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PASTURE QUALITY IN TERMS OF SOLUBLE CARBOHYDRATES AND VOLATILE FATTY ACID PRODUCTION

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SUMMARY

Studies of autumn-saved perennial ryegrass in Canterbury have shown it to have a composition of proximate constituents and coefficients of digestibility similar to those of young spring pasture. These saved pastures can contain up to 20% soluble carbohydrate.

Rumen contents of fistulated grazing sheep were sampled regularly. A repeatable diurnal pattern of levels of volatile fatty acids (VFA) and proportions of individual fatty acids was established. The mean concentration of VFA and the mean proportion of propionic acid can be predicted accurately from three 9 a.m. samples. The application of this technique for predicting energy available to grazing animals is discussed.

INTRODUCTION

EVALUATION of quality of food and prediction of amount eaten are important aspects of animal nutrition. There are two methods of indirect evaluation of forage quality. One is by use of techniques involving an artificial rumen. The other is through use of relationships between chemical composition and nutritive value.

Similarly, with predicting intake or energy available to grazing animals, many differing methods have been proposed. Some have limited use in specific conditions, but, generally, all leave something to be desired in their standard error of prediction (Minson, 1963).

Obviously, it would be desirable to have an intimate knowledge of pasture quality in all regions of a country relying extensively on pastoral production. Unfortunately, nutritive value must be obtained from costly and tedious direct experiment until reliable methods of prediction are developed. In this paper a method for predicting herbage quality and energy available to grazing stock is discussed. It is based on volatile fatty acid analysis from the rumen of grazing sheep.

EXPERIMENTAL

PASTURES

Trials evaluating autumn-saved pasture (A.S.P.) (unpublished data) were conducted at Lincoln from 1960 to 1962

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(designated as L60, L61, L62) and at Methven in 1962 (M62). Methven is 44 miles west of Lincoln.

Climatic conditions were: 1960, a prolonged drought until heavy rain in late March and moderate winter: 1961, cool autumn with adequate moisture and fairly severe winter: 1962, an ideal autumn and moderate winter.

Pastures at Lincoln were perennial ryegrass-white clover and those at Methven, cocksfoot-white clover. By early August, in all trials, except L61 where it was 50%, clover comprised between 6 and 14% of the sward. All pastures were nearly weed-free except M62 where *Bromus* species were present. The date of closing these pastures is shown in Table 1.

During 1963 a further trial with A.S.P. was conducted at Lincoln, this time for grazing experiments. Closing was on March 21 and there were three areas: (a) Perennial ryegrass-white clover with no nitrogen fertilizer (P); (b) Perennial ryegrass-white clover with 5 cwt of nitrolime per acre applied in early April (P₅); (c) A cocksfoot-dominant pasture with some perennial ryegrass and white clover (C).

The late spring regrowth (SP) from the P treatment and a pure white clover (Cl) stand were also grazed for comparison of results with those of the A.S.P. trials.

ANIMALS

Digestibility coefficients of herbage in all trials from 1960 to 1962 were assessed by individually feeding three mature Romney wethers in metabolism cages. During 1960 and 1961 each sheep was fed at 3 p.m. with 7.0 lb of freshly cut herbage. For the 1962 trials, herbage was dried in an air-draught oven and 1.5 lb were fed daily to each sheep. The minimum length of each digestibility trial was ten days.

The three sheep in the 1963 trial were aged pregnant Romney ewes. Permanent rumen fistulas were fitted in the latter half of April. Sheep No. 3 had not recovered sufficiently from its operation for inclusion in the first trial. All sheep lambed twins by early September and lambing troubles caused the death of No. 3. The lambs were taken from the ewes immediately after their delivery.

On six occasions the reticulo-rumen contents were sampled at three-hourly intervals beginning at 9 a.m. and extending through 48 hours. The two 3 a.m. samples and the midnight and 6 a.m. samples on the second day were omitted. At all times the sheep were subjected to only very lenient grazing pressure and were free to graze at any time. Details of this trial are given in Table 2.

CHEMICAL

All analyses for proximate constituents were according to the handbook of the AOAC except that crude fibre determinations were not preceded by an ether extraction. Soluble carbohydrate was estimated after 80% ethanol extraction of freeze-dried samples by use of anthrone reagent. The procedure used gave equivalent intensities of colour for both glucose and fructose.

Between 150 and 200 g of rumen samples were collected and 50 ml of liquor, expressed through muslin, were stored in 10 ml of 10 N.H₂SO₄.

RESULTS

CHEMICAL COMPOSITION OF PASTURES

Proximate Constituents

In these trials perennial ryegrass-white clover pastures closed in February or March have, by early August, yielded between 800 and 2,400 lb D.M./acre. At this time up to 30% of the foliage is dead as a result of frosting and mutual shading. Such pastures, however, have a proximate chemical composition only slightly inferior to an entirely vegetative spring pasture which has grown for a month.

An autumn-saved pasture which gives a higher yield than another has a diminished crude protein (CP) content and a higher crude fibre (CF) content. This is evident if comparisons are made between years. It is also evident within a year if the comparison is made between pastures grown from different dates of closing.

From early closed treatments (Feb./March) the CP content at the beginning of August has varied between 17 and 24%; the CF content between 16 and 21%. Pastures closed from early to mid-April have had levels of CP from 18 to 25% and CF from 15 to 19%.

Early closed, cocksfoot-dominant pastures tend to contain slightly less CP but more CF than perennial ryegrass pastures closed at a similar date. Delaying closing makes the two pastures more comparable.

Soluble Carbohydrate

The two observations in Fig. 1 show that there is a diurnal pattern in the level of alcohol-soluble carbohydrate. These and other results (*e.g.*, Waite and Boyd, 1953) show the trough to be around 9 a.m. Overseas workers have not found as great a difference between peak and trough as was

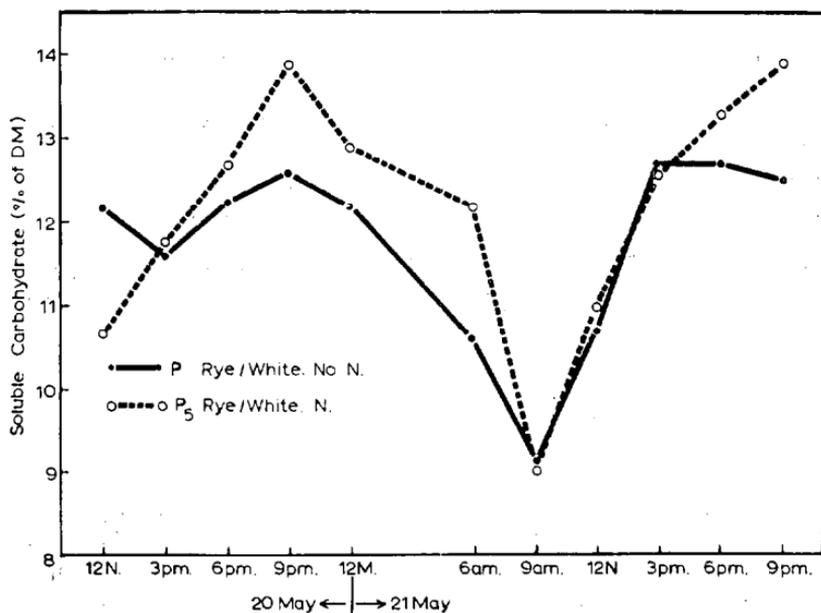


Fig. 1: Diurnal variation of alcohol-soluble carbohydrate content of two pastures.

found here. This may in part be caused by a buffering effect of large amounts of fructosan, a carbohydrate present to only a limited extent in New Zealand pastures (Bailey, 1962).

To characterize New Zealand pastures fully, further studies of diurnal changes should be made and they should extend to other seasons of the year.

When the P treatment in the 1963 trials was persistently sampled at between 2 and 3 p.m., three features became evident (see Fig. 2): First, there is a large day-to-day variation which is closely related to the number of sunshine hours preceding the sampling. This agrees with the results of MacKenzie and Wylam (1957) when they artificially shaded plants.

Secondly, the peak of soluble carbohydrate tends to occur at about the shortest day. This was also evident in all trials before 1963. In Britain, Baker (1957) and Corbett (1957b) obtained the same pattern and they explain it through the influence of an increasing amount of dead material on the plant because pastures kept short and green at this time have a relatively constant level of soluble carbohydrate (Baker, 1957). This does not explain the

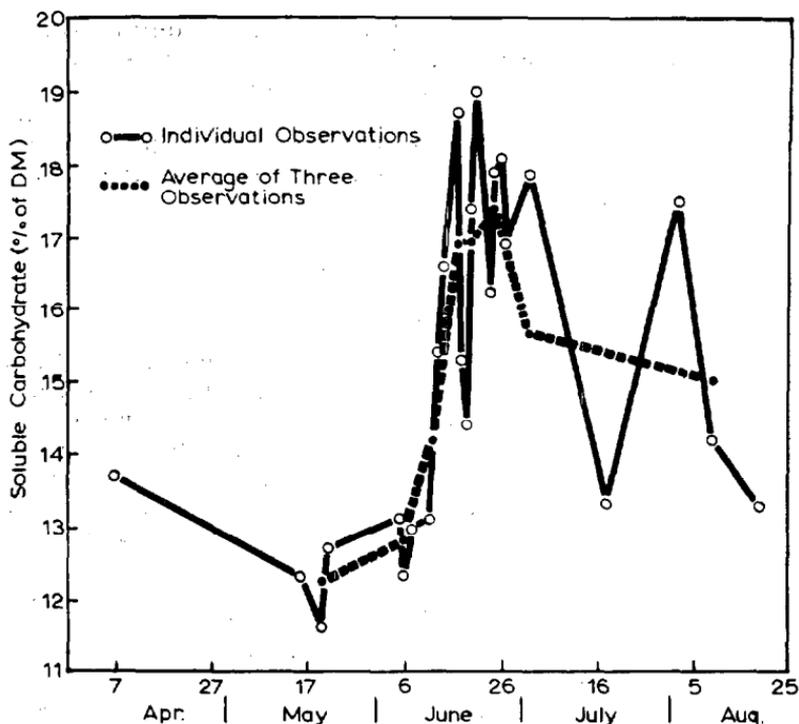


Fig. 2: Seasonal variation of the alcohol-soluble carbohydrate content of perennial ryegrass-white clover pasture in 1963.

present results because pastures kept short in the 1960 and 1962 trials had the greatest increase in the level of soluble carbohydrate. Other New Zealand workers (McIlroy and Bartrum, 1940; Johns, 1955) tend to confirm the latter observation but their results are inconclusive.

The third feature is the extremely high level of soluble carbohydrate present; it exceeds all reports in the literature for pastures at this time of year. If allowance is made for the influence of dead material on long A.S.P., or if herbage from short green pastures at this time is analysed, the level of carbohydrate can, on a bright sunny afternoon, reach 25% of D.M.

In 1960 when clover was analysed separately from perennial ryegrass, this, too, showed a mid-winter peak of soluble carbohydrate. This level was consistently lower (3 to 4% of D.M.) than the grass.

Proportions of sugars making up the carbohydrate fraction were judged by comparing against standards, intensi-

ties of colours of developed spots on paper chromatographs. The following are averages of 54 observations from the 1960 and 1961 trials: Glucose and fructose about $1/5$ each, sucrose about $1/3$, and an unknown about $1/4$. This unknown corresponds in R_{Glucose} value to Bailey's (1958) "reducing disaccharide B". No xylose was present in the clover. This is contrary to Bailey's results.

ANIMAL MEASUREMENTS

Digestibility

It is surprising to find autumn-saved perennial ryegrass-white clover pastures with coefficients of apparent digestibility (Table 1) only just below those of young spring pasture. There is a variation of digestibility between years which is paralleled by chemical composition. The early closed cocksfoot-dominant pasture (M62) has suffered marked deterioration of nutritive value throughout winter. Later closing of such a pasture markedly improved the digestibility, while later closing of a perennial ryegrass pasture has only a small effect on digestibility.

The starch equivalent content of early, closed perennial ryegrass has ranged from 61 in 1961 to 71 in 1960. The nutritive ratio has varied from 1: 4.5 in 1962 to 1: 2.7 in 1960. Lancaster (1950) reports an S.E. of 61 for A.S.P. in the North Island.

Volatile Fatty Acid Production

Before the sheep were put out to graze they were fed indoors on hay and sheep nuts. Sampling from the mid-rumen region gave consistent results between days. When the sheep were grazing, the sampling point was located by pushing a $3/4$ in. glass tube through the fistula at an angle inclined both forward and to the middle of the sheep. To ensure that sampling was always relative to the level of rumen fill, the sampling tube was pushed to the floor of the rumen and the depth of fill judged when the tube was removed. The sample was taken by reinserting the sampling tube to half the depth of fill.

The diurnal pattern of the level of VFA in the rumen of the sheep in the six grazing trials is summarized in Fig. 3. With only a few exceptions, the form of the curve for each sheep in each trial was consistent with the average presented in this figure. The exceptions were when the sheep in both the spring (SP) and summer (C1) trials and one

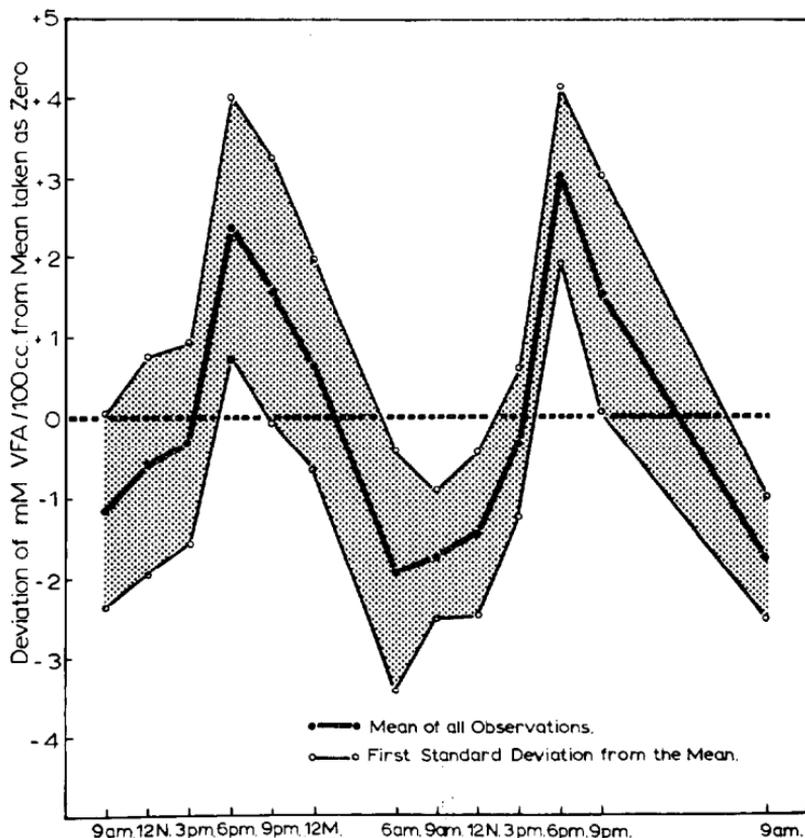


Fig. 3: Diurnal pattern of VFA in the rumen of grazing sheep.

sheep (No. 2) in the mid-winter trial (P) had their peak VFA concentrations at 9 p.m. instead of 6 p.m. This change is reflected by the larger standard errors at these times.

It would be of interest if any point(s) on this curve could be used to predict the mean level of VFA. This is best done by using the average of the three 9 a.m. samples (x) (the points where the standard deviations are lowest). The relationship is presented in Fig. 4 where the mean concentration of VFA (y) is predicted by:

$$y = 2.47 + 0.92 \left(\pm 0.029 \right) x \left(\pm 0.27 \right)$$

This regression accounts for 98.7% of the total variance. Actual and predicted levels of VFA are in Table 2. Allowing for the standard error of prediction, a difference of 1.0 m-mole of acid between predicted means (either between trials or between sheep within a trial) is necessary for statistical significance.

TABLE 1: DIGESTIBILITY OF ORGANIC MATTER OF A.S.P.

Trial	Closing Date of	% Digestibility at									
		23.4	12.5	26.5	26.6	6.7	20.7	6.8	18.8	1.9	19.9
L60	29.3 15.8			85.3	84.6	84.7	83.3	83.8	83.5	83.5	84.8*
L61	1.2 1.6 10.7	78.4		77.6	77.1		80.5			77.3	84.9*
L62	10.3		83.7				79.1		78.6		
M62	21.2 26.3	77.0				70.8		82.2	66.2		

* Young spring pasture.

TABLE 2: SUMMARY OF DIURNAL SAMPLINGS OF THE RUMEN CONTENTS OF GRAZING SHEEP

Trial	Pasture	No. of Sheep	Date	Av. mM V.F.A./100 ml		Average percentage of Propionic			
				Actual	Predicted	Acetic	Actual	Predicted	Butyric
I	P	2	5-7.6	10.37	10.49	56.7	27.7	28.0	15.6
II	P ₅	3	11-13.6	12.35	12.38	53.5	29.0	29.1	17.5
III	C	3	18-20.6	11.14	11.11	51.2	30.5	30.1	18.3
IV	P	3	25-27.6	13.46	13.38	51.0	29.9	29.9	19.0
V	SP	2	22-24.10	14.94	14.82	53.5	29.9	30.0	16.6
VI	Cl	2	18-20.12	17.42	17.53	53.7	33.1	33.3	13.2

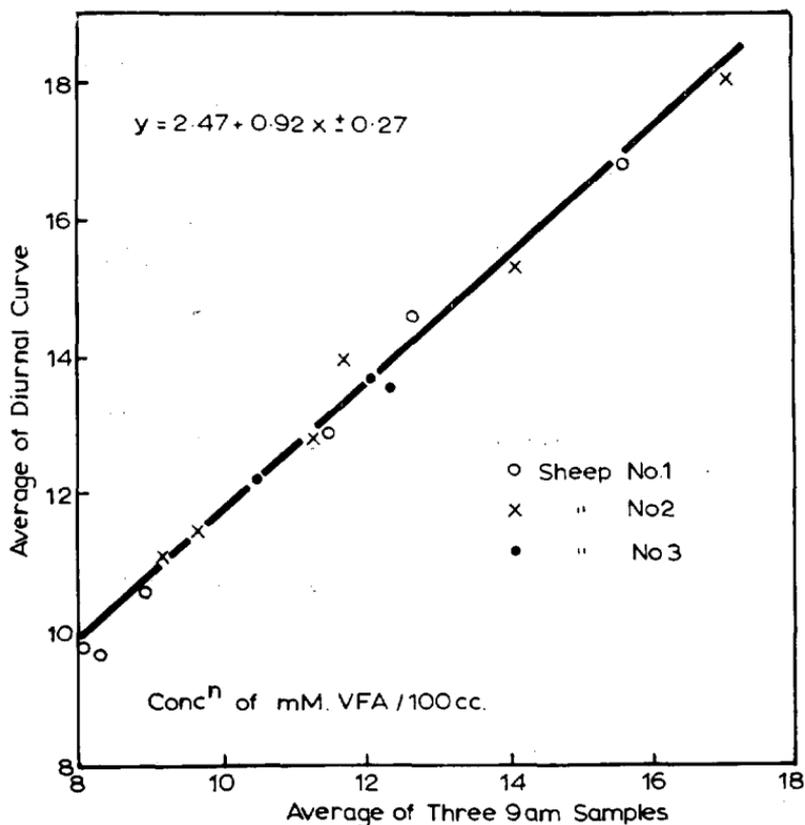


Fig. 4: Relation of 9 a.m. to mean daily VFA concentration in the rumen of grazing sheep.

There are no consistent sheep or trial deviations from the regression. An explanation follows as to why the standard deviations for individual times in Fig. 3 are relatively large (± 0.75 to ± 1.66 mM) and the S.E. of the estimate of regression is relatively low in two parts:

- The trough (x) is related to the peak ($r=0.94$) by a coefficient of x of 0.85. This causes a smaller amplitude between peak and trough as the level of VFA in the rumen increases. The intermediate points between peak and trough are also affected by this change in amplitude.
- Aberrant variations at different sampling times tend to cancel out.

The percentage of individual acids also show a diurnal pattern. The percentage acetic is least when VFA concentra-

TABLE 3: SUMMARY OF DIURNAL SAMPLINGS OF THE RUMEN SHOWING DIFFERENCES BETWEEN SHEEP

Av. of Trials	Sheep No.	Av. mM VFA/100 ml		Average percentage of			
		Actual	Predicted	Acetic	Propionic		Butyric
					Actual	Predicted	
I, V, VI	1	13.69	13.70	53.4	31.5	31.7	15.1
	2	14.79	14.85	55.8	29.0	29.1	15.2
II, III, IV	1	11.08	11.17	51.7	29.8	29.7	18.5
	2	12.73	12.49	50.9	30.7	30.2	18.4
	3	13.14	13.21	53.2	28.9	29.2	17.9

TABLE 4: % COMPOSITION OF FOOD IN DIURNAL GRAZING TRIALS

Trial	Pasture	Crude Protein	Crude Fibre	N.F.E. & Ether Extract	Ash	Soluble Carbohydrate	Ratio sol. CHO to CF
I	P	19.9	15.1	54.8	10.2	12.7	1 to 1.19
II	P ₅	26.4	16.2	47.2	10.2	13.4	1.21
III	C	19.9	18.5	50.0	11.6	13.3	1.39
IV	P	18.6	16.3	55.5	9.6	18.7	0.87
V	SP	17.5	17.5	56.7	8.3	11.6	1.51
VI	Cl	19.9	13.4	56.6	10.1	8.0	1.68

tion is the highest and greatest when VFA concentration is lowest. The percentage propionic acid is inversely related to acetic. The mean percentage of propionic acid (y) can best be predicted from the average of the three 9.00 a.m. samples (x) by the relationship

$$y = 4.2 + 0.89 (\pm 0.056) x (\pm 0.44)$$

This regression accounts for 95% of the total variance and a difference of 2% would be needed for statistical significance.

The percentage butyric acid shows no clear diurnal trend.

The contribution of each of these acids is shown for each trial in Table 2 and as an average for each sheep in Table 3. The differences between sheep are variable and are of doubtful significance.

The analysis of the food is shown in Table 4. There are no statistically significant relationships between the percentage soluble carbohydrate or the ratio of soluble carbohydrate and the mean percentage of propionic acid or the mean level of VFA in the rumen. The relationship between the mean percentage of propionic acid and the mean level of VFA just fails to reach statistical significance.

DISCUSSION

AUTUMN-MAINTAINED PASTURE

The relatively steady percentage of crude fibre and crude protein and high level of digestibility throughout winter indicate that closing date of perennial ryegrass-white clover pastures is not critical to the grazing animal. This means that the dead material with a composition of proximate constituents similar to mature ryegrass must maintain a fairly high level of digestibility. This is contrary to the results from Aberystwyth where it is shown by *in vitro* digestion that the "burnt" fraction has a digestibility markedly less than the green fraction (Miles *et al.*, 1964). The extent to which dead material in the sward influences acceptability of the pasture to the grazing animal is unknown. From the VFA data and the consistency of rumen samples, it appears that during winter the amount eaten was less than in spring or summer. This may not be entirely correct because pregnancy causes changes in the alimentary canal (Graham and Williams, 1962).

Results with early closed cocksfoot are not consistent with those of perennial ryegrass. The deterioration of food value means that time of closing is more critical if a good yield of highly nutritious food is required.

Throughout mid-winter there is a loss of D.M. yield from all closed pastures. The extent of loss depends on the date of closing, the extent of growth, the severity of winter, etc. Especially in an autumn when growth is extensive, the yield of A.S.P. in August may be as great from a closing in early April as from a closing in early March. The total yield of pasture from March through to August will be in favour of the later closed pasture. Brougham (1956) obtained similar results at Palmerston North.

The response to 3 cwt/acre of nitrolime applied by early April has in all trials from 1960 to 1962 been variable. Compared with the yield of untreated controls in early August, nitrolime has given an added yield ranging from 8 to 75% in various trials. The largest difference in yield was in 1960 when the growing period was limited. In other years mid-winter loss of herbage disproportionately reduced the yield of swards treated with nitrogen. For this reason applications of nitrogen appear to be uneconomical in most years in Canterbury.

In a climate like that in Canterbury, autumn saving of ryegrass-based pastures is recommended. This is in contrast to results from the United Kingdom, where, for various reasons, cocksfoot is recommended (Corbett, 1957a; Baker *et al.*, 1961) in spite of the starch equivalent content being low (Castle and Watson, 1961).

SOLUBLE CARBOHYDRATE

Because of the diurnal variation Waite and Boyd (1953) suggest that a time for routine sampling is at the trough of the curve (*i.e.*, 9 to 10 a.m.). From limited analyses done in connection with this work this does not seem to be a realistic time to sample because (a) carbohydrate levels at the trough exist for only a short period of the day, and (b) it does not measure accurately the composition of the food the animal grazes because the period of maximum grazing appears to be during mid-afternoon.

Because of this and because of a higher soluble carbohydrate content at this time, it might be advantageous when break-feeding leaf crops in winter to do so in late afternoon.

There is little doubt that in Canterbury there is a mid-winter peak in the level of soluble carbohydrate in the plant. It could be induced by changes in day-length and/or temperature and could be one of the plant's mechanisms to resist freezing (Levitt, 1956). There is no apparent explanation as to why the extent of increase should be greater in Canterbury than elsewhere.

Recent work shows that the level of soluble carbohydrate in plants influences the animals' actions and reactions. Bland and Dent (1964) show animal preferences for strains of cocksfoot to be related to the level of soluble carbohydrate but they do question whether it is a direct relationship. Bailey (1964) suggests that the ratio of soluble to structural carbohydrate influences animal production from different pasture species.

VOLATILE FATTY ACID PRODUCTION

Because of many variables, there are always difficulties in interpreting levels of VFA in samples from the rumen.

The first arises through stratification of concentration of VFA. In these experiments this was minimized by always sampling relative to the mid-point of the digesta. Bryant (1964) has shown that this point is representative of the rumen as a whole.

Secondly, any sample represents the balance between production and absorption. The rate of absorption is dependent on two main factors. The pH in the rumen is one; the other, which is more important, is the concentration of VFA in the rumen. From Bryant's work it would be expected that pH would be relatively constant, so leaving absorption being mainly dependent on VFA concentration.

The volume of digesta is the third factor affecting interpretation of results. This usually shows a diurnal pattern. From visual observations in these trials this does not appear to be great and changes are certainly insignificant in comparison with changes in volume of rumen contents of stalled animals. Also, the volume of rumen contents varies characteristically between foods (Johns *et al.*, 1963; McLean *et al.*, 1964). Rook (1964) claims that changes in volume of digesta in the rumen preclude VFA concentration from being an index of VFA production.

However, if diurnal changes of volume of digesta are small, and the above conditions are fulfilled, the level of VFA in the sample will indicate the amount of energy available for absorption. The variation of volume of digesta caused by different foods may not affect interpretation of results as seriously as Rook suggests. Support for this claim comes from calculations of data given by McLean *et al.* (1964). Although rumen volume varies markedly, there is a good correlation ($r=0.75$) (66 d.f.) between the concentration of VFA at slaughter and liveweight gain (corrected for rumen fill) in the experimental period. The correlation should be greater had all lambs been killed at

exactly 9 a.m. instead of having removed groups of sheep from pasture at noon and taking up to four hours to kill them.

Warner (1964) and Rook (1964) say that for accurate results the rumen should be sampled at regular intervals. Although this was done in these experiments, results show that the mean concentration of VFA can be predicted reliably from 9 a.m. samples, so making diurnal sampling unnecessary.

From the consistency of rumen contents, it is obvious that the major period of food intake is during the afternoon. Ulyatt (1964) observes this with his grazing sheep and Hancock (1950) shows that cattle graze mostly during the hours of daylight although there is a large difference between individuals in the time they spend grazing.

The factor causing the strong diurnal pattern of rumen VFA is not known. It could be influenced by the diurnal pattern of soluble carbohydrate in the pasture or it could be the influence of duration of daylight on the grazing habits of sheep. Hancock's work suggests the latter and this could explain the shift of peak rumen VFA concentration between winter and summer. A similar diurnal pattern was obtained at Palmerston North by Bryant (1964).

If this technique can predict and give valid comparisons of energy available to grazing animals, and there are indications that it may do this, it could be of value to plant breeders — that is, it may be used to predict the strain or species of pasture from which the grazing animal will ingest and assimilate the most energy. In this respect the significant differences in VFA concentration within the rumen between sheep poses a problem. One way of overcoming it is to graze and move all sheep to different pasture strains as a group, but this immediately sets a time factor in which the maturity of a pasture could alter. Also, it is not known how long the changeover period should be to allow the animal to adjust itself to a different food. The other way is to sample the rumen contents of all sheep on a standard pasture, then with appropriate sampling graze them individually or in small groups on the strains under test. Correction for individual variation could then be made.

It must be remembered that this technique has been shown to work under lenient grazing pressure only. If other criticisms are answered and the technique studied proves itself under more intensive grazing pressure, it may then be an aid in predicting available energy to sheep under different systems of management.

PASTURES GRAZED

Because of the effect of pregnancy on the alimentary canal, differences in levels of VFA in the rumen of the sheep grazing A.S.P. may not entirely be a reflection of *ad libitum* grazing. Nevertheless, when the sheep were grazing cocksfoot, the concentration of VFA in the rumen was significantly less than when they were grazing perennial ryegrass either immediately before, or afterwards. This agrees with previous observations with autumn-saved cocksfoot.

The spring and summer trials are free from any bias and results agree with those of Johns *et al.* (1963) and McLean *et al.* (1964) in showing clover as superior food to perennial ryegrass.

It is surprising that there are no statistically significant relationships between soluble carbohydrate and fermentation patterns. It is possible that the relationships may be obscured by other factors such as the pattern of lignification. It is clear that other factors are involved because spring and summer pastures have a similar gross chemical composition throughout New Zealand, but performance of stock and pattern of rumen fermentation appear to be different. This is evident if the work at Palmerston North (Johns *et al.*, 1963; Rae *et al.*, 1964; Bailey, 1964) is compared with that at Lincoln (McLean *et al.*, 1962, 1964, and with the spring and summer results reported here). The existence of such differences is evident on a farm scale when lamb performance between the North and South Islands is compared. This offers a line of research which may well prove fruitful and may have important consequences in increasing the efficiency of the livestock industry in New Zealand.

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DISCUSSION

J. W. STICHBURY: *The digestibility of spring and autumn grass was almost the same. Was lamb growth on these pastures also similar?*

L. R. KINGSBURY: I have no data that would allow me to answer this question. The result of any such trial would be confounded with the effect of season on the wellbeing of the lamb.

DR C. S. W. REID: *Is the high soluble carbohydrate level seen in winter pasture related to a pattern of sunny days and cold night temperatures?*

MR KINGSBURY: Sunny days do have an effect in increasing the level of carbohydrate in the plant. Low night temperatures could presumably reduce the rate of respiration and so aid the rise in level of soluble carbohydrate.

DR R. W. BAILEY: *I agree with Mr Kingsbury that sampling should be in the afternoon and not at 9 a.m. as recommended by other authors. Does Mr Kingsbury think that the accumulation of soluble sugars during the winter is because conditions are such that photosynthesis can occur but not growth? In the Manawatu, growth*

continues during the winter and sugars do not accumulate to the same extent.

MR KINGSBURY: This is another factor which could help explain the results I have reported. It does not explain clearly the peak level in June because temperatures recorded at the Meteorological Station one mile away are similar in both June and July. Another factor influencing results could be translocation of carbohydrates to the roots of plants.

DR K. J. MITCHELL: The build up in soluble carbohydrate in June at Lincoln could arise from the differential sensitivity of new growth and photosynthesis to low temperatures. New growth would probably be more strongly restricted at a higher level of temperature than photosynthesis. On this thinking the June increase in soluble carbohydrate would arise from temperatures being at a level which restricted new growth proportionately more than photosynthesis. The decline in July would then follow from July temperatures being low enough to restrict both substantially. This differential effect of low temperatures agrees with Palmerston North and English experience.

MR KINGSBURY: Meteorological records do not indicate this, but detailed measurements of the micro-climate might show it to be so.

DR BAILEY: *Has Mr Kingsbury looked for fructosans in the soluble sugar extracts? Short chain fructosans may be present to quite a reasonable extent in New Zealand grasses and these would be soluble in 80% alcohol.*

MR KINGSBURY: Only after running paper chromatograms with ten times the recommended amounts of carbohydrate was there any indication of trace amounts of a tri- or tetrasaccharide.

PROF. I. L. CAMPBELL: One of the most interesting features of Mr Kingsbury's data is the low acetic and high propionic acid values obtained in rumen samples. He has suggested that these are associated with rapid growth, but in fact no growth data were obtained. Reference has been made to the work of McLean and co-workers for comparative results. It seems dangerous to assume that data obtained from samples taken at slaughter were necessarily typical of the fermentation during the growing period in McLean's work and, further, to assume that the growth rates obtained in other experiments would have applied in the present work if the pasture had been fed to sheep.

It would be interesting to have comment on the respective growth rates of sheep in South and North Island trials where the indications are that the proportions of the VFA were radically different.

MR KINGSBURY: With reference to McLean's work, if fermentation patterns are widely different between groups of sheep on different pasture species, data taken from samples at slaughter should be valid for purposes of comparison. My calculations from McLean's data were a check to see if concentration of VFA in the rumen was related to performance of the animals. As it was so, this gives weight to my thesis that differences of VFA measured in the rumen by the technique proposed here are related to energy available to the grazing animal. More direct measurements of such relationships are obviously necessary.

From the limited data available it seems that growth rates of lambs (and sheep in general) in the South Island are better than those in the North Island. However, comparisons are complicated by such variables as breed and age. Strictly comparative trials are needed.

A. M. BRYANT: When Mr Kingsbury's results on patterns of VFA production in the rumen are compared with those obtained in the Manawatu marked differences are found. If it is true that high propionic acid production is connected with increased animal growth, then sheep grazing pasture such as described by Mr Kingsbury should have growth rates considerably greater than sheep in the Manawatu.

PROF. I. E. COOP: I cannot recall the comparative figures for growth rate of lambs on the pasture species trials at Massey and at Lincoln. But as a generalization I would say that the growth rate of lambs in the South Island is significantly higher than that in the North Island.