The potential benefits of ensiling the forage legume sulla compared with pasture

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Abstract

With high dry matter yields of high quality forage, high soluble carbohydrate levels and a suitability for harvest by cutting and removing, the forage legume sulla (*Hedysarum coronarium*) has the potential to be an important silage crop in New Zealand. In three experiments the ensiling potential of sulla was compared with conventional pasture using a mini-silo system which allows for rapid evaluation of forages using 3–4 kg of herbage. Experiment 1 evaluated the effect of increasing the proportion of sulla in pasture silage (0/100, 25/75, 50/50, 75/25 and 100/0 sulla/pasture). The principal findings were that increasing sulla content of the silage decreased ($P<0.001$) ammonia content from 5.9% of total N to negligible detectable levels, and increased ($P<0.0001$) lactic acid content of silage from 3.3% to 9.9% of dry matter (DM) which resulted in a lower final pH (4.9 vs 4.0; $P<0.0001$). Experiment 2 examined the rate of ensilation of pure sulla and pasture after 1, 4, 8, 11, 13, 15, 28 and 42 days. Silage pH and carbohydrate levels declined more rapidly in sulla than pasture silage, while lactic acid content increased more rapidly. Silage ammonia levels increased rapidly in pasture silage but remained low in sulla silage. In Experiment 3, sulla and pasture mixtures as used in Experiment 1 were ensiled at three moisture levels, in a 5*3 factorial design. Final pH was lower ($P<0.001$) 17 days after ensiling with increasing moisture content and by increasing the proportion of sulla in the silage ($P<0.0001$). High moisture silage or silage with a high proportion of sulla, had the highest lactic acid and soluble carbohydrate contents. These studies suggest that sulla has the potential to be used to produce high quality silage. Sulla silage needs to be evaluated in feeding trials to determine if its potential as a high quality supplementary feed can be realised as animal performance.

Keywords: ammonia, condensed tannins, *Hedysarum coronarium,* lactic acid, pasture, pH, silage, sulla

Introduction

Future intensive pastoral livestock production systems will require more and better quality supplemental feeding than is currently practised owing to changing climatic conditions, demands for year-round supply, less consumer tolerance of starving or stressed animals, disorders associated with intensive grazing and/or underfeeding, and our inability to meet the nutrient demands of animals having high genetic value from current pastures. Technological developments, including labour-saving mechanical devices, inoculants, and new herbage species and cultivars should encourage increased ensiling of forages. However, little research is being done in New Zealand to screen forage species for efficient ensiling.

Research on silage production in New Zealand over the past 10–20 years has determined the best time to harvest conventional pasture for silage and the impacts of silage making on the whole farm (generally dairy farm) productivity and economics. One study that has assessed different forage species for their silage-making potential demonstrated large improvements in animal performance from feeding silage made from chicory/hybrid pasture compared with standard pasture (Stevens *et al.* 1994). Liveweight gains of hoggets fed sole diets of improved silage were similar to those which grazed brassicas or brassica/Italian ryegrass pasture swards (Stevens *et al.* 1994).

Sulla (*Hedysarum coronarium* cv. Grasslands Aokau) is a leguminous forage species which produces high dry matter (DM) yields in the southern half of the North Island and has high growth rates during the autumn and spring (Krishna 1993). It is highly palatable to grazing stock and results in very good lamb performance (Terrill *et al.* 1992; Niezen *et al.* 1995; Niezen *et al.* 1998). It contains about 8% condensed tannin (CT), which can reduce proteolysis associated with ensiling (Albrecht & Muck 1991). The current recommendation is that sulla be grazed hard but infrequently (Krishna 1993), but observations during experimental studies indicate that sulla regenerates very well from a cut and removal management system, and therefore has potential as a silage crop (Waghorn *et al.* 1998).

This work reports on three experiments which compared the ensiling properties of sulla with ryegrass–

white clover pasture, using mini-silos that enable rapid screening of different forage species (Makoni *et al.* 1997) and a very effective evaluation of ensiling management techniques.

Materials and Methods

Experimental design

Experiment 1
Experiment 1 compared silage made from sulla and pasture and three sulla/pasture mixes (0/100, 25/75, 50/50, 75/25 and 100/0 sulla/pasture on a fresh basis). There were 2 replicates for each mixture, and the forages were ensiled for 30 days.

Experiment 2
Experiment 2 determined the effects of ensiling time on silage quality. Silages were made from either sulla or pasture which were ensiled for either 1, 4, 8, 11, 13, 15, 28 or 42 days.

Experiment 3
Experiment 3 determined the effects of moisture content on silage quality. Sulla, pasture and three sulla/pasture mixtures were ensiled at 3 moisture levels (cut 2 days, 1 day and immediately before ensiling). Silages, which comprised mixtures as in Experiment 1, were ensiled for 20 days in a 5*3 factorial design with 2 replicate silos for each combination, a total of 30 silos.

Silo and silo filling description

The mini-silo, 600 mm in length and 100 mm in diameter, was constructed from PVC pipe with detachable rubber caps on each end (Makoni *et al.* 1997). For all experiments, the herbage for ensiling was cut and conditioned in the field using conventional equipment. It was then chopped using a silage harvester, and aliquots of chopped sulla and pasture were mixed as appropriate and sprayed with a commercially available silage inoculum containing *Streptococcus faecium, Lactobacillus plantarum, Pediococcus acidilactici* (20 billion CFU per g), cellulase, hemicellulase, pentosanase and amylase (SIL-ALL® Alltech). A rubber cap was placed on the bottom of the silo and 3–4 kg of herbage was rammed into the tube. A concrete weight (2.5 kg) was placed on top of the herbage to maintain compaction and a rubber cap with a vent valve was used to cap the silo. All herbages were in the vegetative state at the time of ensiling.

Silage sampling and analysis

The silos were opened by removing the top cap and weight. The silage was then removed by hand. A grab sample from the middle of each silo was taken, pH measured and the sample dried at 60°C for 18 hours. Silage DM was determined and the dried material analysed for organic matter digestibility (OMD), lactic acid content, soluble carbohydrate (CHO), fibre (neutral detergent fibre (NDF)), ammonia, metabolisable energy (ME; MJ/kg DM) and protein (N × 6.25) levels using near infrared reflectance spectroscopy (NIR – FeedTech® AgResearch) (Ulyatt *et al.* 1995). Data were compared by analysis of variance using General Linear Models (GLM® SAS Inst. 1987).

Results

As the season progressed pasture protein levels declined, while protein levels in sulla increased slightly (Table 1). Mean values for soluble carbohydrate concentrations and ME values were higher in sulla than pasture (Table 1). Lipid content, protein, ash and NDF levels were lower in sulla than pasture, while ADF, *in vitro* digestibility and organic matter digestibility (OMD) did not differ (Table 1).

Table 1 Chemical composition* (% DM), metobolisable energy* (ME; MJ/kg DM) and *in vitro* organic matter digestibility* (OMD, (%)) of forages before ensiling. All 3 experiments.

	Protein	Lipid	NDF	CHO[1]	ASH	OMD[2]	ME[3]
Expt. 1	(ensiled 10/9/97)						
Pasture	23.1	3.7	35.8	9.9	9.9	83.4	12.4
Sulla	12.7	1.9	26.3	18.2	9.5	85.3	12.7
Expt. 2	(ensiled 25/9/97)						
Pasture	20.4	3.7	44.9	8.9	10.8	81.0	12.1
Sulla	12.4	1.9	27.1	14.9	9.0	84.5	12.6
Expt. 3	(ensiled 29/10/97)						
Pasture							
LM[4]	18.6	3.2	48.2	8.8	10.9	77.0	11.5
MM	19.0	3.6	49.1	7.4	11.4	76.5	11.4
HM	18.1	3.4	48.3	8.6	10.9	78.1	11.6
Sulla							
LM	16.2	2.1	30.7	10.2	10.3	80.7	12.0
MM	13.9	2.0	33.8	12.6	9.1	78.3	11.7
HM	10.8	1.6	33.0	14.3	8.6	80.4	12.0

[1] CHO – soluble carbohydrate.
[2] OMD – organic matter digestibility.
[3] ME – metabolisable energy (MJ/kg DM)
[4] LM – low moisture, MM – medium moisture, HM – high moisture.
* Estimated by Near Infrared Spectrometry (NIR).

Experiment 1

Increasing sulla content of silage decreased ($P<0.001$; Table 2) the ammonia content of silage from 5.9% of total N to negligible levels. Pasture silage pH was 4.9 compared with 4.0 for sulla silage ($P<0.0001$), and this was associated with increased lactic acid content of silage from 3.3% of DM with pasture to 9.9% with sulla ($P<0.0001$; Table 2).

Experiment 2

Initiation of the ensiling process was more rapid with sulla than pasture, as evidenced by the more rapid decline in pH and soluble carbohydrate concentrations in sulla than in pasture silage (Figure 1A, 1C); lactic acid content increased more rapidly (Figure 1B). Silage ammonia concentrations increased rapidly in pasture silage but remained low in sulla silage (Figure 1D).

Experiment 3

Increasing moisture content decreased ($P<0.001$) pH of silage (Figure 2A) but increased ($P<0.0001$) lactic acid (Figure 2B) and soluble carbohydrate content of silage ($P<0.0001$; Figure 2C). Increasing moisture content also decreased ammonia content ($P<0.0001$), ammonia levels declining more rapidly in response to moisture with increasing proportion of sulla in the silage ($P<0.003$; Figure 2D).

Table 2 Composition of silage with increasing levels of sulla in the silage (0/100, 25/75, 50/50, 75/25 and 100/0 sulla/pasture on a fresh basis). Expt. 1.

	--- Proportion of Sulla in Silage --- 0	25	50	75	100	Pooled SEM	Sulla Effect (P<)
pH	4.9	4.9	4.6	4.1	4.0	0.017	0.0001
Lactic acid (%)	3.3	4.1	5.9	9.5	9.9	0.098	0.0001
Ammonia (%N)	5.9	5.6	3.8	0.8	Trace	0.21	0.001
Protein (%)	22.2	21.7	19.1	18.1	15.7	0.29	0.02
NDF[1] (%)	38.5	39.7	38.4	34.9	36.6	0.48	NS
CHO[2] (%)	7.0	6.7	7.3	8.2	9.2	0.30	NS
ME[3] (MJ/kg DM)	12.2	12.1	12.0	12.2	11.9	0.028	NS
OMD[4] (%)	80.0	78.7	78.7	80.2	77.4	0.41	NS

Estimated by NIR.
[1] NDF – neutral detergent fibre
[2] CHO – soluble carbohydrate
[3] ME – metabolisable energy (MJ/kg DM)
[4] OMD – organic matter digestibility

Increasing the proportion of sulla in silage reduced silage pH ($P<0.001$; Figure 2A), carbohydrate content ($P<0.0006$; Figure 2C) and ammonia content ($P<0.0001$;

Figure 1 Changes in the chemical composition of pasture and sulla during ensiling. Silage pH (A), lactic acid content (% DM; B), soluble carbohydrate content (% DM; C), and ammonia (% total N; D). Estimated by Near Infrared Spectrometry (NIR).

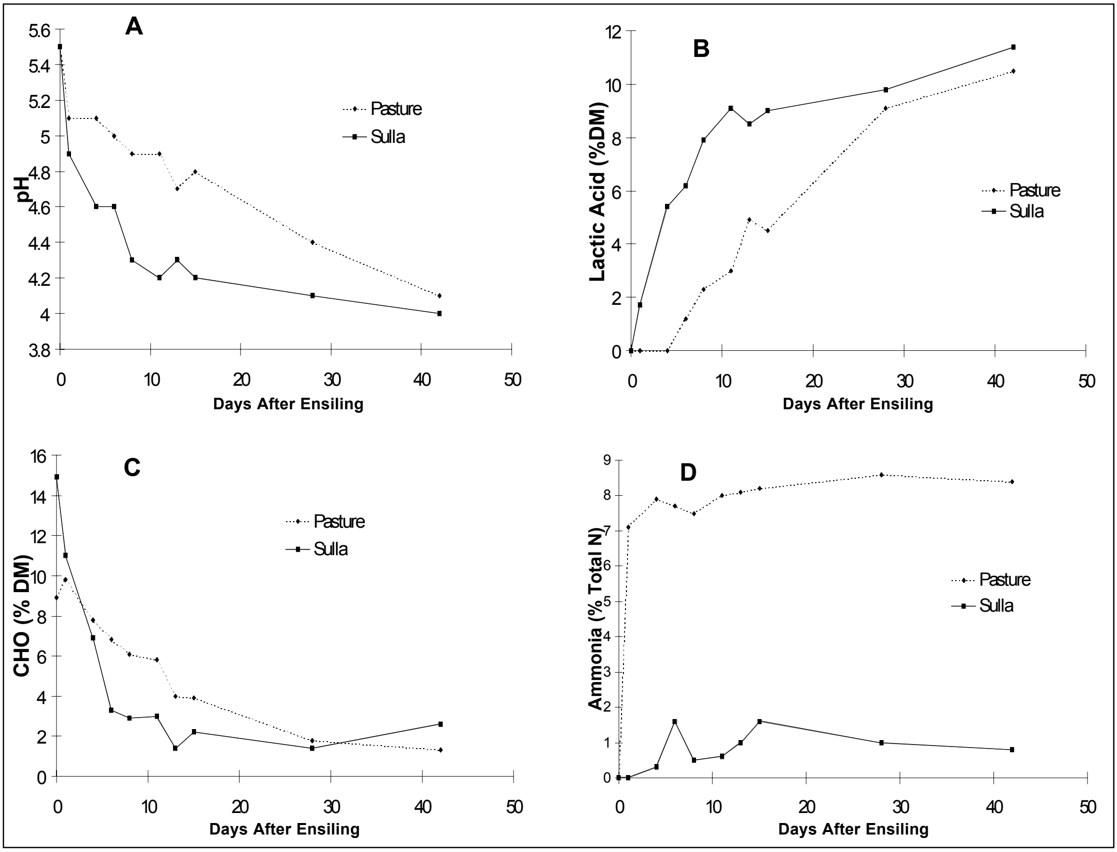
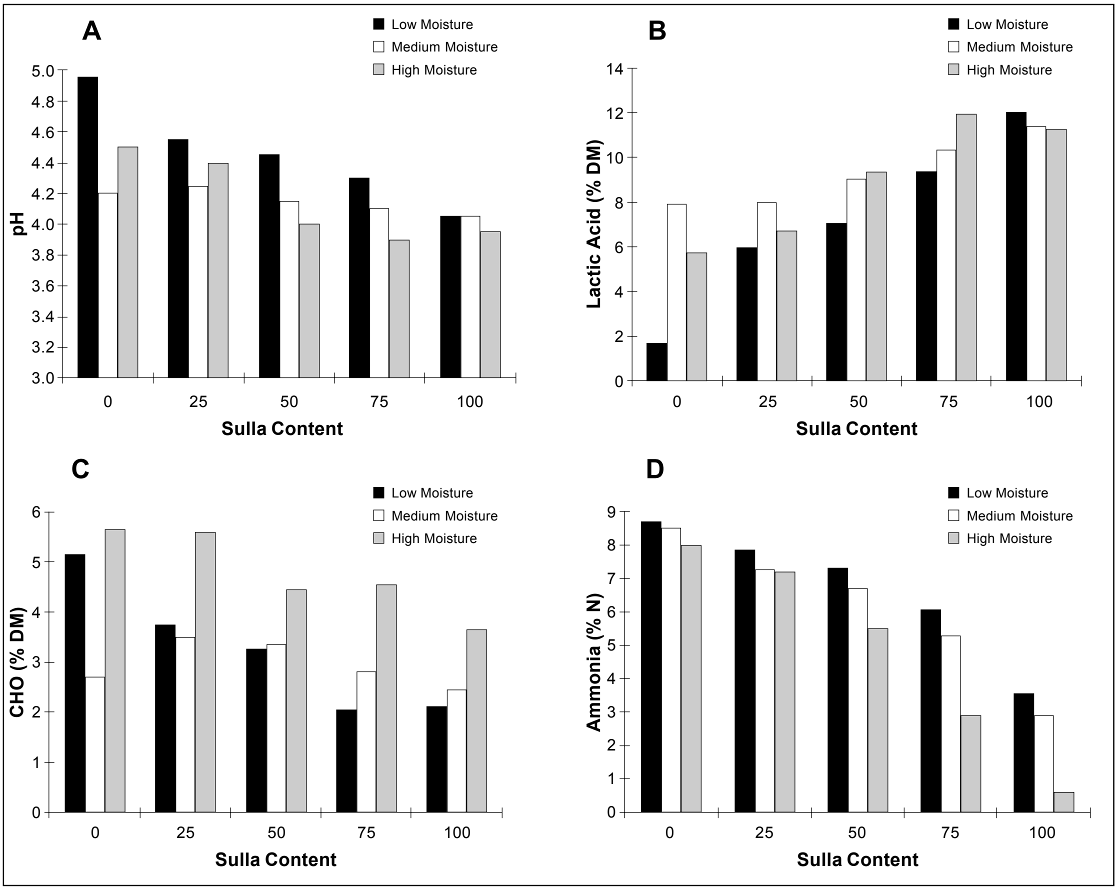


Figure 2D), and increased (P<0.0001) lactic acid content (Figure 2B).

Discussion

This study clearly demonstrates the value of sulla as a crop for silage, as pH drops rapidly after ensiling, ensuring better preservation of forage. Sulla silage also has low levels of ammonia, which should increase palatability (Castle *et al.* 1980). Ensiled sulla also has better aerobic stability, and lower levels of ethanol and butyric acid, and yeasts and moulds than ensiled maize, sorghum or wheat (Weinberg *et al.* 1993), further indicating that a high quality silage is produced. The very low levels of ammonia recorded from sulla silage suggest that the condensed tannins (CT) in sulla are reducing the proteolysis commonly associated with the ensiling process (Albrecht & Muck 1997). The rapid rise in ammonia when pasture was ensiled (Figure 1D) suggests that proteolytic micro-organisms were active in the pasture, while proteolytic activity when sulla was ensiled was less evident, possibly because the limited substrates for lactic acid-producing bacteria in pasture caused extensive degradation of plant components. While sulla appears to ensile well, information on animal performance is needed, as the benefits of sulla silage may exceed the analytical predictions. Condensed tannins in sulla silage may confer additional benefits by reducing proteolysis in the rumen (Terrill *et al.* 1992) and increasing post-ruminal protein absorption, as occurs with fresh herbages (Waghorn *et al.* 1987). While the decreased rumen proteolysis observed with *Lotus corniculatus* still has to be demonstrated for sulla, the high performance of lambs grazing sulla would suggest that the CT in this forage is beneficial (Terrill *et al.* 1992; Niezen *et al.* 1995; Niezen *et al.* 1998). The CT in ensiled sulla may also affect parasite burdens, as studies have shown a reduction in parasite establishment in lambs which grazed sulla (Niezen *et al.* 1995), as well as a decline in established worm burdens (Niezen

Figure 2 Silage pH (A), lactic acid content (% DM; B), soluble carbohydrate content (% DM; C), ammonia (% total N; D), made from pasture, sulla or pasture/sulla mixtures (% sulla on a fresh basis) at three moisture levels. Estimated by Near Infrared Spectrometry.



et al. 1998). Sulla silage may be particularly useful as a supplement to peri-parturient ewes in which protein supplementation alleviates the peri-parturient rise in faecal egg counts (Donaldson *et al.* 1997), and may also be useful to finishing lambs, weaner cattle and dairy cows.

This study has demonstrated that mini-silos can be used to assess rapidly and efficiently the effect of herbage species and ensilation techniques on silage quality. It can become a useful tool for plant breeders to screen promising new cultivars for ensiling capabilities and to determine the management techniques for making the best quality silage. While silage quality, as measured by the range of parameters reported here, has to be confirmed by animal performance trials, studies overseas have shown that animal performance is related to silage quality (Castle *et al.* 1980). The studies with sulla demonstrates an excellent silage quality. The high quality of the sulla silage is a consequence of readily available, fermentable carbohydrate which results in a rapid decline in pH, and this, together with the effect of CT in sulla, have minimised plant protein loss to ammonia. Although optimal silage quality appears to have been achieved from pure sulla, mixtures with pasture have also shown good quality. Sulla has very good levels of DM production and may hold an important place as a green supplement in winter and a crop for ensiling in late spring.

ACKNOWLEDGEMENTS

The authors would like to thank G. Hunt, P. Wallis and A. Sidey for their assistance with this project. This project was funded by the Foundation for Research Science and Technology (FRST).

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