decrease in milk production (P <0.05), as the lucerne hay included in the diets for dairy cows increased in maturity, hence the corresponding NDF content. The efficiency with which dietary energy was utilized for milk production decreased (P <0.0001) following the Prime lucerne treatment (Table 3). This was probably as a result of sub-clinical acidosis. Due to a lack of physical effective fibre (NDF) early symptoms of sub-clinical acidosis could develop (Mertens, 1997), as a result of decreased rumination, saliva secretion and hence a lower buffering capacity. The PSPS score (Table 1) of the Prime treatment showed that this treatment did not contain enough course material to stimulate effective rumination. The percentage of material in the top sieve of the PSPS (>19 mm in length) should ideally be more than 10%.

Table 3 The effect of lucerne hay quality in total mixed diets on the production performance and milk composition of Jersey cows

Parameter	**[*]Treatment**			**[#]SEM**	**Significance (P -value)**
	Prime	**Grade 1**	**Grade 2**		
Feed intake:					
[#]DMI (kg/day)	19.5^{a}	19.6^{a}	17.9^{b}	0.28	0.01
[#]MEI (MJ/day)	204^{a}	167^{b}	153^{c}	2.76	<0.0001
Production Performance:					
Initial body weight (kg)	386	399	381	9.23	0.36
End body weight (kg)	403	420	407	10.03	0.46
Body weight change (kg)	+17.7	+21.1	+26.1	2.64	0.09
[#]BCS (Start)	2.11	2.04	2.08	0.03	0.38
[#]BCS (End)	2.41	2.29	2.28	0.07	0.32
[#]BCS (Change)	+0.31	+0.25	+0.20	0.05	0.31
[#]FCR (kg DM feed intake/kg milk yield)	1.02	1.02	1.02	0.04	0.99
[#]FCR (kg DM feed intake/kg 4% FCM yield)	1.03	1.02	1.03	0.03	0.95
Milk yield (kg/day)	19.8	19.9	18.2	0.73	0.25
4% [#]FCM yield (kg/day)	19.9	19.9	18.4	0.48	0.13
MJ [#]ME/kg milk yield	10.3^{a}	8.48^{b}	8.40^{b}	0.33	<0.0001
Milk composition (% fresh milk):					
Milk fat	3.99	4.00	4.12	0.11	0.66
Milk protein	3.69^{a}	3.52^{b}	3.53^{b}	0.05	0.04
Milk lactose	4.76	4.72	4.64	0.04	0.14
[#]SCC (X10^3)	207	196	293	44.3	0.25
[#]MUN (mg/dL)	15.9^{a}	13.5^{b}	13.5^{b}	0.42	0.0002

^{a,b,c} Means in the same row with different superscripts differ significantly (P <0.05).
[*] Presented as a TMR and lucerne hay quality evaluated according to the New Lucerne Quality Index.
[#]SEM = Standard error of the mean, DMI = Dry matter intake, MEI = Metabolizable energy intake,
BCS = Body condition score, FCR = Feed conversion ratio, FCM = 4% Fat-corrected milk yield,
ME = Metabolizable energy, SCC = Somatic cell count, MUN = Milk urea nitrogen.

Lucerne hay quality did not affect (P >0.05) the fat and lactose content, nor somatic cell count (SCC) of the milk (Table 3). A decreased ruminal pH due to low dietary fibre content can decrease the ratio of acetate to propionate, which in turn could cause a reduction in the milk fat content (Mertens, 1997). Grant *et al*. (1990) reported that a reduction in hay particle size resulted in a decreased (P = 0.05) milk fat content, and eventually a reduction in 4% fat corrected milk (FCM) production. This, however, was not the case in the present study. It can clearly be seen in Table 3 that the Prime lucerne hay treatment significantly increased (P <0.05) both the protein and milk urea nitrogen (MUN) content of Jersey milk, when compared to the Grade 1 and Grade 2 lucerne hay treatments. This significant increase was associated with the higher (and alternate) protein content of the Prime lucerne hay treatment (Tables 1 and 2). This effect is supported by data presented by Emery (1978). According to Miller *et al*. (2004) the feeding of high levels of young lucerne hay may result in high concentrations of MUN (>15.5 mg/dL for Jersey cows) due to the higher levels of CP. The high levels of MUN in the milk of the cows fed the Prime lucerne hay diet may therefore be the result of this immature lucerne hay used in this treatment. In addition, the digestibility of the protein fraction of different feeds may also have had an effect on the milk protein and MUN content (Baker *et al*., 1995). Kalscheur *et al*. (2006) reported that as the rumen degradable protein levels in the feed increased, the cows subsequently produced milk with higher protein and MUN levels. The MUN content of the present study, however, indicated that the CP was not a limiting factor in any of the treatments, as the proposed norm fell between 8 to 16 mg/dL (NRC, 2001).

Conclusions

Results of the present study indicate that Grade 2 lucerne hay quality may decrease the DMI of Jersey cows. Even though milk yield was not affected by lucerne hay quality, the efficiency with which dietary ME is utilized for milk production was reduced when Prime lucerne hay was included, probably as a result of sub-clinical acidosis, due to a lack of effective diet fibre. Prime grade lucerne hay recorded very low NDF values and should therefore be used in combination with other roughage sources in a TMR for dairy cows. The protein and MUN content of the milk increased, following the higher CP content of the Prime lucerne hay treatment.

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