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Feeding napier hay as supplement to sheep given poor quality natural pasture hay: effects of level of napier hay supplement and inclusion of urea in the basal diet on intake and digestibility

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Abstract

Three experiments were carried out using lambs to assess the effect of level of napier hay and urea supplements on the utilization of poor quality natural pasture (veld) hay. In all the experiments the lambs were given graded levels of napier hay as supplements to the basal diet of veld hay. In Experiment 1, the veld hay was not supplemented with urea; in Experiment 2, the veld hay was supplemented with 1% urea while in Experiment 3, the veld hay was supplemented with 1% or 2% urea. In all the experiments napier hay supplements increased total feed intake and in vivo digestibility of the diet ($P < 0.05$). High levels of napier supplementation tended to reduce the intake of veld hay below the level achieved on the unsupplemented control diet. However this decrease in veld hay intake was not as much as anticipated had the napier hay (corrected for its digestibility) simply replaced veld hay. Increasing the level of urea from 1 to 2% did not increase feed intake or digestibility or alter the pattern of substitution of veld hay by the napier. Across treatments, there was some evidence that the gain in the intake of veld hay resulting from napier supplementation was greater when urea was not added to the veld hay. In all the experiments, the increase in food intake was associated with an increase in faecal dry matter excretion suggesting that the increase in feed intake was facilitated by an increase in digesta passage rate. These results confirm that forage supplements are effective in increasing the

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utilization of poor quality forages and the response to the napier supplements was not entirely due to increasing nitrogen intake.

Keywords: Sheep; Intake; Digestibility; Forage; Supplementation; Urea

1. Introduction

When ruminants are given low quality forages, low voluntary food intake is recognized as one of the most important constraints to animal performance (Elliott and Topps, 1963). Supplementation with nitrogen (Campling et al., 1962) or treatment with alkali (Sundstol and Coxworth, 1984; Manyuchi et al., 1994b), are effective in increasing intake and digestibility of low quality forages. However, the wide-scale use of these technologies is largely hindered by high costs, especially to small-holder farmers.

Research work has shown that high quality forages in the form of legume hay (Minson and Milford, 1967; Mosi and Butterworth, 1985; Smith et al., 1989), dried grass (Mbatya et al., 1983; Silva, 1985) or ammonia treated straw (Manyuchi et al., 1992) can be fed as supplements to increase intake and digestibility when animals are consuming poor quality forages. The exact mechanism by which these forage supplements increase feed intake is not fully understood. The response to forage supplements has been attributed to the increased supply of dietary nitrogen (e.g. Minson and Milford, 1967; Siebert and Kennedy, 1972) or increased supply of easily degradable fibre (Silva, 1985; Manyuchi et al., 1992). Both these factors would have the effect of increasing the population of rumen cellulolytic microorganisms and fibre digestion in the rumen. In light of this controversy, the current study was undertaken to assess the effect of including or not including urea in the basal diet on intake and digestibility when poor quality natural pasture (veld) hay was supplemented with napier hay.

2. Materials and methods

Three experiments were carried out using lambs. The lambs were fed a basal diet of veld hay supplemented with graded levels of napier hay. In Experiment 1, the veld hay was not supplemented with urea, in Experiment 2, the veld hay was supplemented with 1% urea while in Experiment 3, the veld hay was supplemented with 1 or 2% urea.

2.1. Source of forages

Veld hay was harvested, when the natural pasture was mature and dormant. The hay consisted of a mixture of grasses dominated by Hyperrhenia species. Napier hay was from a hybrid cross between napier grass (*Pennisetum puerperium*) and pearl millet (*Pennisetum americanum*). The napier was grown as a single sward and the hay was harvested during the wet season at approximately 1 m height (4 weeks growth) and was chopped and sun dried.

2.2. Experiment 1

2.2.1. Animals

Sixteen lambs of the Dorper × Merino breed with an average initial live weight of 28 kg were used. The lambs were ranked according to live weight and allocated four dietary treatments balanced for weight.

2.2.2. Dietary treatments

(1) Veld hay offered ad libitum	(Control)
(2) Control plus 150 g day^{-1} napier hay	(150Nap)
(3) Control plus 300 g day^{-1} napier hay	(300Nap)
(4) Napier hay offered ad libitum	(Nap)

2.3. Experiment 2

2.3.1. Animals

Twenty lambs of the Dorper × Merino breed with an average live weight of 28 kg were used. The lambs were ranked according to live weight and allocated to five dietary treatments, balanced for live weight.

2.3.2. Dietary treatments

(1) Veld hay with 1% urea offered ad libitum	(Control)
(2) Control plus 100 g day^{-1} napier hay	(100Nap)
(3) Control plus 200 g day^{-1} napier hay	(200Nap)
(4) Control plus 300 g day^{-1} napier hay	(300Nap)
(5) Napier hay offered ad libitum	(Nap)

2.4. Experiment 3

2.4.1. Animals

Eighteen lambs with an average initial live weight of 28 kg were used. The lambs were allocated to the six dietary treatments in groups of three balanced for weight. At the end of the first period, the lambs were re-randomized and re-allocated to the six diets, giving a total of six observations per diet.

2.4.2. Dietary treatments

(1) Veld hay with 1% urea offered ad libitum	(Control-1)
(2) Control-1 plus 150 g day^{-1} napier hay	(150Nap-1)
(3) Control-1 plus 300 g day^{-1} napier hay	(300Nap-1)
(4) Veld hay with 2% urea fed ad libitum	(Control-2)
(5) Control-2 plus 150 g day^{-1} napier hay	(150Nap-2)
(6) Control-2 plus 300 g day^{-1} napier hay	(300Nap-2)

2.5. Management

Animals were housed in individual pens with free access to clean drinking water.

2.6. Diets

All the forages were chopped prior to feeding using a hammer-mill fitted with a 14 mm screen. The veld hay was supplemented with minerals and vitamins (0.5 g salt, 0.5 g monocalcium phosphate, 0.15 g calcium sulphate, 0.1 g Vit/trace element mixture per kg fresh weight). The amount of urea added to the veld hay was dissolved in water equivalent to 10% of the weight of hay to be supplemented. The urea solution was then sprayed onto the hay and thoroughly hand mixed just before feeding. A single batch of veld hay and napier hay were used in the experiments to minimize variation.

The napier hay supplement was fed separately at 08:00 h, followed by veld hay as soon as all the supplement had been consumed (normally within 30 min). Fresh feed was offered daily. After 21 days of adaptation, the lambs were moved into metabolism crates to enable total collection of faeces. Digestibility and intake were then measured over 7 days. Daily faeces and refusals were oven dried at 60°C for 48 h and the dry weight determined.

2.7. Veld hay equivalent of napier hay supplement

In calculating substitution, it was necessary to correct for the differences in the digestibility of veld hay and napier hay. The assumption was that substitution of veld hay by the napier hay supplement was due to the contribution to gut-fill of the indigestible fraction of napier hay. The veld hay equivalent of the supplement (V_e) was therefore calculated by multiplication of the intake of the napier supplement (I_s) by the ratio of the measured digestibility of the veld hay given alone (V_d) to the calculated digestibility of the napier supplement (S_d) in the mixed diets. Thus:

$$V_e = I_s \times \frac{V_d}{S_d}$$

The calculated digestibility of the supplement (S_d) was estimated as the intercept of the linear regression of diet digestibility (dependent variable) on the proportion of veld hay in the diet (independent variable).

Anticipated intake of veld hay was calculated by subtracting the veld hay equivalent of the supplement from the intake of veld hay on the unsupplemented Control diet. The gain in veld hay intake was calculated as the difference between the anticipated intake and the observed intake of veld hay.

2.8. Analysis

2.8.1. Chemical analysis

Dry matter was determined by drying samples in an oven at 60°C for 48 h. Acid Detergent Fibre was analyzed by the method of Goering and Van Soest (1970).

2.8.2. Statistical analysis

The data from each experiment were analyzed as a randomized block design with 9 degrees of freedom in the residual for Experiment 1, 12 degrees of freedom in the residual for Experiment 2, and 25 degrees in the residual for Experiment 3. Differences between treatment means were tested using *t*-tests.

3. Results

3.1. General

The compositions of feed offered and of feed refused in Experiments 1, 2 and 3 are shown in Table 1. All the supplements offered were eaten, and the refusals consisted of veld hay alone, except in treatments when the supplement was given on its own. The composition of refusals did not differ from the composition of the feed offered indicating no evidence of diet selection by the sheep.

3.2. Experiment 1

Results for Experiment 1 are summarized in Table 2. Napier hay contributed 22% and 40% to total dry matter intake on the 150Nap and 300Nap diets, respectively.

3.2.1. Dry matter intake

Compared with the Control, total dry matter intake was 50% and 67% greater on the 150Nap and 300Nap diets, respectively (Table 2; $P < 0.05$). Veld hay was not substituted by napier hay, and its intake was increased by 17% on the 150Nap diet. The calculated 'gain' in veld hay intake on 150Nap and 300Nap diets, respectively, was 38% and 44% over the anticipated had the napier (corrected for its better digestibility) simply substituted veld hay. Intake on the Nap diet was 3.5-fold greater than the Control.

3.2.2. Diet digestibility

Dry matter digestibility was lowest on the Control, and was increased by supplementation (Table 2; $P < 0.05$). The relationship between dry matter digestibility (Y) and proportion of veld hay in the diet (X) (16 data points) was given by:

$$Y = 0.672(\pm 0.054) - 0.003(\pm 0.0009)X \quad R^2 = 0.56$$

The value 0.672 for the intercept represents a calculated value for the digestibility of the napier supplement and is the value used to calculate the veld hay equivalent of the supplement using the equation presented earlier. Compared with the Control, intake of digestible dry matter was increased by 93% and 137% on 150Nap and 300Nap diets, respectively. The intake of digestible dry matter was 6.2 times greater on the Nap diet compared with the Control.

3.2.3. Faecal excretion

Daily faecal excretion of dry matter was increased by supplementation from 259 g on the veld hay Control to 326 g on the 300Nap diet. The highest faecal excretion was on the Nap diet, representing a 1.6-fold increase over the Control.

Table 1
Experiments 1, 2 and 3. Composition of feed offered and refused by lambs

	Dry matter ($g\ kg^{-1}$)	Nitrogen (g per kg DM)	ADF (g per kg DM)	Ash (g per kg DM)
Experiment 1				
Feed offered				
Veld hay	910	4.6	516	78
Napier	899	21.6	331	61
Veld hay refused on				
Control	–	4.7	506	71
150Nap	–	4.6	513	69
300Nap	–	4.8	511	70
Napier refusals on				
Nap	–	22.1	319	64
Experiment 2				
Feed offered				
Veld hay + 1% urea	897	8.8	515	89
Napier hay	910	21.6	335	69
Veld hay refused on				
Control		8.9	506	90
100Nap		7.9	518	
200Nap		8.0	520	85
300Nap		8.6	516	89
Napier hay refused on				
Nap		22.6	319	
Experiment 3				
Veld hay plus 1% urea	899	8.7	495	69
Veld hay plus 2% urea	901	13.1	501	66
Napier hay	904	22.6	326	70
Veld hay refused on				
Veld hay + 1% urea				
Control		8.91	509	66
150Nap		7.80	525	69
300Nap		8.23	525	67
Veld hay + 2% urea				
Control		12.8	510	59
150Nap		12.9	513	68
300Nap		13.0	523	73

3.3. Experiment 2

Results for Experiment 2 are summarized in Table 3. Napier hay contributed 0%, 16%, 30% and 45% of total dry matter intake on Control, 100Nap, 200Nap and 300Nap diets, respectively.

3.3.1. Dry matter intake

As observed in the previous experiment, napier supplementation increased total dry matter intake ($P < 0.05$). However, intake of veld hay tended to decrease as the level

Table 2
Experiment 1. Intake and digestibility measured in lambs fed veld hay alone, napier hay alone (Nap) or veld hay supplemented with 150 g or 300 g napier hay (fresh weight basis; 150Nap, 300Nap, respectively) (values are means of four observations)

	Diet fed				
		150Nap	300Nap	Nap	SED
Dry matter offered ($g\ day^{-1}$)					
Veld hay	630	720	630	–	
Napier hay	0	134	269	1980	
Dry matter intake ($g\ day^{-1}$)					
Veld hay	409	480	412	0	
Napier	0	134	269	1412	
Total	409 [a]	614 [b]	681 [b]	1412 [c]	64.0
$g\ W^{-0.75}$	33.3 [a]	47.2 [b]	52.6 [b]	96.6 [c]	4.2
Intake of basal hay as percentage of that offered	65	67	65	71	–
Napier in the diet (%)	0	22	40	100	
Veld hay equivalent of supplement (g) [1]		61	123		
Anticipated veld hay intake (g) [2]	409	348	286		
Gain in veld hay intake (g)	0	132	26		
Nitrogen content of the diet (%)	0.46	0.85	1.17	2.24	
Faecal DM ($g\ day^{-1}$)	259 [a]	324 [b]	326 [b]	408 [c]	30.1
DM digestibility	0.367 [a]	0.472 [b]	0.522 [c]	0.661 [d]	0.022
Digestible DM intake ($g\ day^{-1}$)	150 [a]	290 [b]	355 [b]	933 [c]	34.7

[a,b,c,d] Means in the same row with different superscripts are significantly different ($P < 0.05$).
[1,2] Calculated allowing for the higher digestibility of napier hay.

of napier supplement was increased. The percentage decreases in veld hay intake were 13%, 23% and 38% on 100Nap, 200Nap and 300Nap diets, respectively. This decrease in veld hay intake was not as much as anticipated had the napier hay (corrected for its digestibility), simply replaced veld hay. The calculated gain in veld hay intake was, however, smaller than that observed in Experiment 1. Dry matter intake on the Nap diet was 2.2 times greater than dry matter intake on the Control diet.

3.3.2. Diet digestibility

Supplementation with napier increased diet dry matter digestibility, but only significantly ($P < 0.05$), when the Control was compared with the highest level of napier supplementation (300Nap diet). The relationship between dry matter digestibility (Y) and proportion of veld hay in the diet (X) (20 data points) was given by:

$$Y = 0.600(\pm 0.049) - 0.001(\pm 0.007)X\ R^2 = 0.202$$

Table 3
Experiment 2. Feed intake and digestibility measured in lambs given veld hay plus 1% urea alone (Control), napier hay alone (Nap) or veld hay plus 1% urea supplemented with 100 g, 200 g or 300 g napier hay (100Nap, 200Nap or 300Nap, respectively) (values are means of four observations)

	Diet fed					
		100Nap	200Nap	300Nap	Nap	SED
Dry matter (DM) offered ($g\ day^{-1}$)						
Veld hay	810	720	630	630	–	–
Napier hay	0	90	180	270	1800	–
DM intake ($g\ day^{-1}$)						
Veld hay	534	462	410	329	0	–
Napier	0	90	180	270	1162	–
Total	534 ^{a}	552 ^{a}	590 ^{a}	599 ^{a}	1162 ^{b}	83
$g\ W^{-0.75}$	40.7 ^{a}	43.2 ^{a}	44.9 ^{a}	45.5 ^{a}	90.6 ^{b}	7.3
Intake of basal hay as a percentage of that offered	66	64	65	52	65	–
Napier hay in the diet (%)	0	16	31	45	100	
Veld hay equivalent of supplement (g) [1]	–	76	152	228	–	–
Anticipated veld hay intake ($g\ day^{-1}$) [2]	534	458	382	306	–	–
Gain in veld hay intake (g)	0	4	28	23	–	–
Percentage nitrogen in the diet	0.88	1.10	1.30	1.49	2.24	–
Faecal DM excretion ($g\ day^{-1}$)	280 ^{a}	276 ^{a}	310 ^{a}	266 ^{a}	434 ^{b}	41
DM digestibility	0.476 ^{a}	0.499 ^{a}	0.474 ^{a}	0.556 ^{b}	0.627 ^{c}	0.032
Digestible DM intake ($g\ day^{-1}$)	254 ^{a}	275 ^{a}	280 ^{a}	333 ^{b}	729 ^{c}	42.3

[a,b,c] Means in the same row with different superscripts are significantly different ($P < 0.05$).
[1,2] Calculated by correcting for the higher digestibility of napier.

The value 0.600 for the intercept represents a calculated value for the digestibility of the napier supplement and is the value used to calculate the veld hay equivalent of the supplement using the equation given previously. Compared with the Control, intake of digestible dry matter was increased by 8%, 9% and 24% on 100Nap, 200Nap and 300Nap diets, respectively. The intake of digestible dry matter was 2.9 times greater on the Nap diet compared with the Control.

3.4. Experiment 3

Results for Experiment 3 are summarized in Tables 4 and 5. Napier hay contributed 0%, 18% and 32% of total dry matter intake on the Control, 150Nap and 300Nap diets, the contribution being similar on the two urea levels.

Table 4
Experiment 3. Feed intake measured in lambs given veld hay supplemented with 1% urea or 2% urea fed without napier hay or with 150 or 300 g napier hay (fresh weight basis) (150Nap and 300Nap, respectively) (values are means of six observations)

	Veld hay + 1% urea			Veld hay + 2% urea			
			300Nap			300Nap	SED
Dry matter offered (g day^{-1})							
Veld hay	900	900	810	900	900	810	
Napier	0	135	270	0	135	270	
Dry matter intake (g day^{-1})							
Veld hay	626	624	596	673	651	581	47.9
Napier	0	135	270	0	135	270	
Total	626^{a}	759^{bc}	864^{c}	673^{a}	786^{bc}	849^{c}	49.8
Total (g $W^{-0.75}$)	53.9^{a}	65.5^{1}	69.1^{b}	55.6^{a}	66.0^{b}	69.9^{b}	4.4
Percentage napier in the diet	0	18	31	0	17	32	–
Intake of basal hay as percentage of that offered	69	69	74	75	72	72	
Veld hay equivalent of supplement (g) [1]		91	180		93	186	
Anticipated veld hay intake (g day^{-1}) [2]	626	535	446	673	580	487	
Gain in veld hay intake (g)	0	89	150	0	71	94	
Nitrogen content of the diet (%)	0.87	1.08	1.29	.31	1.47		

[a,b,c] Means in the same row with different superscripts are significantly different ($P < 0.05$).
[1,2] Calculated allowing for the higher digestibility of napier hay.

Table 5
Experiment 3. Digestibility measured in lambs given veld hay supplemented with 1% urea or 2% urea fed without napier hay or with 150 or 300 g napier hay (fresh weight basis) (150Nap and 300Nap, respectively) (values are means of six observations)

	Veld hay + 1% urea			Veld hay + 2% urea			
	Con	150Nap	300Nap	Con	150Nap	300Nap	SED
Total dry matter intake (g day^{-1})							
Intake of acid detergent fibre (g day^{-1})	328	365	400	352	385	392	26.0
Faecal dry matter excretion (g day^{-1})	353^{a}	391^{ab}	434^{b}	375^{a}	406^{b}	428^{b}	23.8
Faecal acid detergent excretion (g day^{-1})	185	208	227	199	214	225	13.7
Dry matter digestibility	0.439^{a}	0.457^{b}	0.497^{b}	0.443^{a}	0.483^{b}	0.494^{b}	0.018
Acid detergent fibre digestibility	0.438	0.415	0.432	0.439	0.446	0.425	0.021
Digestible dry matter intake (g day^{-1})	275^{a}	366^{b}	427^{c}	298^{a}	380^{b}	419^{bc}	24.8

[a,b,c] Means in the same row with different superscripts are significantly different ($P < 0.05$).

3.4.1. Dry matter intake

There was no significant effect of urea level or urea level by napier level interaction on dry matter intake ($P > 0.05$; Table 4). There was a slight tendency for the intake of veld hay to be greater with 2% urea (626 vs. 673 SED 48 g day^{-1}), but this difference did not approach significance. Supplementation progressively increased DM intake ($P < 0.05$), that of the 300Nap diets being (on average) 32% greater than the control. Veld hay intake fell slightly at the higher level of supplementation, but not as much as anticipated had the napier hay (corrected for its greater digestibility) simply replaced the poorer material. The difference between veld hay intake observed, and that anticipated is described as 'gain in veld hay' in Table 4, and as such represented gains of 34% and 19% in veld hay intake (observed/anticipated) for the two 300Nap diets.

3.4.2. Diet digestibility

There were no differences between the 1% and 2% urea control diets in their DM or ADF digestibilities (0.439 and 0.443 SED 0.018, and 0.438 and 0.439 SED 0.021, respectively, Table 5). Supplementation with napier increased diet DM digestibility $P < 0.05$). The relationship between DM digestibility (Y), and the proportion of veld hay in the diet (X) (36 data points) was given by:

$$Y = 0.571(\pm 0.051) - 0.0012(\pm(0.0006)\,X \quad R^2 = 0.09$$

The value of 0.571 ± 0.051 for the intercept represents a calculated value for the digestibility of napier, and is the value used to calculate the veld hay equivalence of the napier hay. The combined effects of dry matter intake and slight improvement in digestibility meant that digestible dry matter intake was improved by 55% and 41% with the two 300Nap diets compared with the veld hay controls.

4. Discussion

In all the experiments, the rate of offer of veld hay exceeded 30% of intake. This ensured that voluntary intake was not limited by selection. However, analysis of refusals showed no evidence of selection, probably reflecting the effects of chopping prior to feeding. If there had been selection for better material, the refusals would have had less nitrogen and more ADF than the feed offered. The digestibility of the napier in each of the three experiments was obtained from a regression relationship of DM digestibility on the proportion of veld hay in the diet. Despite the low correlation values, especially in Experiments 2 and 3, there was an acceptable agreements between the three digestibility values obtained for napier. In addition, this method was the most appropriate to derive the digestibility values that were used to examine the effects of supplementation intake of veld hay.

4.1. Effect of level forage supplement

In all the experiments, napier hay supplements increased total feed intake. Although the intake of veld hay tended to be reduced with high levels of napier supplementation, the intake of veld hay was always greater than that anticipated if there had been simple substitution. Fig. 1 summarizes data from all the experiments, and shows that. after

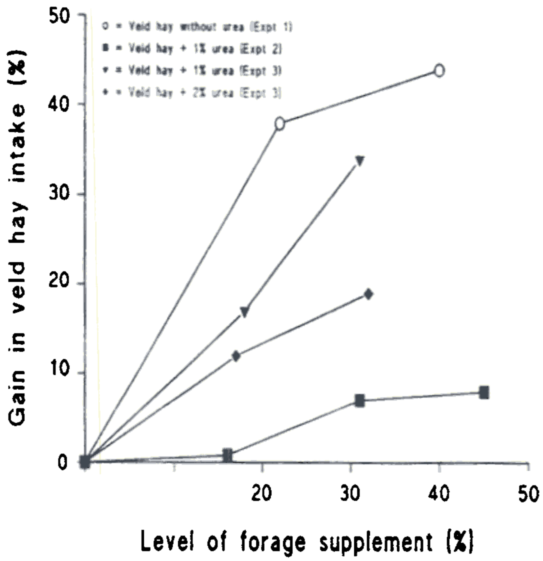

Fig. 1. Effect of level of forage supplement on the calculated gain in veld hay intake. O, veld hay without urea (Experiment 1); ■, veld hay plus 1% urea (Experiment 2); ▼, veld hay plus 1% urea (Experiment 3); ♦, veld hay plus 2% urea (Experiment 3).

correcting for differences in the digestibility of napier and veld hay, the gain in veld hay intake over anticipated was as high as 44%. In most of the experiments reported in the literature, one of the highlighted limitations of forage supplements is that they cause a substitution of the basal forage (Minson and Milford, 1967; Mosi and Butterworth, 1985). This substitution is, however, not always assessed taking into consideration the differences in the digestibility of the supplement and the basal forage as was done in this study.

4.2. *Effect of urea supplementation*

The veld hay used in this study had a low nitrogen content. Previous analysis showed that 60% of the total nitrogen in veld hay was associated with the ADF fraction. The ADF nitrogen is unlikely to be available for rumen fermentation hence exacerbating the dietary nitrogen deficiency. Intake of such poor quality forages will be increased by nitrogen supplementation (Elliott and Topps, 1963). Although the effect of including or not including urea was not tested in a single experiment, it is evident that intake of veld hay was greater on the urea supplemented Control diets (Experiment 2: 40.7 g $W^{-0.75}$ and Experiment 3: 69.0 and 75.0 g $W^{-0.75}$) compared to when veld hay was not supplemented with urea (Experiment 1: 33.3 g $W^{-0.75}$). In Experiment 3, the intake and digestibility of veld hay were not altered significantly by increasing the level of urea from 1 to 2%, suggesting that 1% urea was probably optimum (Tables 4 and 5). This suggestion is supported by data obtained in other experiments showing that rumen ammonia remained above the critical level 50 mg l^{-1} throughout the day on a Control diet of veld hay supplemented with 1% urea (Manyuchi, 1994). There is some indication that gain in veld hay intake at different levels of forage supplementation was greater when the veld hay was not supplemented with urea (Experiment 1) compared to when urea was added (Experiments 2 and 3; Fig. 1), indicating the benefits of the supplemental nitrogen. In Experiment 3, gain in veld hay intake also tended to be greater with 1% compared with 2% urea.

One of the consequences of supplementing veld hay with napier was to increase nitrogen intake (Table 2, Tables 3 and 4). The increase in dietary nitrogen intake would have the predictable effects of increasing intake of poor quality forage (Elliott and Topps, 1963). However, if the stimulation in food intake was entirely due to an increase in nitrogen intake, it would have been expected that the rate of substitution of veld hay by napier would have approached 1:1 once urea was added to the basal diet. Since the substitution was always less than 1:1, this is an indication that the response to napier supplementation was not entirely due to nitrogen. It has been suggested that intake of poor quality forages is increased by increased intake of rumen undegraded dietary protein (UDP) (Kempton et al., 1977). In this study, napier hay is not likely to have contributed significant amounts of UDP since the potential degradability of napier hay was almost attained within the estimated 48 h retention time of digesta in the rumen (83% versus 78%) (Manyuchi, 1994).

Although the increase in feed intake was associated with an increase in digestibility of the diet, there is no evidence of a positive associative effect of the napier hay supplement on the digestibility of veld hay. Similar observations were made in previous experiments (Siebert and Kennedy, 1972; Smith et al., 1989; Manyuchi et al., 1994a). Faecal dry matter excretion increased as feed intake increased, indicating a greater passage of digesta. Related studies (Manyuchi, 1994) confirmed that the increase in feed intake following forage supplementation was associated with an increase in digesta out-flow while digesta pool size was not altered. The increase in digesta outflow would result in an increase microbial protein yield and hence the amount of protein absorbed in the small intestine (Chen, 1989).

The data from these experiments showed that napier hay supplements increased total feed intake and digestibility of the total diet, without reducing the intake of veld hay. The increase in feed intake was not entirely due to increased intake of nitrogen, since the inclusion of urea in the basal diet did not alter the pattern of intake.

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