The role of pasture and silage in supporting milk production in dairy goats in New Zealand – a case study approach.

W King[a]*, V Burggraaf[a], N Mapp[a], E Ganche[b], K Hutchinson[a] and M Johnson[c]

[a]AgResearch Limited, Ruakura Research Centre, Private Bag 3123, Hamilton; [b]DairyNZ Ltd, Ruakura Rd, Hamilton; [c]BHU Future Farming Centre, P.O. Box 69113, Lincoln 7640, New Zealand

**Corresponding author:* Email: warren.king@agresearch.co.nz

Abstract

Milk production on dairy goat farms in New Zealand is highly variable: the average is around 75 kg total solids/doe/year with a range of 39-135 kg total solids/doe/year. The source of variability in production is unclear but is potentially due in part to the diversity in forage-supply systems used by dairy goat farmers. The majority of milking herds that supply the Dairy Goat Cooperative are housed indoors for health and production reasons and are fed a mix of freshly-cut pasture and silage in a cut-and-carry system with the addition of concentrates and other supplemental feeds when required. To determine how pasture and silage were used in dairy goat feeding systems, four farms were enrolled in a case study approach. Estimates of the quantity of pasture and silage fed were made and samples were taken and analysed for quality periodically over a one-year period. Results showed that pasture quality generally followed the expected seasonal curve for the Waikato. Pasture quality declined from about 12.5 MJ ME/kg DM in early spring to 11 MJ ME/kg DM or less in December and was largely unavailable from March. At this time, silage becomes a much more important component of the feed-supply system. The quality of the silage was, however, variable with dry matter content, metabolisable energy and crude protein (CP) levels sometimes outside recommended limits. Total diets were deficient in nutrients at some times on some farms, especially with respect to protein. A comparison of calculated feed requirements with what was actually fed showed that protein was deficient in six of the twelve sample periods, by up to 211 g of CP/doe/day. These deficits were associated with lower milk production. This study highlighted the potential for higher milk production from maintaining both pasture and silage quality.

Keywords: dairy goats; milk production; feed supply; silage.

Introduction

The Dairy Goat Cooperative (DGC) is comprised of 72 farms in the Waikato, Taranaki and Northland regions of New Zealand. Milk is processed into high-quality infant-milk powders that are exported to over 20 countries. A key component of the DGC marketing strategy is that premium nutritional products are made from New Zealand-origin goats' milk, produced in pastoral-based systems with strict quality standards.

Although the majority of milking herds are housed for health and production reasons, the diet is still pasture-based, with the goats being fed mixtures of freshly cut pasture and/or silage in a cut-and-carry system. Concentrates are added to the diet to increase milk production but the DGC stipulates that farmers must feed a minimum of 75% home-grown forage (based on wet weight).

The average milk production is around 75 kg total solids (MS)/doe/year but there is considerable variation among herds, ranging from 39 to 135 kg MS/doe/year.

This variability is likely to be at least partly due to the diversity in forage-supply systems used by dairy-goat farmers. These systems reflect the diversity and entrepreneurial spirit of investors, the relative newness of the industry and possibly a lack of specific goat knowledge amongst advisors and feed companies.

One of the most important components of dairy-goat feed-supply systems in NZ is grass silage. Silage is a valuable addition to the diet (Eik et al. 1991; Morand-Fehr et al. 2007; Flaten et al. 2012) but becomes increasingly important when access to fresh pasture is limited, whether due to normal seasonal variation or events such as heavy rain or prolonged dry periods. However, a survey of dairy goat farms (Ganche et al. 2014) suggested that (1) farmers do not make effective use of silage to support dairy goat production and (2) they are not always aware of how to make, store and feed good-quality silage.

There is little practical information available to dairy goat farmers on the use of pasture silage to support milk production in dairy goat herds in New Zealand. This study aimed to assess the use of silage on a number of dairy goat farms over a complete season to provide information on the most cost-effective use of silage in a forage-supply system.

Materials and methods

To determine how silage was used in dairy goat feeding systems, four farms were visited on a regular basis. Farms were selected on four criteria: they were producing over 100 kg MS/doe/year; they were already feeding fresh cut pasture and grass silage; the herds were being managed indoors on a cut and carry system reflecting the majority of producers in the dairy goat industry; the farmers were committed to being part of the study.

In the 2013-2014 season, four farms were visited from August through until April: Farm 1 milked 516 goats producing 115 kg MS/doe/year from 55 ha; Farm 2 milked 673 goats producing 115 kg MS/doe/year from 39 ha; Farm 3 milked 643 goats producing 104 kg MS/doe/year from 31 ha; and Farm 4 milked 411 goats producing 135 kg MS/doe/year from 42 ha.

Representative samples of feed types offered to the goats were taken monthly from each farm from August 2013 to April 2014. The samples were sent to a commercial laboratory (Eurofins NZ laboratory Services, Hamilton, New Zealand) and analysed to determine the dry matter percentage (DM), crude protein (CP) and metabolisable energy (ME) content utilising standard commercial laboratory protocols.

The farmers were asked to record the amounts of pasture and silage being fed on a weekly basis. For the farms that were not using a feed-out wagon equipped with scales, the amount of pasture fed was calculated by hand harvesting and weighing a strip of pasture the width of the mower and 3 m long. The area harvested by the farmer for feed that day was then calculated and the amount of pasture fed to the goats computed using the yield of the hand-harvested area. The amount of silage offered was calculated by weighing a selection of bales. Where possible, a weighed bale was matched to feed quality analysis (Eurofins NZ laboratory Services).

On two occasions, feed waste was dissected into grass, clover, herbs, weeds and dead matter and compared to the feed given on a dry matter basis.

Individual farmers recorded feed inputs throughout the year. The data was used in conjunction with feed quality analysis to calculate the energy offered to the goats over the milking period.

The components of the feed being offered were recorded at each visit: grass, other forages, pasture silage, other silages and concentrates.

Milk production data was obtained from the Dairy Goat Cooperative for each farm for the dates on which visits occurred. A random selection of 10% of each milking herd was weighed on four occasions during the year.

Table 1 Quality of pasture being fed to dairy goats on case study farms during early, mid and late lactation.

		Early			Mid			Late		
	Farm	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Dry matter (%)	1	17	18	14	17	15	20	25	20	11
	2	na[1]	na	na	13	na	na	-[2]	-	-
	3	18	23	15	19	19	30	-	-	-
	4	14	19	18	35	25	na	-	-	-
Metabolisable energy (MJ/kg DM)	1	12.5	12	12	11	11	10.5	10	na	9.5
	2	na	na	11.5	10.5	na	na	-	-	-
	3	12.5	12	12	12	10.5	10.5	-	-	-
	4	11	11	12	10	10	na	-	-	-
Crude protein (% of DM)	1	24	20	24	18	21	20	19	23	24
	2	na	na	23	21	na	na	-	-	-
	3	23	14	25	18	17	19	-	-	-
	4	16	18	10	10	12	na	-	-	-

[1]na = data not available
[2]- = little or no fresh pasture fed at this time

Table 2 Nutritional value of silage being fed to dairy goats on case study farms during early, mid and late lactation.

		Early			Mid	Late	
	Farm	Aug	Sept	Oct	Nov	Feb	Apr
Dry matter (%)	1	24	17	23	na[1]	31	na
	2	na	na	na	37	na	na
	3	17	na	na	na	45	24
	4	22	26	27	na	na	34
Metabolisable energy (MJ/kg DM)	1	11.5	11.5	10	na	11	na
	2	na	na	na	9.5	na	na
	3	12.5	na	na	na	11	11
	4	10.5	9.5	na	na	na	10.5
Crude protein (% of DM)	1	25	20	18	na	16	24
	2	na	na	na	17	na	na
	3	23	na	na	na	16	na
	4	18	20	18	na	na	na

[1]na = data not available

Results

Pasture and silage

During early lactation (August – October) nutritive values of the pasture were meeting the Dairy NZ recommendations for dairy cows with respect to ME (11 – 12.5 MJ/kg DM; DairyNZ, 2017; Table 1) and CP (18 – 35%; Table 1), except for Farm 4 which had low CP values in August and October and Farm 3 which had low CP in September. During mid lactation (November to January), all farms' pastures were showing typical ME values (9 – 10.5 MJ/kg DM for a normal summer; DairyNZ, 2017; Table 1). Crude protein values were also in the expected range (14 – 22% for a normal summer; DairyNZ 2017; Table 1), except for Farm 4, which again had CP values lower than this. During late lactation, (February to May) only Farm 1 and 2 were able to feed fresh pasture, but at a reduced level. Due to dry conditions, Farm 3 and 4 had switched to predominantly silage and concentrate diets. The nutritive value of the pasture fed by Farm 1 (Table 1) over late lactation was below the recommended levels for cows provided by DairyNZ (2017) for both ME (11 – 11.5 MJ/kg DM) and CP (15 – 20%).

Where data were available, silage nutritive quality was somewhat variable among farms. In general, silage samples were consistently above the ME recommended for good quality silage (10 MJ/kg DM; DairyNZ, 2017; Table 2), except Farm 2 in November and Farm 4 in September. Similar results were observed for CP, with CP being generally higher than the minimum levels recommended for good quality silage (17%; DairyNZ, 2017; Table 2), except for Farms 1 and 3 in February. With respect to dry matter content, however, only two samples were within the recommended range of 30-35% (DairyNZ, 2006).

Figure 1 Total metabolisable energy and relative composition of diet offered to lactating dairy goat herds on 4 case-study farms in early, mid- and late lactation.

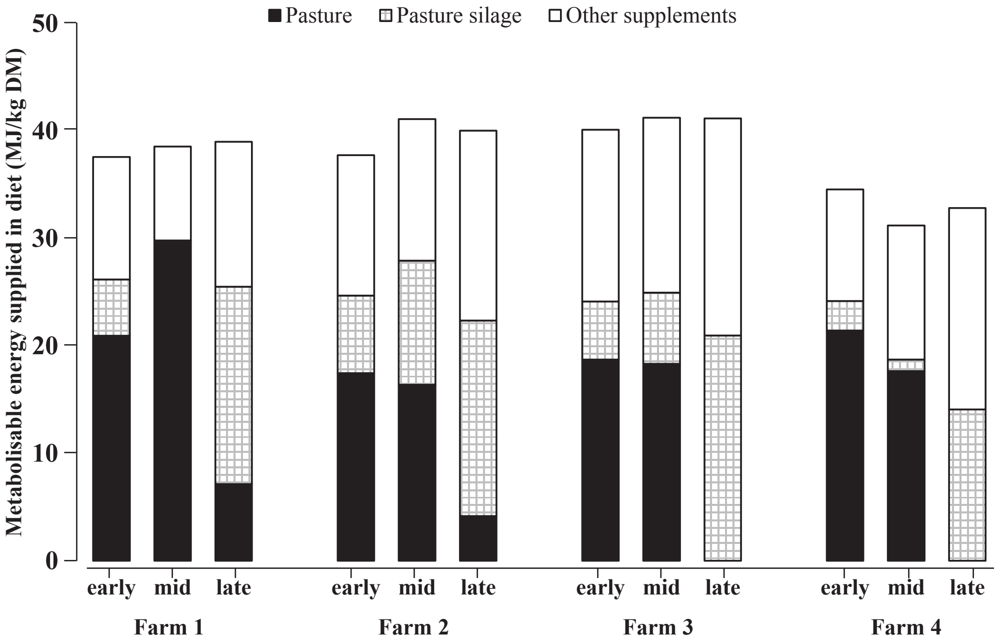

Table 3 Production metrics of the farms in the study.

Farm	No. goats in milk	Season milk yield (L/doe)	Season total solids (kg/doe)	Season protein yield (kg/doe)	Season fat yield (kg/doe)	Peak milk yield (L/doe/day)	Peak total solids (kg/doe/day)
1	516	1028	115	31	33	3.7	0.47
2	411	1158	135	36	41	4.5	0.53
3	673	985	115	31	35	3.8	0.42
4	643	875	104	28	31	3.3	0.39

Table 4 Milk production, energy and protein requirements, energy and protein provided on the case study farms.

Farm	Sample period[1]	Milk yield (L/doe/day)	Doe weight (kg)	ME required[2] (MJ/doe/day)	ME fed[3] (MJ/doe/day)	CP required[2] (g/doe/day)	CP fed[3] (g/doe/day)
1	Early	3.5	na[4]	30.1	40	472	990
	Mid	3.5	64.8	31.6	40	511	300
	Late	2.5	78.5	29.6	25	446	400
2	Early	4.2	70.3	33.3	na	550	na
	Mid	4.3	79.0	35.9	40	595	660
	Late	2.5	76.9	29.6	34	446	620
3	Early	3.0	na	30.1	40	472	670
	Mid	3.6	64.3	31.6	43	511	500
	Late	2.9	71.0	31.0	34	490	280
4	Early	3.0	na	30.1	33	472	340
	Mid	3.3	63.8	31.6	30	469	600
	Late	2.2	70.7	27.3	29	375	250

[1]Sample period early lactation (August), mid lactation (December), late lactation (April) The average doe live weight was calculated from sampling 10% of the milking herd.
[2]Calculated from Nutrient Requirements of Small Ruminants (2007). The CP@20%UIP value was used as UIP levels are low in pastures (Lardy et al. 2001) and there are no data from this trial to indicate the actual UIP values.
[3]Calculated from the analysis of pasture and silage and the book values of CP and ME levels in supplements that were fed.
[4]na = data not available.

Other diet components

All of the farms fed a range of concentrates in addition to pasture and silage. The metabolisable energy available from each diet component (including pasture, silage and each concentrate) was then calculated to determine the total dietary energy provided on each case-study farm (Figure 1).

Farms 1-3 offered as much as 45 MJ ME/doe/day, while Farm 4 fed their goats to a somewhat lower level – usually less than 35 MJ ME/doe/day. The proportions of each diet component differed on each farm but all used concentrates to provide additional energy and protein.

Milk production

Farm 2 recorded the highest milk yield per doe, peak milk, protein and fat per doe. Farm 4 had the lowest overall production (Table 3).

Estimation of energy and protein requirement for milk production

The feed requirements of the does on each farm were then estimated (from Nutrient Requirements of Small Ruminants, 2007) and compared with the ME and CP in the diet (Table 4). The ME provided generally exceeded the estimated requirement but, on six out of 12 occasions, CP was below the estimated requirements for the level of production measured (Table 4).

Discussion

Pastures that are managed to support milk production should ideally have: an ME of 11.5-12.5 MJ/kg DM and a CP of 18-35% in spring; an ME of 9.5-10.5 MJ/kg DM and a CP of 14-22% in a typical summer; an ME of 9-10 MJ/kg DM a CP of 9-14% in a dry summer; and, ME of 11.0-11.5 MJ/kg DM and a CP of 15-20% in autumn (DairyNZ 2017). The pastures sampled during the course of this study generally conformed to these expectations, given the dry seasonal conditions (Baars et al. 1991). There were some exceptions however, where either ME or CP (or both) were below the recommended values. These occurred mostly in early lactation, and mostly on Farm 4.

Pasture silage can be a useful tool to maintain pasture quality and support milk production (Thomson et al. 1984). Baled silage made from good-quality pasture should have 9.5 -11.0 MJ ME/kg DM and a CP approaching 17% (DairyNZ 2017). Milk production can be strongly affected by the quality of the silage fed (Howse et al. 1996) and trials in dairy cattle in New Zealand have clearly demonstrated the impact of poor quality silage in the diet of dairy cows on their production (Macdonald et al. 2000). Howse et al. (1996) observed that pasture silage made by New Zealand dairy farmers is usually of poor quality. The samples analysed as part of the present study, however, showed that this was rarely the case (Table 2). All farms fed silage and, providing that this was well coordinated with other feed components in the diet, it is unlikely that silage quality limited milk production.

In general, farmers offered the goats diets in which the ME requirements of the goats were being met, with the exception of Farm 1 in late lactation and Farm 4 in both mid and late lactation (Table 4). However, CP requirements were more often not being met by the diet with deficits observed in more than half of the samples periods (Table 4). Only Farm 2 avoided this. Farm 4 had protein deficits in both early and late lactation and also provided the lowest energy diets; it also had the lowest production metrics (Table 3).

Protein is the main source of dietary nitrogen required for growth and production. The quantity and quality of the total amount of protein that reaches the small intestine affects milk yields in early lactation (Hadjipanayiotou & Koumas 1991) and feeding at kidding and in early lactation affects overall yields (Morand-Fehr & Sauvant 1978). The protein levels of grasses vary with species, management and maturity (Parish & Rhineheart 2011). Silage made from younger, leafy pasture has a higher CP and higher levels of water-soluble carbohydrates than that made from mature pasture and is, therefore, of higher quality (Nadeau et al. 2015). Protein levels in silage are dependent upon the levels in the harvested grass but are also affected by the fermentation achieved (Li & Nishino 2013). Fermentation of silage (and hence its quality) is directly affected by the DM of the harvested grass. The target DM for quality baled silage is 30-35% (DairyNZ, 2006) but only two the twelve silage samples tested fell into this range (Table 2). While both ME and CP values were generally within recommended ranges, the dry matter content was usually too low, indicating that the quality of the silage was compromised to some degree.

In French dairy goat systems, it is expected that pasture-based diets will require supplementation with concentrates to support high production (Morand-Fehr & Sauvant 1980; Morand-Fehr et al. 2007). All the case-study farms were adding concentrates to the diet in an effort to increase milk production. While it is difficult to "portion" the effects of concentrate and forage, forage quality often underpins the effectiveness of concentrate supplementation (Goetsch et al. 2011). Effective and efficient coordination of forages with concentrates is imperative and it is, therefore, critical to know the quality of the forage being fed. Few farmers in this study tested their pasture or silage, so efficient use of concentrates cannot be assured. The ratio of forage to concentrate can have significant impacts on milk yield (Morand-Fehr et al. 2007). To optimise yield, the goats must be provided with a diet balanced for energy, protein, fibre and other nutrients. In the pasture and silage bales tested in this study, the nutritive value varied considerably, making the task of balancing the diet in a cost-effective manner very difficult.

The Committee on Nutrient Requirements of Small Ruminants (2007) suggested that a 60-kg goat in early lactation should produce a minimum of 4.65 kg/day of milk with an ME intake of 30.9 MJ ME/day. In this study, no farms produced this much yet most were supplying their goats more energy than this. Genetics, animal health, herd age structure and management stressors all have a role in production but farmers may be simply not feeding their animals efficiently enough, especially with respect to protein.

This study highlighted the potential for increased milk production from maintaining pasture quality and focusing on making quality pasture silage. New Zealand dairy goat farmers know that silage is a critical component in the diets of their goats. Grass quality typically deteriorates from summer and silage becomes a greater part of the diet. The results of this study indicate that farmers should plan carefully to maintain high quality pastures as long as possible and also to make or buy only high-quality silage. This will provide a seamless transition from pasture-dominated diets in early lactation to silage –dominated diets later in the season.

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