
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Importance of dry matter content to voluntary intake of fresh grass forages

A. JOHN AND M.J. ULYATT

Biotechnology Division
DSIR, Palmerston North

ABSTRACT

Voluntary consumption (VC) of wet feed and feed dry matter (DM) was measured indoors with sheep fed 3 ryegrass and 2 tall fescue cultivars at different stages of maturity. Increasing plant maturity, indicated by increasing proportion of stem and flowerhead and of neutral detergent fibre and cellulose contents, was associated with decreasing wet feed intakes. VC of wet feed was about 15% higher with ryegrass cultivars than tall fescue cultivars.

VC of feed DM was positively correlated (r = 0.89) with forage DM content at all stages of forage maturity and over a wide range of forage DM contents (12 - 25% DM). VC of wet feed was not affected by changes in DM content so that with forage at the same stage of maturity DM intake was increased with an increase in forage DM content.

Studies with rumen fistulated sheep showed 90% of cells in eating boli are ruptured during 1 h incubation in rumen fluid *in vitro* or *in vivo*. Also VC of immature and mature perennial ryegrass was not affected when a balloon containing 1.5 *l* water was placed in the rumen whereas VC of chaffed lucerne hay was significantly depressed.

It is concluded that VC of fresh forage is limited by a mechanism regulating intake of wet feed, not feed DM, and that DM content may be an important factor limiting nutrient intake.

Keywords Voluntary intake; dry matter content; ryegrass; fescue.

INTRODUCTION

Current understanding of factors which influence voluntary consumption (VC) of forages has been largely developed from studies conducted with dried forages (Minson, 1982). It has been assumed that similar relationships apply to fresh forages, however, there have been few detailed studies done. The poor correlations between intake and plant composition (eg: digestibility) obtained in grazing studies are difficult to interpret due to the influence of sward structure on intake (Hodgson, 1986). There is evidence that VC of dry matter (DM) is limited by DM content of fresh forages. This has been observed over a wide range of DM contents in most studies involving fresh feeds (Arnold, 1962; Duckworth and Shirlaw, 1958; Halley and Dougall, 1962; Johns, 1954; Lloyd-Davies, 1962; Moral, 1982). There is confusion over whether this effect occurs only with immature feeds. However although the mechanism is poorly understood, it is usually assumed to be due to a bulk effect on rumen fill. Comparisons using wilted or partly dried forage have produced conflicting results (Lloyd-Davies, 1962; see Minson, 1982).

This paper reviews VC data from a series of studies on influences of plant composition and the role of rumen fill with fresh grasses.

METHODS

Trial 1-3

Forages were cut daily and fed twice daily (0930 and 1630h) to groups of 2-year-old Romney wether sheep housed individually in metabolism crates. Three or 4 forages were offered and VC was recorded with 8 sheep per forage over 25-30 days, DM digestibility *in vivo* was measured over the last 9 days with 4 sheep in each group. Dry matter content of feeds, refusals and faeces was determined by drying at 95 °C for 24 h in a forced draught oven. Feed samples were stored at —10° and analysed for proportions of total DM in leaf sheath, stem and flowerhead. Freeze dried and ground feeds were analysed for ash, nitrogen (N), starch, soluble sugars, and lipid (John, 1984). Neutral detergent fibre (NDF), acid detergent fibre and lignin were determined by the van Soest sequential extraction procedure (see John and Reid, 1986).

Trial 4

This trial was run concurrently with Trial 3. Six 2-year-old wether sheep fitted with large rumen cannulae were fed (800g DM/day, in hourly aliquots) either Nui ryegrass, Ellett ryegrass or Roa tall fescue. Rumen contents were removed and sheep offered 1kg wet forage. Eating boli were collected at the cardia and mixed. Ingesta samples were incubated in nylon bags in saline at 39° for 30 mins or in the rumen for various times. Bags were removed, washed, freeze dried and the proportion of initial NDF, total N and neutral detergent solubles (NDS) remaining was determined.

Trial 5

Nui pasture turf was grown in a glasshouse and watered with nutrient solution containing rubidium chloride, as a marker for K^+. Vegetative grass (500 g wet weight) was fed to 2 mature sheep and eating boli collected as in Trial 4. Ingesta was incubated *in vitro* in rumen fluid under CO_2 at 39° and rumen fluid sampled after various intervals. Total Rb^+ in ingesta was extracted by homogenising in 0.4 M HCl. All samples were filtered through glass wool, centrifuged (15,000 g, 10 min) and made to 0.4 M HCl. Rb^+ was determined by atomic absorption spectrophotometry by reference to Rb^+ standards made up in 0.4 M HCl and 100 mM K^+.

Trial 6

Fifteen-month-old wether sheep fitted with small rumen cannulae were fed *ad lib.* either immature and mature fresh Nui ryegrass, or chaffed lucerne hay. While being fed each diet soft rubber balloons filled with 1.5 *l* water were placed in the rumen of half the sheep (balloon treatment) with the other half serving as a control treatment. After 8 d the treatments were changed over. VC was recorded daily. With ryegrass diets rumen fluid volume and fractional outflow was measured twice in each treatment period by monitoring the decay of a single dose of ^{51}Cr EDTA.

RESULTS

Trial 1-3

Botanical and chemical composition data (Table 1) showed forage maturity varied between trials. The proportion of stem plus flowerhead (SFH) was negatively correlated with N (r = −0.78**) and pectin contents (r = −0.82**, not shown) and positively correlated with NDF (r = −0.87***) and cellulose (r = −0.90***, not shown). These relationships agree with expected changes in chemical composition of plants as they mature and support the use of SFH as an index of maturity for between trial comparisons.

VC of wet feed (feed water plus DM) decreased with increasing SFH (r = −0.83**), NDF (r = −0.84**) and cellulose (r = −0.88***) contents and was positively correlated with N (r = 0.76**) and pectin (r = 0.84**) contents. VC of wet feed had a low correlation with DM digestibility (r = 0.65*). DM digestibility was negatively correlated with NDF content (r = −0.90***).

Separate regressions ($P<0.05$) between VC of wet feed (g/kg live wt$^{0.75}$/d) and SFH (g/100 g DM) could be fitted for ryegrass and tall fescue cultivars:

Ryegrass VC = 401 − 1.59 SFH r = −0.94

Tall fescue VC = 368 − 1.26 SFH r = −0.91

These regressions indicate that for the same SFH content VC of ryegrass wet feed was about 15% higher than tall fescue cultivars.

VC of feed DM (Table 1) showed low and non-significant correlations with botanical composition, chemical composition and DM digestibility. This differs markedly to dried forages where VC is usually well correlated with forage composition (Minson, 1982).

VC of feed DM could be predicted from multiple regressions using a combination of an index of forage maturity and the DM content (g DM/g wet feed) of the feed. The best fit was obtained when SHF was used as an index of maturity.

Ryegrass VC = 15 + 321 DM − 0.295 SFH $R^2 = 0.92$

Tall fescue VC = 24 + 245 DM − 0.248 SFH $R^2 = 0.90$

The results predict that VC of feed DM was increased with feeds of higher DM content but decreased as forage maturity increased. For example, the DM intakes (mean of ryegrass and tall fescue cultivars) of forage with 12% DM and 0 or 50 g

TABLE 1 Botanical composition, chemical composition and voluntary consumption in trials 1-3.

Trial	Forage	Proportion stem plus flower head (%)	Nitrogen content (%)	Neutral detergent fibre content (%)	Starch plus soluble sugar content (%)	Dry matter digestibility (%)	Voluntary consumption (g/kg live wt$^{0.75}$/d) Wet feed	Dry matter
1	Nui[1]	42.2	1.9	58.8	21.8	68.6	325	68.6
	Ellett[1]	49.7	1.8	57.2	21.5	68.1	323	68.5
	Manawa[2]	25.9	1.9	51.1	27.7	72.1	364	74.9
2	Nui[1]	0	3.0	49.3	14.9	70.9	400	76.8
	Ellett[1]	0	2.5	44.0	22.6	73.4	401	73.0
	Roa[3]	1.0	2.7	47.9	20.6	70.6	384	71.6
	S170[3]	0.6	2.7	46.5	23.4	69.4	356	72.6
3	Nui[1]	20.1	2.3	47.8	18.4	75.3	355	59.7
	Ellett[1]	26.5	2.5	48.0	17.1	77.3	380	61.6
	Roa[3]	20.3	1.8	53.3	15.3	67.5	333	60.7
	S170[3]	51.2	2.1	57.0	12.8	67.1	307	59.3

[1] Perennial ryegrass
[2] Short rotation ryegrass
[3] Tall fescue

SFH/100 g DM were 53.2 and 39.7 g/kg live $wt^{0.75}$/d, while for grass with 20% DM intakes increased to 75.9 and 62.0 g/kg live $wt^{0.75}$/d.

The association between VC of DM and forage DM content was also evident from comparisons of daily feed intake data obtained within individual trials. VC of wet feed stayed relatively constant while DM intake was markedly affected (up to 2.5 x) by DM content, ($r = 0.89 \pm 0.065$). This is illustrated in Fig. 1 with data for Ellett ryegrass in Trial 3. The positive relationship between VC of DM and DM content was evident in all trials showing that it occurs over a wide range of forage maturity and DM contents respectively.

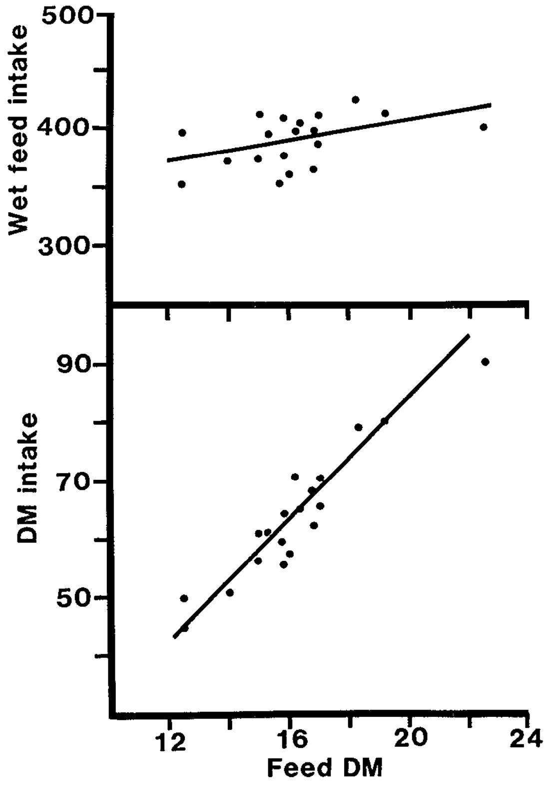

FIG.1 Relationship between voluntary consumption (g/kg live $wt^{0.75}$/d on wet feed and dry matter basis) and feed dry matter content (%) for Ellett perennial ryegrass (Trial 3). Data are mean daily intakes of 8 sheep, changes in feed dry matter content were due to local weather conditions.

Trial 4

The proportions of NDS, total N and NDF retained in nylon bags after incubating ingesta in saline for 30 min were (mean of 3 forages) 41.9 ± 4.0, 58.8 ± 5.9 and 99.8 ± 0.01%. The substantial release of NDS (=cell contents) and total N indicates that a large portion of plant cells were ruptured during eating; less than 5% of these fractions disappeared during incubation with unchewed whole forage (A. John and M.J. Ulyatt, unpublished data).

The proportions of NDS remaining after incubation of ingesta in the rumen for 2.0, 4.7, 8.0 and 11.5 h were 20.1 ± 2.0, 18.4 ± 2.33, 13.4 ± 0.81 and 8.5 ± 0.49%, respectively. The proportions of total N remaining were 43.4 ± 4.2, 31.0 ± 5.7, 27.0 ± 4.1 and 16.6 ± 2.0% while the proportions of NDF remaining were 90.4 ± 4.4, 75.4 ± 1.7, 63.6 ± 3.5 and 47.9 ± 5.1% respectively. These data show that apparent rate of disappearance of cell contents and total N is very rapid. This also indicates that a large portion of plant cells are damaged during or shortly after eating.

Trial 5

The proportion of Rb^+ released from ingesta during incubation in rumen fluid *in vitro* at 0, 15, 30, 45, 60, 80 and 120 min were (mean $\pm$ range) 61 ± 6, 73 ± 4, 83 ± 4, 87 ± 2, 92 ± 3, 93 ± 1 and 94 ± 1%, respectively. Rb^+ has been used extensively as a marker for K^+, both are located entirely within plant cells (Mengel, 1974). The virtually complete release of Rb^+ into rumen fluid by 60 min shows that the majority, if not all, ingesta cells are damaged enough to release at least small intracellular plant solutes. The results from Trial 4 and 5 are strong evidence that most intracellular water would be readily available for absorption from the rumen and would not contribute to digesta load in the rumen. This would make it unlikely that any inhibitary effect of plant water on VC could be via rumen distension.

Trial 6

VC of Nui ryegrass wet feed and feed DM by growing sheep were not affected by the presence of a balloon containing 1.5 *l* water in the rumen (Table 2). Rumen digesta liquid volumes and fractional outflow rates for immature ryegrass were control, 4688 ml and 0.133 h^{-1}; balloon treatment, 4531 ml and 0.137 h^{-1} respectively. Corresponding values for mature ryegrass were control, 4815 ml and 0.114 h^{-1}; balloon treatment 4525 ml and 0.127 h^{-1} respectively. There were no significant differences between rumen volumes (LSD = 524) but fractional outflow rates (LSD = 0.07) were slightly higher with balloon treatment ($P < 0.025$) and were lower with mature feed ($P < 0.05$). VC of wet feed in Trial 6 was close to that predicted by the relationship between VC and SFH content for ryegrasses in Trial 1—3.

VC of lucerne chaff was significantly depressed with balloon treatment (Table 2.) The depression in intake was evident on the day the balloon treatment

TABLE 2 Effect of placing balloons in the rumen on the voluntary consumption (g/kg live wt$^{0.75}$/d on wet feed and dry matter basis) of sheep feed Nui ryegrass (n = 14) lucerne chaff (n = 8).

Feed	Wet feed intake		Dry matter intake		Significance
	Balloon	Control	Balloon	Control	
Nui ryegrass					
Vegetative[1]	370	380	59.3	61.6	NS
Mature[1]	277	281	48.4	50.9	NS
Lucerne chaff[2]	—	—	74.3	82.9	***

[1] Proportion stem plus flower head — vegetative 18.4%, mature 54.9%[1]

[2] Dry matter digestibility 54.6%

commenced and returned to near control values on the day the balloon treatment was terminated.

DISCUSSION

The evidence surveyed here and results from previous studies provide convincing evidence that forage DM content has a strong effect on VC of forage DM. The importance of changes in surface water to changes in DM content of forages in these studies is not known as the proportion of surface:internal water has not been reported. This may be important if the ratio does alter significantly. Comparison of VC of fresh and partly dried forages (Verite and Journet, 1970) has suggested that inhibition of DM intake only occurs below a threshold DM content. However, the present study, in agreement with other studies, shows VC of fresh grass DM and forage DM content are positively correlated over a wide range (12-25%) of DM contents.

VC of wet feed was a major factor limiting intake of forage nutrients. While wet feed intake is clearly depressed with increased forage maturity it is not so obvious that mechanism limits wet feed intake. It is widely believed that intake may be limited by the bulkiness of wet feed. This work shows that any limitation due to bulk does not act through negative feedback from distension of the rumen. Damage to plant cells by chewing during eating allows for the virtual complete release of intracellular solutes so that plant intracellular water would be readily absorbed (Trial 4 and 5). Placement in the rumen of bulk in the form of a balloon containing water equivalent to about one-third of digesta volume did not reduce feed intake with perennial ryegrass diets (Table 2). These results show that the rumen had the capacity to increase digesta volumes as rumen fluid volumes were the same with control and balloon treatments. The reduction in VC of lucerne chaff with balloon treatment (Table 2) confirms conclusions that rumen fill limits intake with dry feeds. Although results with ryegrass and lucerne chaff feeds may not strictly be compared for statistical analysis, because they were fed at different times, it is interesting that intakes of lucerne chaff DM were substantially higher than with fresh ryegrass (Table 2). This may suggest that intake of fresh grass DM was too low for rumen fill to limit VC. Intake of fresh grass DM may have been limited by the capacity to eat wet feed as DM intake rates during eating are substantially lower with fresh grass than with chaffed hay feeds and also decrease with increasing grass maturity (John and Reid, 1986). However, further work is needed to identify whether this or some other factor, such as palatability, limits fresh grass intake.

Wet feed intake with indoor feeding is recorded but is rarely reported. Measurement of wet feed intake in grazing trials may be more difficult as forage water content may change rapidly with changes in evapotranspiration. The present evidence, however, indicates that some estimate of wet feed intake may assist interpretation of intake responses in grazing trials.

REFERENCES

Arnold G.W. 1962. Effects of pasture maturity on the diet of sheep. *Australian journal of agricultural research* **13:** 701-706.

Duckworth J.E.; Shirlaw D.W. 1958. A study of factors affecting feed intake and the eating behaviour of cattle. *Animal behaviour* **6:** 147-154.

Halley R.J.; Dougall B.M. 1962. The feed intake and performance of dairy cows fed on cut grass. *Journal of dairy research* **29:** 241-248.

Hodgson J. 1986. Grazing behaviour and herbage intake. In *Grazing*. Ed. J. Frame. Occasional Symposium No. 19, British Grassland Society. p. 51-64.

John A. 1984. Effects of feeding frequency and level of feed intake on chemical composition of rumen bacteria. *Journal of agricultural research, Cambridge* **102:** 47-57.

John A; Reid C.S.W. 1986. Factors affecting rate of feed intake by sheep. *Proceedings of the Nutrition Society of New Zealand* **11:** 108.

Johns A.T. 1954. Bloat in cattle on red clover. *New Zealand journal of science and technology* **36:** 289-320.

Lloyd-Davies H. 1962. Intake studies in sheep involving high fluid intake. *Proceedings of the Australian Society of Animal Production* **4:** 167-171.

Mengel K. 1974. Ion uptake and translocation. In *The plant root and its environment.* Ed. E.W. Carson. Virginia University Press, Charlottesville. p. 83-100.

Minson D.J. 1982. Effects of chemical and physical composition of herbage eaten upon intake. In *Nutritional limits to animal production from pastures.* Ed. J.B. Hacker. Commonwealth Agricultural Bureaux, Slough. p. 167-182.

Moral M.M.C. del 1982. Study of the nutritive value of a mixed pasture: variations in digestibility and intake. *Pastos 12:* 119-133 (summarised in *Nutrition abstracts and reviews (series B)* Vol. 56 (4)).

Verite R.; Journet M. 1970. Influence de la teneur en ean et da la deshydratation de l'herbe sur sa valeur alimentaire pour less vaches laitieres. *Annales de zootechnie* **19:** 255-268.