FIFTH SILAGE CONFERENCE

SUMMARY OF PAPERS

SILAGE PRODUCTION AND UTILIZATION

1978

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HELD AT

THE HANNAH RESEARCH INSTITUTE
AYR, SCOTLAND

18 - 20 SEPTEMBER 1978

ACKNOWLEDGEMENTS

Participants are most grateful to the Council and Director of The Hannah Research Institute for providing facilities for this Fifth Silage Conference.

The organisers acknowledge the valuable assistance given to the conference secretariat by Miss B Watt and Miss E Macdaid of The Hannah Research Institute. Mrs N Lennox of the West of Scotland Agricultural College prepared the manuscript for offset litho reproduction which was undertaken by the Colleges' Reprographic Unit.

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INTRODUCTION

J A F ROOK

THE HANNAH RESEARCH INSTITUTE, AYR

The first of the present series of Silage Conferences was held in 1970 on the initiative of Dr P McDonald, who, with W F Raymond, CBE, formed the first organizing committee.

A regular biennial pattern of conferences has now been established, and previous meetings were held at either the Edinburgh School of Agriculture or the Grassland Research Institute, Hurley. The selection of the Hannah Research Institute as the venue on this occasion has given great pleasure to the staff of the Institute, especially since this year is the Golden Jubilee of the foundation of the Institute. Grassland research has been an important feature of the Institute's work from the beginning, and silage research has become a dominant interest in recent years.

There has been a most encouraging response to the present Conference and we are particularly pleased to welcome those from overseas. The topics selected for discussion cover many aspects of work on silage and have attracted scientists from widely different backgrounds. There is the promise of a most useful meeting.

Dr M E Castle, of the Institute staff, has acted as Secretary for the Conference but he has had considerable assistance and support in the planning of the meeting from Dr P McDonald and Dr R J Wilkins. The papers have been edited by Dr R Harkess, of the West of Scotland Agricultural College. All concerned with the Conference are most grateful to these four people.

SESSION 1 SILAGE FERMENTATION AND AEROBIC DETERIORATION

PAPERS 1 TO 4

CHAIRMAN - PROFESSOR J A F ROOK

Paper No. 1.

GRASS CONSERVATION RESEARCH WITH REGARD TO THE DEVELOPMENT OF SPORES OF LACTATE-FERMENTING BUTYRIC ACID BACTERIA

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The present-day method for conservation of grass in the Netherlands includes wilting. In general silage making comprises the following activities: mowing and tedding, natural drying of the grass up to about 40-50% dry matter then the transporting of wilted material with a pick-up trailer to a clamp or silo.

With this approach some important objectives are attained: evenly and sufficiently wilted grass by intensive tedding (at least once a day during dry weather), rapid ensiling (if possible within one day) and then immediately, air-tight sealing of the clamp with two polyethylene sheets or with one sheet and a soil cover.

Successful ensiling is achieved if conditions of high osmotic pressure and sufficient lactic acid are produced to inhibit growth of unwanted bacteria (e.g. clostridia). Good quality silage has less than 0.2% butyric acid and less than 8.0% ammonia-N in the total N.

A good herbage conservation method has in principle the following objectives:

- small losses of dry matter, digestibility and feeding value
- good intake of silage when fed
- practicability for the farmer (it must also fit into the farming system) and
- no disadvantage for the cheese industry.

As far as this last factor is concerned, large numbers of spores of lactate-fermenting butyric acid bacteria in silage can be harmful. These spores can reach milk via manure and lead to late-blowing in cheese during the storage period. A serious lactic acid fermentation appears during which butyric acid, carbon dioxide and hydrogen are formed and the presence of these products make the cheese unsuitable for consumption.

In wilted silage (high dry matter content and high osmotic pressure) the growth of the unwanted butyric acid bacteria is usually inhibited. However, in practice, wilted silage sometimes proves to be harmful because of large numbers of spores of lactate-fermenting butyric acid bacteria. These bacteria grow in wilted silage in places where sufficient lactic acid is present, pH is not too low and other conditions for growth are favourable (e.g. anaerobic conditions, temperature and humidity).

The following aspects require further research:

- the measurement of contamination of grass with spores of lactate-fermenting butyric acid bacteria before ensiling (initial contamination)
- the increase in the number of spores of these bacteria in grass after ensiling and during storage and
- the increase of spores in the digestive tract of the lactating cow.

Current research work is examining the first two aspects on a practical scale and also with one-litre jars at the laboratory. The preliminary results from the farm scale investigations are:

- applying slurry (30 tons/ha) did not increase the number of spores on grass at the time of mowing or in the silage after 3 months in the silo.
- contamination of grass with soil (molehills) seemed to increase the number of spores in silage.
- following a long wilting period, (5 days or more), higher numbers of spores were found in untedded grass than in intensively tedded grass.
- loading machinery (pick-up trailer versus chopper) also influenced the number of spores in grass silage. Using a chopper, lower numbers were found in a 3-4 months old silage than where a self-loading pick-up trailer was used.
- where the clamp was not immediately made air-tight there was a temperature rise. A wet layer was then formed due to condensation and a large number of spores were found in this layer.

Paper No. 2.

THE AEROBIC DETERIORATION OF GRASS SILAGES

R CRAWSHAW and R H LLEWELYN

ADAS, BRYN ADDA, BANGOR, GWYNEDD, WALES

It is widely recognised that ensilage losses will be high when aeration of the silo is prolonged during silage making. Only recently has it been pointed out that the losses associated with the aerobic deterioration of silage during the feeding period can also be significant. The purpose of the work reported here was to attempt to quantify such losses using typical grass silages from commercial farms.

The procedure involved the aerobic exposure of 50 g samples of silage under controlled laboratory conditions at a constant ambient temperature of 20^{0}C. A solution of 20% potassium hydroxide was used to absorb any carbon dioxide produced as a consequence of microbial activity. Replicate aerobic units were opened for chemical analysis after 3, 6 and 9 days and CO_2 production measured by pH titration with HCl. Dry matter (DM) losses were calculated from the equation $C_6H_{12}O_6 + 6O_2 - 6CO_2 + 6H_2O$.

The potential for aerobic degradation of silage in these units was demonstrated with maize silage. DM losses were as high as 8.4% after 3 days, 17.5% after 6 days and 30.9% after 9 days. Grass silages were on the whole more stable and much lower values were recorded for DM loss. This marked distinction between the deterioration of maize and grass silages is shown in Table 1 - all samples being taken from the silage face.

Table 1. Comparison of cereal and grass silages

Silage type	No. of samples	Mean % DM	Mean % DM Loss			Mean pH	
			3 days	6 days	9 days	0 days	9 days
Maize	2	18.0	4.1	12.7	26.1	3.7	6.8
Barley	1	22.6	0.14	1.5	3.3	3.9	4.4
Grass	10	35.6	0.20	0.83	1.9	4.3	4.5

The grass silages were also core sampled - usually about one metre back from the face. It was expected that face samples when exposed to air in the laboratory would begin to deteriorate more quickly as a consequence of their previously greater aeration. This did not happen. Very little CO_2 was produced from any samples within the first 3 days, and at 6 and 9 days the core samples were associated with slightly higher values in most cases.

There were 3 grass silages in which the extent of deterioration could have been of practical significance. Their chemical composition is contrasted in Table 2 with that of grass silage from 6 other farms. Similarities in analyses make it difficult to predict aerobic stability.

Table 2. Chemical composition of stable and unstable silages

Silage group	% DM loss after 9 days	DM (%)	pH	NH_3N (% TN)	Acid (% in DM) Lactic	Acetic
Stable	0.5 (0.15-1.47)	32.2 (19.0-45.5)	4.29 (3.6-4.7)	7.1 (1.3-15.3)	4.2 (0.9-9.8)	1.4 (0.2-3.8)
Unstable	5.9 (1.4-10.4)	39.2 (29.8-45.6)	4.31 (3.9-4.7)	6.6 (2.2-10.7)	6.8 (2.8-8.7)	1.3 (0.7-2.0)

The laboratory studies involved small amounts of material, loosely compressed and retained for several days at a warm ambient temperature. These conditions may be expected to allow a greater rate of deterioration than those typically found on commercial farms in winter. In an attempt to assess the relevance of laboratory findings to farm practice, a parallel study was piloted on one farm in which the in-situ deterioration of the silage was monitored by the use of a box attached to the face. Both systems recorded considerable CO_2 production. In the laboratory system this was calculated as a 8.4% DM loss over 9 days with a pH rise from 4.0 to 5.2. On the enclosed silage face, however, the pH rose only from 4.0 to 4.1 despite the release of 224 g CO_2/m^2. This suggests that laboratory conditions were more conducive to aerobic deterioration than those actually found at the silage face.

A previous study involved the application of formic and propionic acids to grass immediately before ensiling in laboratory silos. The aerobic deterioration of the resulting silages was measured after exposure at 20^{0}C for 6 days. Some results are shown in Table 3.

Table 3. Restriction of aerobic deterioration by additives

Application rate (litres/tonne)	85% Formic acid			99% Propionic acid		
	initial pH	final pH	% DM loss	initial pH	final pH	% DM loss
0	4.45	8.76	11.9	4.45	8.76	11.9
1	4.00	7.90	10.9	4.06	8.39	11.1
2	3.90	6.24	8.5	4.11	8.44	12.1
3	4.09	5.25	6.3	3.95	5.68	7.3
4	4.09	6.30	6.9	3.84	4.60	4.4
6	3.90	4.85	2.9	3.91	3.98	0.6

In this study, with 40 g samples, high DM losses were recorded with a wet, autumn silage. The ineffectiveness of low levels of additive to improve stability suggest that only higher levels are likely to be of significant value for this purpose.

Paper No. 3.

THE DENSITY OF ENSILED GRASS AND RESISTANCE TO AIRFLOW

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Italian ryegrass was harvested at moisture contents varying from 84.4 to 57% by a precision chop forage harvester (Table 1). At each moisture content, weights of grass calculated to give samples with densities ranging from 200 to 700 kg m^3 were compressed into a volume of 1 m^3. The grass was compressed in a container with a floor area of 1.25 m^2 and the container had a false perforated floor which formed a plenum chamber below the grass sample. Air was blown into the plenum by a variable output centrifugal fan and the air pressure in the plenum was measured by four pitot heads connected in parallel to an inclined manometer. Air velocity was measured on the surface of the grass by a special instrument developed to measure low airspeeds on the surface of stacks. After each sample had been compressed to the selected bulk density, 4 to 12 air velocity measurements were taken at static pressures increasing in steps within the range of 5 and 90 mm W.G.

Table 1. Harvest date, grass characteristics and chop length

Run no.	Date harvested	Duration of wilt (h)	Moisture content (%)	Fibre content (%)	Mean chop length (mm)
1	16.5.73	0	84.4	25.8	19
2	17.5.73	24	74.7	26.3	20
3	18.5.73	48	74.3	27.5	17
4	15.6.73	0	67.8	29.8	37
5	18.6.73	0	69.0	29.2	23
6	18.6.73	5	61.5	30.5	26
7	19.6.73	24	57.0	28.6	22

The relationship between air pressure and air velocity can be described by

$$P = KV^n \quad ....(1)$$

where P = the pressure drop - mm W.G.

V = the velocity of the air - ms^{-1}

and K = a constant indicating the resistance to air flow

The plotted curves of the velocity versus the static pressure for each run appeared to have a common relationship and so for each sample, a power curve regression was derived in the form of equation 1. However the computed values for n and K varied making it difficult to compare samples and so it was decided to calculate the mean value for n which was 1.3 (S.D. ± 0.34). Subsequently the K value of each sample was recalculated from $P = KV^{1.3}$ ......(2)

The resistance to air flowing through a material is related in part to its porosity and the calculated porosity of the grass samples decreased with increasing bulk density. As would be expected, measured resistance to airflow also increased with increasing bulk density. However, resistance to airflow also increased with decreasing moisture content at any given density although the porosity of the sample increased only marginally. This suggests that the moisture content of the grass is an indicator of other factors affecting the resistance of grass to airflow such as its turgidity, roughness of the surface of the particles and the way in which the particles pack together when compressed.

Although the interaction between the resistance to airflow and the bulk density of grass is complex, the pressure required to ventilate samples with the same moisture content increased exponentially with increasing bulk density. If, therefore, grass is compacted sufficiently airflow through the grass would cease and the results of the experiment suggest that there would be little airflow, if any, when grass is compacted to values in excess of 700 and 500 kg m^3 at moisture contents of 84 and 60% respectively.

The following conclusions are derived from this work:

1. The porosity of grass decreases with increasing bulk density but variations in moisture content have little effect on porosity at a given bulk density.

2. The resistance to airflow of grass increases with increasing bulk density and also with ~~in~~creasing moisture content at any given bulk density. de

3. Very little air, if any, will flow through grass compacted to 700 and 500 kg m^3 at moisture contents of 84 and 60% respectively.

Paper No. 4.

THE INFLUENCE OF CHOPPING ON THE FERMENTATION PROCESS, LOSSES AND NUTRITIVE VALUE OF GRASS AND MAIZE SILAGES

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Chopping has a twofold affect on fermentation namely;

- better density in the silo enables gas exchange and the deteriorative influence of air to be reduced.
- smaller fractions of forage give improved fermentation by making nutrients more easily available to the micro-organisms.

Investigations were carried out with grass (40 to 50% DM) and maize (27 to 36% DM) to show how far effects of chopping were attainable using the choppers and loading waggons available today. As increasing fineness required a higher energy input and reduced the machine capacity, the most suitable degree of chopping must also be defined.

In order to assess the effect of chopping the following parameters were determined: chopping length, density, pattern of fermentation, losses, stability after unloading, and for maize, losses of kernels in the faeces.

Pilot-silos of 6000 l capacity, 4 m high, were used. Complete control of gas exchange was possible. To simulate practical conditions, the forage surface was covered with plastic and aerobic conditions were maintained above it.

The results showed that the density of grass was increased by 18% in the range from long material (>50mm) to 7 mm chop. Maize density was increased by 13% (14 to 4 mm chop). Recutting did not increase density in all cases compared to shortest chop.

The pattern of fermentation showed a characteristic difference between chopping and recutting. The additional laceration by the latter intensified CO_2 production in the beginning and reduced it later during storage. This was reflected in higher lactic acid percentages, whereas the acid sprectrum was not influenced much by different chopping lengths. The difference in CO_2 production must mainly be caused by more or less intensive surface deterioration under the influence of air. Results with maize were similar.

Dry matter losses were low, 4 to 7% of DM, for grass as well as for maize silage. Changes in nutrient content did not exceed normal fermentation levels and were not influenced by chopping length.

Stability after unloading was best in the recut material, and poorest in the long material (>50 mm).

Determination of undigested maize kernels in the faeces showed increasing passage with increasing chopping length. But this was compensated by a higher proportion of undigested kernel parts with the short chop. Thus net energy losses were the same. A reduction in loss was achieved by additional grinding, Table 1.

Table 1. The effect of chop length on kernel utilization in maize silage.

Treatment	Kernels + kernel parts in the silage (% in DM)	Undigested kernels + parts (% of faeces DM)	Net energy loss (%)
7 mm chop	30.6	7.8	9.0
4 mm chop	27.0	9.0	10.0
7 mm chop + grinding	9.6	1.2	0.8

In conclusion, in these experiments with prewilted grass and maize of high DM contents, fermentation and dry matter losses were low. Thus differences between chopping lengths remained small with the clearest effect being obtained from the most intensive treatment.

There was a tendency for greater and deeper reaching surface losses in the longer material, underlining the influence of density and resistance to gas exchange under practical conditions. This is especially so if an air flow is caused from surface to bottom layers by CO_2 losses through leakages in lower silo walls. To ensure good packing therefore short chopping lengths are necessary, for grass 10 to 15 mm, for maize 4 to 7 mm. For the latter all kernels should be broken as fine as possible to improve their utilization. At higher DM contents this can be achieved best by additional grinding plates integrated in the chopper housing.

SESSION 2 SILAGE ADDITIVES

PAPERS 5 TO 8

CHAIRMAN - DR P McDONALD

Paper No. 5.

ACRYLIC ACID AND SODIUM ACRYLATE AS SILAGE ADDITIVES

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Laboratory assays (Woolford, 1975) of acrylic acid against a range of pure cultures of silage micro-organisms at controlled levels of pH indicated greater effectiveness than formic acid or propionic acid in restricting the growth of bacteria but not of yeasts and moulds. Whilst formic and propionic acids showed increased inhibition of microbial growth with decreasing pH, this effect was less marked with acrylic acid (Table 1), suggesting that salts might be as effective as free acid when used as additives for silage.

Table 1. Minimum inhibitory concentrations (m mol/l) for acrylic, formic and propionic acids against pure cultures of micro-organisms

pH	Acid *	Bacteria	Yeasts and moulds
6	Acrylic	23	>146
	Formic	>200	>200
	Propionic	375	375
5	Acrylic	12	>146
	Formic	92	>200
	Propionic	250	125
4	Acrylic	7	73
	Formic	13	100
	Propionic	63	63

* *Addition of 0.25% of fresh crop weight of acrylic, formic or propionic acid to crops of 25% DM content gives concentrations in the aqueous phase of 46, 72 and 45 m mol/l respectively. Data for formic and propionic acid are from Woolford (1975).*

In two experiments, crops of perennial ryegrass, lucerne and maize were ensiled in laboratory silos either without additive or after the addition of acrylic, propionic or formic acid at 0.25% of fresh crop weight or after the addition of sodium acrylate at 0.33% of fresh crop weight. Silos were opened after 100 days storage at ambient temperature. All crops fermented to give lactic and acetic acids; butyric acid was not detected. The contents of total fermentation acids in the DM of silages are given in Table 2. Sodium acrylate and acrylic acid restricted fermentation to a similar extent, and to a greater extent than formic or propionic acids.

Table 2. Total fermentation acids (% of DM)

Additive and rate (% fresh weight)		Ryegrass		Lucerne		Maize
	Date Cut	2/6/76	22/9/77	8/7/76	28/9/77	8/9/76
	DM %	22.0	16.0	25.3	17.2	27.4
None		11.2	13.9	13.9	11.4	7.6
Acrylic acid (0.25)		2.9	8.9	6.9	7.9	1.1
Sodium acrylate (0.33)*		3.1	7.9	7.5	8.3	2.6
Propionic acid (0.25)		16.3	16.0	10.6	11.8	6.0
Formic acid (0.25)		9.7	10.6	9.7	10.8	4.7

** 0.33% sodium acrylate provides 0.25% acrylate radical*

When the silages were exposed to air for a 13-day period, accumulated temperature measurements were inconsistent for ryegrass and lucerne silages. In the single experiment with maize, the untreated silage and those made with addition of formic and propionic acids heated after 5 days exposure to air, whilst those made with addition of sodium acrylate and acrylic acid showed no heating during the 13-day period of exposure (Table 3).

Table 3. 14-day accumulated temperatures (^{0}C above ambient)

Additive and rate (% fresh weight)	Date Cut	Ryegrass 2/6/76	Ryegrass 22/9/77	Lucerne 8/7/76	Lucerne 28/9/77	Maize 8/9/76
None		66	102	7	104	108
Acrylic acid (0.25)		157	108	23	24	0
Sodium acrylate (0.33)		72	109	30	103	0
Propionic acid (0.25)		163	108	12	104	44
Formic acid (0.25)		159	105	6	66	60

Sodium acrylate and acrylic acid appear to have potential as additives to restrict fermentation, and, with maize silage, may also increase aerobic stability.

Woolford, M K (1975). J. Sci. Fd Agric. 26, 219-228.

Paper No. 6.

EFFECTS OF ACETIC ACID ON SILAGE INTAKE, EATING AND RUMINATING BEHAVIOUR OF SHEEP, AND ITS POSSIBLE USE AS A SILAGE ADDITIVE

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Some experiments have shown that the higher the acetic acid content the lower is the voluntary consumption of silage (WILKINS *et al.*, 1971: DEMARQUILLY, 1973). The relationship found between acetic acid content and intake is, however, not necessarily one of cause and effect.

The experiments reported were undertaken to investigate the possibility that acetate ions may influence voluntary silage intake by altering digestibility, eating and ruminating behaviour and reticulo-rumen cellulolytic activity. The possible use of acetic acid as an additive was also examined.

In Experiment 1, six 30-month-old Texel wethers and two adult rumen fistulated wethers were fed *ad libitum* according to a two period cross-over design (2 x 28 days).

The two treatments were a control silage with 1.40% acetic acid and a silage with added acid to give a level of 6.50% acetic acid in the dry matter. This higher level of acetic acid was nearly the maximum concentration found in silages. Herbage for the silage had been pre-wilted and short chopped and the resultant silage was well preserved. Intake data are presented in Table 1. The pH and moisture content of the silages were held constant.

Table 1. Dry matter intake (2 x 28 days), water intake (2 x 10 days), eating and ruminating behaviour (2 x 3 days) of sheep feed two silages.

Intake and eating activity (per day)	Control (1.4% acetic acid)	Added acid (6.5% acetic acid)	SE treatment means
Silage DM intake (g DM/kg $W^{0\cdot75}$)	56.00	55.39	0.93 NS
Total DM intake (g DM/kg $W^{0\cdot75}$)	56.00	58.67	0.88 NS
Drinking water (g/kg DM intake)	60.60	104.60	2.17 ***
Unitary eating time (min per g DM/kg $W^{0\cdot75}$)	3.99	4.78	0.48 NS
Number of feeds	11.40	12.40	0.36 NS
Real intake activity during the main feed (min)			
beginning (4.1 min)	3.35	2.74	0.12 *
medium (4.1 min)	2.69	2.28	0.18 NS
end (4.1 min)	2.56	2.21	0.15 NS
Unitary ruminating time (min per g DM/kg $W^{0\cdot75}$)	8.96	8.12	0.47 NS

The addition of acetate/acetic acid has not depressed the voluntary DM intake of silage by these adult sheep but drinking water intake was significantly increased ($P<0.001$). The intake rate of the silage with added acetic acid was lower, especially at the beginning of the main feed ($P<0.05$). Differences in the digestibility were very small and only significantly higher ($P<0.05$) for the crude fibre of the silage with added acid. The reticulo-rumen pH of the two rumen fistulated wethers was on avergae 0.16 unit lower with the acetic treated silage. Reticulo-rumen cellulolytic activity was very similar for both silages.

In Experiment 2, sixteen 7-month-old individual housed Texel sheep were fed *ad libitum* according a 2 x 2 factorial design (42 days). Four treatments of a pre-wilted, well preserved, short chopped silage were as follows:

1. control (2.24% acetic acid), with water addition.
2. acetate/acetic acid addition, 4.64%
3. lactate/lactic acid addition, 4.64%
4. acetate/acetic 4.64% and lactate/lactic acid addition 4.64%.

The addition of 4.64% acetate/acetic acid has not depressed the voluntary DM intake of silage by these young sheep. The eating and ruminating behaviour was similar to that in Experiment 1.

In Experiment 3, the use of acetic acid versus formic acid as a silage additive was tested in 90 micro-silos (1.5ℓ) and 24 mini-silos ($1 \cdot m^3$).

Table 2. The mean composition of the micro-silo silages (n = 3 x 30)

Silage	% DM of the green alfalfa	pH	NH_3-N (% TN)	Butyric acid (% fresh)	Lactic acid (% fresh)
control	16.92	5.57	20.55	0.41	1.44
0.4% formic acid	16.92	4.68	10.66	0.18	1.74
0.4% acetic acid	16.92	4.59	9.70	0.04	2.03

The results with acetic and formic acid were very similar.

In conclusion, acetate *per se* up to 6.5 to 6.9% of the DM has not depressed voluntary silage intake. Acetic acid can therefore be used as a silage additive because:

1. its effectiveness is equal to formic acid
2. it can be used as a fungicide, formic acid can not (ZIMMER, 1973)
3. it has a nutritive value (assume 874 k_J (mol acid)
4. Acetic acid *per se* at 0.4% in fresh matter (1.6 to 2.0% on dry matter) has no negative effect on voluntary intake.

DEMARQUILLY C. (1973) Ann. Zootech. 22 (1), 1-35.
WILKINS R.J., HUTCHINSON K.J., WILSON R.F., HARRIS C.E. (1971) J. agric. Sci. Camb. 77, 531-537.
ZIMMER E. (1973) Vaxtodling 28, 90-97.

Paper No. 7.

INTAKE AND DIGESTION OF FORMALDEHYDE-TREATED SILAGES BY YOUNG GROWING CATTLE

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Formaldehyde has been included in silage additives to restrict fermentation and to protect dietary protein. However, feeding experiments have yielded variable results and there is uncertainty concerning the value of formaldehyde. Studies on factors influencing the response to formaldehyde treatment are in progress at the GRI, and results from three experiments are summarized here.

Silages were prepared from primary growth red clover, second growth red clover, and second growth perennial ryegrass in Experiments 1, 2 and 3 respectively, using formic acid (85% w/w) at 2 l/t fresh crop. Formaldehyde was applied at 0, 16, 34, 52, 77 or 117 g/kg crude protein in the crop in Experiment 1, at 0, 31 or 123 g/kg in Experiment 2, and at 0, 47 or 100 g/kg in Experiment 3. Silages were fed *ad libitum,* to British Friesian steer calves, initially 3 months of age; all calves in Experiment 2 and half the calves in Experiment 3 were rumen-fistulated. In Experiments 1 and 2 silages were fed with or without a supplement of urea at 2% of dry matter intake, and in Experiment 3 silages were either fed alone, or with a supplement of maize starch at 20%, or maize starch at 20% plus urea at 2% of dry matter intake.

Table 1. Summary of results from Experiment 2

Treatment	Silage intake (g DM/kg W)	Organic matter digest.	Rumen NH_3-N (kg/l)	Time (min/intake unit) Eating	Ruminating*
Unsupplemented					
Control	28.4	0.607	73.1	13.0	18.9
31g HCHO	27.5	0.592	45.7	14.5	19.5
123g HCHO	25.2	0.539	19.7	15.0	21.1
Plus 2% urea					
Control	27.4	0.617	159.6	12.9	19.7
31g HCHO	28.9	0.602	129.7	13.3	17.7
123g HCHO	26.3	0.560	86.4	15.0	19.6

* *Minutes per unit of intake, g DM/kg liveweight*

Silage dry matter intakes were reduced ($P < 0.001$) by increasing level of formaldehyde application in each experiment, there being a quadratic trend ($P < 0.001$) in Experiment 1, with intake being reduced at formaldehyde levels >40 to 60g. Urea supplementation tended to increase intake at higher levels of application in Experiments 1 and 2, although this interaction did not reach significance inExperiment 1. Starch supplementation reduced silage intake in Experiment 3 ($P < 0.001$), and when comparing the starch supplemented treatments, urea stimulated silage intake at the high level of formaldehyde application ($P < 0.001$).

Liveweight gain ($P < 0.001$) and nitrogen retention ($P < 0.001$) followed quadratic trends with increasing formaldehyde level in Experiment 1, with both parameters declining at application levels >30 to 50g formaldehyde. The digestibility coefficients for organic matter and nitrogen declined linearly with increasing formaldehyde level in Experiment 1 ($P < 0.001$). Organic matter digestibility similarly declined in Experiment 2 ($P < 0.001$), there being no treatment effects on cellulose digestibility in either experiment. In Experiment 2, increasing formaldehyde level reduced rumen ammonia concentration ($P < 0.001$), total VFA concentration ($P < 0.10$), the molar proportions of propionate and butyrate ($P < 0.001$), and increased the molar proportion of acetate ($P < 0.001$). Rumen ammonia concentration declined with increasing formaldehyde level ($P < 0.001$), was increased by urea plus starch supplementation ($P < 0.01$), but unaffected by starch supplementation in Experiment 3.

Table 2. Summary of results from Experiment 3

Treatment	Silage intake (g DM/kg liveweight)	Total intake (g DM/kg liveweight)	Rumen NH_3-N (mg/1)
Unsupplemented			
Control	25.5	25.5	84.8
47g HCHO	25.5	25.5	38.3
100g HCHO	21.2	21.2	15.8
Plus 20% starch			
Control	21.3	26.2	79.2
47g HCHO	20.5	25.2	56.8
100g HCHO	16.6	20.5	11.7
Plus 20% starch and 2% urea			
Control	20.8	26.0	199.5
47g HCHO	21.4	26.8	147.8
100g HCHO	19.5	24.5	70.7

The rate of dry matter disappearance of treatment silages from nylon bags suspended in the rumens of calves in Experiment 2 was slower on the high formaldehyde silage, and this adverse effect was not rectified by urea supplementation. There were small increases in unitary eating ($P<0.05$), ruminating ($P<0.10$), and eating plus ruminating times ($P<0.05$) at the higher level of formaldehyde in Experiment 2.

These data showed no advantages in favour of formaldehyde treatment but considerable disadvantages at higher levels of application.

Paper No. 8.

THE UTILISATION OF SILAGES TREATED WITH FORMIC ACID AND FORMALIN ADDITIVES BY FATTENING BEEF CATTLE

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The objectives of this study were twofold; first to determine the optimum ratio of formaldehyde (as formalin) to formic acid, associated with maximum intake and performance in fattening beef cattle; second to assess the relative importance of formalin and formic acid, either singly, or in combination, as silage additives.

In Experiment 1, Italian ryegrass, wilted for 24 hours, was conserved either untreated (Treatment A) or was treated with 15 g/kg dry matter (3.35 l/t of fresh material) of an 85% w/w formic acid additive mixed with 5.6, 11.0 or 20.8 g/kg dry matter (1.40, 2.73, 5.21 l/t fresh material), of formalin (40% w/v formaldehyde), Treatments B, C and D respectively.

In Experiment 2, Italian ryegrass, wilted for 24 hours in poor weather conditions, was conserved with formalin alone at 6.5 g/kg dry matter (1.11 l/t), Treatment E; with formic acid alone at 16.9 g/kg dry matter (2.68 l/t), Treatment F; or with a mixture of formalin and formic acid at 6.2 and 16.6 g/kg dry matter respectively (1.08 and 2.60 l/t of fresh material), Treatment G.

The silages were fed individually, *ad libitum* to 60 animals (mainly Hereford x Friesian x Charolais heifers) in Experiment 1 and to 72 animals (of similar breed type and sex) in Experiment 2. In both studies the animals were approximately 15 months of age and 375 kg initial liveweight.

In Experiment 1, treatment with additives inhibited fermentation, increasing levels of formalin application being associated with higher levels of water soluble carbohydrates and lower levels of organic acids compared with the untreated material. Although the materials were all ensiled at similar dry matter contents, that of the untreated material (Treatment A) was significantly lower than for the treated silages. The lower dry matter content of Treatment A may have been a feature of the fermentation pattern within this silage. Increasing levels of true protein indicated the extent of protein protection resulting from the use of formalin as an additive. The losses in dry matter from fermentation were low, conversely losses from aerobic deterioration were high, increasing with increases in the level of formalin application.

In Experiment 2, in-silo dry matter losses, were higher than in Experiment 1, especially in Treatment F. These were due, in part, to the lower dry matter content of the grass when it was ensiled. The high ethanol, and relatively low acetic acid contents of this silage, suggest that yeast activity as well as a heterolactic fermentation, must have resulted after ensiling.

Table 1. Daily intake and animal performance data

Treatment		Daily DM intake (g/kg W)	Daily ME intake (kJ/kg W)	Daily LWG (g)
	A	14.5[a]	155.1[a]	237[a]
Experiment 1	B	17.1[b]	189.4[b]	505[b]
	C	17.1[b]	177.5[b]	504[b]
	D	17.3[b]	181.0[b]	609[b]
SE of mean *		0.66	8.19	43.7
	E	17.2	171.0	518[ab]
Experiment 2	F	16.2	181.0	410[a]
	G	17.5	172.4	529[b]
SE of mean *		1.16	17.09	43.4

* *Means with different superscripts differ significantly ($P < 0.05$)*

In Experiment 1, while the intake and performance of the animals on the untreated silage were significantly lower than those on the treated material, differing levels of formalin application had no significant effect on either intake or performance.

In Experiment 2, the dry matter intake and performance of the animals on silage treated with formic acid alone (Treatment F) were lower than those on the silages treated with formalin. The high ME intake of the former reflected the high initial gross energy content of this silage.

In both experiments, the application of formalin reduced the digestibility *in-vivo* of nitrogen, but increased nitrogen retention. It was concluded that low levels of formalin application (19.0 g formaldehyde/kg crude protein) were equally as effective, in enhancing intake and performance, as higher levels (71.6 g formaldehyde/kg crude protein). Likewise, the improvements in intake were effected by the formalin rather than the formic acid, though the latter was necessary to insure against a clostridial fermentation.

SESSION 3 SILAGE DIGESTION AND METABOLISM

PAPERS 9 TO 12

CHAIRMAN - DR R J WILKINS

Paper No. 9

RUMEN FERMENTATION AND MILK YIELD AND COMPOSITION IN COWS GIVEN SILAGE DIETS

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Considerable attention has been given to the effects of diet on milk composition in cows given feeds containing dried forages. It is widely accepted that many of the observed effects operate through the influence of the diet on the products of digestion, those formed in the rumen especially. In contrast, there has been little work on the relationships between the diet, the products of digestion and the composition of milk secreted, in cows given silage diets.

Four experiments were undertaken in Ayrshire cows in mid (Expts 1, 2 and 4) or late (Expt 3) lactation to determine the effects of diet on the composition of the rumen fluid and on the composition of the milk secreted. Expts 1, 2 and 4 were of a balanced 4 x 4 Latin Square design each involving 4 cows and 4 dietary treatments. Expt 3 was of a cross-over design involving 4 cows and 2 treatments. All silages used were of high quality and prepared from precision chopped ryegrass with added formic acid (2.3 l/t). Feeding was controlled and within each experiment dietary treatments were designed to be isoenergetic in metabolizable energy. Expt 1 was concerned with the effects produced by varying the composition of the concentrate mixture from one containing solely barley to one containing a high proportion of flaked maize (Table 1). Expt 2 was concerned with the effects produced by varying the composition of the mixture of forage in the diet from one consisting solely of silage to one consisting solely of ground and pelleted dried grass (Table 1). Expts 3 and 4 were concerned with the effects produced by varying the proportions of silage and concentrate in the diet (Table 1).

The results of the experiments (Table 1) indicate that variations in the composition of the concentrate mixture (Expt 1) or a less than complete replacement of silage with dried grass (Expt 2) has little effect on the composition of the mixture of short-chain fatty acids in the rumen. However, the fermentation pattern was altered by changes in the dietary ratio of silage to concentrate (Expts 3 and 4). The changes in fermentation were characterized by a depression in the molar proportion of acetic acid and most consistently by an increase in the molar proportion of butyric acid; the proportion of propionic acid was increased only in Expt 4.

Replacement of less than 100% of the silage in the diet with dried grass (Expt 2) had no effect on milk fat content but fat content was affected by both the proportion (Expts 3 and 4) and type (Expt 1) of concentrate in the diet. Milk protein content was consistently increased with the proportion of concentrate in the diet (Expts 3 and 4) but the effects were small and in Expt 3 non-significant. Milk protein contents were unaffected by diet in Expt 1 and in Expt 2, despite the fact that in the latter experiment the 100% dried grass treatment was associated with a high proportion of propionic acid in the rumen and a low acetate to propionate ratio.

Table 1. The effect of the composition of the diet on the molar proportions of short-chain fatty acids in the rumen fluid and on the yield and composition of milk in Ayrshire cows.

Expt.	Composition of the diet	Rumen fluid: Short-chain fatty acids (molar %) Acetate	Propionate	Butyrate	Milk Composition: Milk yield (kg/day)	Total solids (%)	Fat (%)	Crude protein (%)	Lactose (%)
1	50 Silage + 50 Barley	58.9	19.1	18.1	13.1	12.99	4.58	2.93	4.65
	50 Silage + 43 Barley + 7F.M.	59.0	18.8	18.1	13.9	12.81	4.37	3.01	4.58
	50 Silage + 35 Barley + 15F.M.	59.7	17.8	18.8	13.9	12.84	4.36	2.94	4.71
	50 Silage + 28 Barley + 22F.M.	59.0	19.2	17.9	14.6	12.69	4.25	2.96	4.62
2	50 Silage + 50 Conc(a)	61.8	17.8	16.4	17.9	12.81	3.59	3.60	4.81
	30 Silage + 20 Dried Grass + 50 Conc(a)	52.7	16.5	19.1	17.9	12.60	3.40	3.56	4.83
	20 Silage + 30 Dried Grass + 50 Conc(a)	62.3	15.3	19.2	18.3	12.94	3.67	3.69	4.82
	50 Dried Grass + 50 Conc(a)	52.8	31.8	9.7	17.8	11.91	2.63	3.62	4.84
3	50 Silage + 50 Barley	59.8	19.8	16.9	10.0	13.00	4.75	3.14	4.35
	25 Silage + 28 Barley + 22F.M. + 25 Conc(b)	56.4	19.8	19.6	11.9	12.68	4.27	3.22	4.38
4	60 Silage + 40 Conc(c)	64.2	16.9	14.9	12.7	13.39	4.31	3.44	4.86
	22 Silage + 78 Conc(d)	55.6	21.4	17.4	13.9	13.10	3.90	3.52	4.62 87
	60 Silage + 40 Conc(e)	64.1	16.5	15.4	14.0	13.35	4.20	3.49	4.87
	22 Silage + 78 Conc(f)	56.9	19.7	17.3	14.2	13.15	3.75	3.62	4.85

Key: F.M. = Flaked Maize.
Conc(a) = 45% Flaked Maize; 23% Barley; 22% Soya Bean Meal; 10% Sugar Beet Pulp
Conc(b) = 60% Barley; 25% Sugar Beet Pulp; 7.5% Groundnut; 5% Dried Grass; 2.5% Min/Vit Supplement
Conc(c) = 90% Barley, 10% Soya Bean Meal
Conc(d) = 32% Flaked Maize; 11.5% Groundnut; 51.5% Barley; 5% Soya Bean Meal
Conc(e) = 69% Barley; 31% Soya Bean Meal
Conc(f) = 32% Flaked Maize; 11.5% Groundnut; 39% Barley; 17.5% Soya Bean Meal

Paper No. 10.

THE EXTENT OF RUMENAL DIGESTION OF SILAGE AND SILAGE/CONCENTRATE DIETS FED TO SHEEP

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Recent research has shown that, for dairy cows fed a basal diet of highly digestible silage, milk yield increased as the protein level of the concentrate increased. The present work was carried out to provide preliminary information on the digestion of silages fed either alone or in combination with a concentrate feed.

The three silages fed were made from perennial ryegrass swards. An additive (Sylade 2 ℓ/t) was applied during harvesting with a precision-chop machine. Silage 1 and Silage 2 were from first cut grass in the early part of May and differed in dry matter content and fermentation quality. Silage 3 was made from nine week re-growth material. The chemical composition of these silages and of the concentrate are shown in Table 1.

Table 1. Chemical composition of silages and the concentrate

	Silage 1	Silage 2	Silage 3	Concentrate
pH	3.6	4.2	3.9	
DM (g/kg)	256.7	210.3	238.7	888.8
Nitrogen (g/kg DM)	20.7	25.1	20.8	42.1
Digestible Energy (MJ/kg DM)	13.6	13.7	12.4	

The silages were fed to six wethers in 6 x 6 balanced square design either alone or in a 1:1 ratio with the high protein concentrate. Sheep were fitted with rumen cannulas and re-entrant cannulas in the proximal duodenum. Silage was fed once daily, the concentrate twice daily and chromic oxide impregnated paper (as an indigestible marker) was given twice daily. Digestibility measurements were made and were followed by the sampling of duodenal digesta. The apparent digestibilities of dry matter and energy for the six diets are shown in Table 2.

The apparent digestibility of dry matter and energy of the first-cut Silages 1 and 2 were similar and were higher than that for the regrowth Silage 3. However, this difference was reduced when the silages were fed with the concentrate. The proportions of digestible dry matter and energy apparently disappearing prior to the proximal duodenum were similar for all three silages when fed alone. This disappearance was greater than that observed when the silage plus concentrate diets were fed.

Table 2. Mean daily dry matter intake, apparent digestibility of dry matter and energy and the disappearance of digestible dry matter and energy prior to the proximal duodenum.

	Silage 1		Silage 2		Silage 3	
	Alone	Plus conc	Alone	Plus conc	Alone	Plus conc
Dry matter intake (g/d)	812	1166	740	1156	756	1134
Digestibility of dry matter (g/kg)	710	780	700	786	640	740
Digestibility of energy (KJ/MJ)	711	779	703	782	639	743
Digestible dry matter disappearance in fore-stomachs (g/kg)	787	623	852	660	852	763
Digestible energy disappearance in fore-stomachs (KJ/MJ)	893	684	923	702	956	794

Table 3 shows the apparent digestibility of nitrogen, the amount of nitrogen entering the proximal duodenum relative to that ingested and apparent nitrogen retention for the six diets fed. The apparent digestibility of nitrogen was higher for the silage plus concentrate diets than for the silage only diets. The higher apparent digestibility of nitrogen observed for Silage 2 may be partially attributed to the high level of non-protein nitrogen in this material resulting from its relatively poor fermentation. The high level of non-protein nitrogen in this silage may also explain the greater decrease in the amount of nitrogen entering the proximal duodenum of sheep when fed this diet. The marked increases in nitrogen retention found when the silage plus concentrate diets were fed is thought to be a reflection of the higher intakes of readily fermentable carbohydrate and nitrogen and, also, the lower overall solubility of the nitrogen provided by these diets.

Table 3. Mean daily nitrogen intake, apparent digestibility of nitrogen, amount of nitrogen entering the small intestine and nitrogen retenti[illegible].

	Silage 1		Silage 2		Silage 3	
	Alone	Plus conc	Alone	Plus conc	Alone	Plus conc
Nitrogen intake (g/d)	16.69	36.42	17.74	38.21	15.71	36.17
Digestibility of nitrogen (g/kg)	581	741	671	782	639	750
Nitrogen entering small intesting (gN/gN ingested)	0.84	0.75	0.65	0.76	0.71	0.60
Nitrogen retention (gN/gN ingested)	0.09	0.24	0.09	0.27	0.10	0.25

In conclusion, the results of this study indicate that digestion of silages in the ruminant forestomachs can be influenced by silage composition and can be further modified when fed in combination with a concentrate feed.

Paper No. 11

THE METABOLIZABLE ENERGY CONTENTS OF SOME GRASS AND MAIZE SILAGES

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The remit of the Feed Evaluation Unit is to determine the ME values of feedstuffs for ruminants and where possible to attempt to predict these values from simple chemical analyses. Because of the importance of silage in winter feeding and the relatively small number of determined ME values of silages it was decided that the ME contents of a number of silages should be measured.

The ME contents of 2 groups of 16 grass silages, made in 1973 and 1974; and 1 group of 16 maize silages made in 1975 have been determined. The majority of these silages were from commercial farms and were thought to be reasonably typical of these found in the areas from which they were taken. The experimental design used was that described in the First Report of the Feed Evaluation Unit (1975). Each silage was fed with two different concentrate sources to sheep at the maintenance level of feeding. This method permits the simultaneous determination of the ME of both the silage and the concentrate source and allows us to see how ME changes with:-

1) The quality of silage and concentrate.

2) The type of concentrate fed with the silage.

3) The level of incorporation of concentrate with silage.

4) Any associative effects between concentrate and silage.

The 1973 silages were fed with oats and barleys, the 1974 silages with wheats and wheat offals. The maize silages were fed with beans or peas and with sugar beet by-products or sorghums.

The determined ME values and some of the analyses are given in Table 1.

Correlation of the analytical data with the determined ME values for the 1973 grass silages showed N and MADF to be the best predictors with correlation coefficients of about 0.7. However, N did not correlate well for the 1974 grass silages, the best predictors for this group were lignin and cellulase solubility (Jones and Hayward method, 1975) with correlation coefficients of about 0.8. Using the combined data of both groups cellulase solubility gave the best single prediction of ME and this was not improved by the inclusion of any other variable.

The maize silages showed no significant correlations with any of the analytical estimates. The mean value for the ME of maize silages of 11.1 MJ/kg DM was slightly higher than that given in MAFF Technical Bulletin

33. The mean value for the grass silages at 11.4 MJ/kg was much higher than the 10.2 MJ/kg DM for very high digestibility grass silage given in the same bulletin.

Table 1. Analyses of grass and maize silages

	1973 Grass silages	1974 Grass silages	1975 Maize silages
Mean ME (MJ/kg DM)	11.2	11.7	11.1
range	10.1 - 12.4	10.2 - 12.5	10.4 - 11.7
Mean oven DM (g/kg)	195	235	304
range	163 - 233	182 - 377	225 - 343
Mean CP (g/kg DM)	151	141	84
range	113 - 183	125 - 198	74 - 99
Mean MADF (g/kg DM)	372	367	237
range	323 - 429	321 - 403	204 - 288
Mean GE (MJ/kg DM)	19.5	19.0	18.5
range	19.1 - 20.2	18.1 - 19.5	18.3 - 18.8

Feed Evaluation Unit (1975). First Ann. Rpt. pp 55
Rowett Res. Institute, Aberdeen.

Jones, D.I.H. and Hayward M.V. (1975). J. Sci. Fd Agric., Vol 26, 711-718.

Paper No. 12.

LACTIC ACID METABOLISM IN SHEEP RECEIVING DIETS OF GRASS SILAGE

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In sheep receiving silage diets, the efficiency of utilization of metabolizable energy (ME) was generally similar to that observed with dried forages of similar energy concentration, (Kelly and Thomas 1978). However, for one spring silage given at a high level of feeding the proportion of ME lost as heat was especially high and the efficiency of utilization of ME for fattening (k_f) was unusually low. The silage was characterized by a high concentration of lactic acid, 12%, a large proportion of which, 42%, was the D (-) isomer. A possible explanation for the poor utilization of the silage energy was an impairment of metabolism associated with a slow breakdown of D (-) lactic acid in the rumen and its consequent absorption and presence in the peripheral circulation.

In an initial experiment sheep receiving a silage diet were given single injections of 20g of either L (+) or DL-lactic acid into the rumen and the rate of disappearance of the lactic acid relative to that of polyethylene glycol, an unabsorbed marker, was determined over the following 90 minutes. The disappearance of both isomers obeyed 1st order kinetics and the half life of the DL acid, 18.7 ± 2.7 mins was not significantly different from that of the L (+) acid, 21.8 ± 1.5 mins. Changes in the composition of the mixture of short-chain fatty acids in the rumen following lactic acid infusions suggested that a substantial proportion of the lactic acid was being metabolised to propionic acid.

In a second experiment, sheep receiving a silage diet were given 80 g/d of DL-lactic acid intraruminally during a 24 day infusion period which was preceded and followed by 24 day control periods when water was infused. The acid solution was infused in four equal portions each day given over a 2-hour period following a feed of silage. The infusion of lactic acid resulted in an increase in its ruminal concentration (Table 1) but effects on the pH of blood plasma and on the plasma concentrations of L (+) and D (-) lactic acid were small.

In a third experiment, calorimetric determinations were made of the utilization of the ME of a silage containing 14% lactic acid of which 45% was the D (-) isomer. The intakes of ME in this experiment (Table 2) were slightly higher than those for the poorly utilized spring silage studied by Kelly & Thomas (1978) but there was no evidence of abnormalities in energy utilization. The efficiency of utilization of silage ME for maintenance (k_m) was 76% and for fattening was 52%, the latter figure being in agreement with that predicted from the equations for dried forages published by the Agricultural Research Council (1965).

Table 1. The effect of intraruminal infusions of DL-lactic acid on the pH and concentrations of total, L (+) and D (-) lactic acid in the rumen and blood plasma of sheep receiving diets of grass silage (Values are means with SE for three animals).

Treatment	Rumen pH	Rumen Total lactic acid (mg/l)	Blood plasma pH	Blood plasma Lactic acid (mg/l) Total	L (+)	D (-)
Control	6.46 ±0.15	399.9 ±2.9	7.66 ±0.03	114.3 ±7.3	99.4 ±5.4	14.9 ±2.6
Lactic acid infusion	6.00 ±0.19	631.5 ±78.3	7.77 ±0.03	146.7 ±2.7	116.0 ±3.7	30.8 ±3.0
Control	6.45 ±0.07	287.5 ±39.4	7.68 ±0.01	127.2 ±14.1	97.0 ±14.1	30.2 ±0.7

Table 2. The intake of gross energy (GE), digestible energy (DE) metabolizable energy (ME), the losses of energy in methane and urine and the energy retained by sheep receiving diets of grass silage (Values are means with SE for four animals and are expressed as MJ/d)

Treatment	GE	DE	Methane	Urine	ME	Energy retained
			(MJ/d)			
Silage+ (3kg/d fresh weight)	12.39	9.79 ±0.07	1.00 ±0.08	0.53 ±0.05	8.25 ±0.10	1.06 ±0.19
Silage (4kg/d fresh weight)	16.23	12.65 ±0.12	1.24 ±0.09	0.66 ±0.05	10.76 ±0.04	2.35 ±0.10

+ *values for 3 animals only*

On the basis of these experiments, the evidence suggests that both L (+) and D (-) lactic acid present in silages is rapidly broken down in the rumen, that little D (-) lactic acid enters the peripheral circulation and that there is no association between high levels of lactic acid in silage and poor utilization of silage ME for fattening.

Agricultural Research Council (1965). The Nutrient Requirements of Farm Livestock No 2 Ruminants. Agricultural Research Council : London.

Kelly, N.C. & Thomas, P.C. (1978). Br. J. Nutr. 40, 205

SESSION 4 SILAGE NITROGEN

PAPERS 13 TO 16

CHAIRMAN - DR J C TAYLER

Paper No. 13.

EFFECT OF PROTEIN DEGRADATION IN HAY-CROP SILAGES ON INTAKE AND UTILIZATION OF ENERGY AND NITROGEN BY GROWING DAIRY CATTLE

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Five 2 x 2 factorial experiments were conducted to determine the effects of protein degradation on utilization of hay-crop silages. First-growth orchardgrass was direct-cut and ensiled as untreated or as treated with either formic acid, paraformaldehyde, or a mixture of formic acid and formaldehyde. The first four untreated silages contained 2.38% nitrogen in the dry matter, of which 36.2% was insoluble in hot water and 21.0% was ammoniacal; treated silages contained 2.33% nitrogen in the dry matter, of which 47.6% was insoluble in hot water and 7.27% was ammoniacal. Untreated and treated silages were each fed without and with supplemental protein to growing Holstein cattle; these weighed 110 kg at the start and 521 kg at the end of the experiments. Supplemental protein was either sodium caseinate or soybean meal treated with formaldehyde and fed to supply from 16 to 23% additional nitrogen. All experiments included intake, growth, digestion, and nitrogen-balance measurements; the last three experiments included respiration calorimetry; and the final experiment included measurement of slaughter balance.

Average daily gain from untreated unsupplemented silage was 59% of that from treated unsupplemented silage in four experiments (Table 1). Supplementation increased the gains from both silages. Average intake of digestible energy per unit of metabolic size from untreated unsupplemented silage was 94% of that from treated unsupplemented silage. Total intake was increased by supplementation of both silages. Digestible energy intake per unit of gain on untreated unsupplemented silage was 176% of that on treated unsupplemented silage. The digestible energy required per unit of gain was decreased by supplementation of both silages. Similarly, the digestible energy above maintenance per unit of gain on untreated unsupplemented silage was 155% of that on treated unsupplemented silage. The digestible energy above maintenance per unit of gain was decreased by supplementation of both silages. The changes in gross and partial feed conversions from treating hay-crop silages were relatively greater than the changes in intake.

Nitrogen retention from untreated unsupplemented silage was 58% of that from treated unsupplemented silage (Table 1). Supplementation increased nitrogen retention from both silages. Ruminal ammonia from untreated unsupplemented silage was 119% of that on treated unsupplemented silage. Supplementation did not increase ruminal ammonia. Essential amino acids in plasma of cattle fed untreated unsupplemented silage were 85% of the level for cattle fed treated unsupplemented silage. Supplementation increased plasma essential amino acids on both silages.

The increase in feed conversions for untreated silage in growth trials appeared inconsistent with published data that indicated no change in energetic efficiency for untreated silage in calorimetric trials. Energy balances were essentially equal for all four diets adjusted to equal gross energy intake within each year (Table 1). Nitrogen balances were increased by both silage treatment and supplementation. The apparent inconsistency of growth and calorimetric data can be explained by a difference in the form of energy retained. Untreated silages are deficient in true protein. Weight gains from them are proportionately lower in protein and water, but higher in fat and energy density than weight gains from treated silages which are more adequate in true protein. Preliminary analyses of the slaughter-balance measurements confirm that cattle fed treated silages gain proportionately more protein and water, but less fat, than cattle fed untreated silage.

Weight gain and its composition are affected by the degradation of protein during the ensiling of hay crops. The control of protein degradation is a very important requirement of good preservation by ensiling.

Table 1. Growth, intake, energy and nitrogen utilization in growing cattle as affected by silage treatment and protein supplementation.

	Untreated silage		Treated silage	
Supplement	None	Protein	None	Protein
Unadjusted data from *ad libitum* feeding[a]				
Daily gain (g)	330	608	557	708
Daily DE intake (kcal/$kg^{.75}$)	232	250	248	260
Total DE/unit gain (Mcal/kg)	59.0	27.4	33.5	24.9
DE above maintenance/unit gain (Mcal/kg[b])	20.8	11.4	13.4	10.8
Nitrogen retention (g/day)	10.2	18.9	17.5	27.4
Ruminal ammonia (mg NH_3/100 ml)	23.0	23.1	19.3	19.1
Essential amino acids (μ moles/100 ml)	71.8	82.8	84.8	88.5
Covariance adjusted within year to equal gross energy per metabolic body size[c] (kcal/$kg^{.75}$)				
Gross energy	369.0	369.0	369.0	369.0
Digestible energy	247.0	249.5	242.6	245.0
Metabolizable energy	201.9	203.0	201.4	203.6
Energy balance	34.9	34.0	37.0	34.6
Nitrogen balance (g/day)	9.3	16.4	17.8	25.1

[a] *Mean of Experiments 1, 2, 3 and 4.*

[b] *Assuming 145 kcal DE/$kg^{.75}$ for maintenance.*

[c] *Mean of Experiments 3 and 4.*

Paper No. 14.

THE EFFECTS OF NITROGEN AND CARBOHYDRATE SUPPLEMENTS ON SILAGE INTAKE AND UTILIZATION BY SHEEP

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The efficiency with which nitrogen in silage is utilized by animals may be reduced by degradation of herbage protein during ensilage. In addition, the loss of soluble carbohydrate during ensilage, may restrict the energy available for the synthesis of microbial protein in the rumen of silage fed animals.

To examine the importance of these factors on silage intake and utilization by sheep, an experiment was carried out in which sheep were fed grass silage alone (control), or supplemented with protein (casein, 17.1 g/kg silage), non-protein - nitrogen (urea, 4.56 g/kg silage), or soluble carbohydrate (sucrose, 20.6 g/kg silage). The supplements were mixed into the silage daily before feeding. The four treatments were fed to twelve store lambs (aged about 10 months and weighing about 40 kg) in a triple 4 x 4 Latin Square design experiment. Each period lasted 21 days. Excreta was collected from eight of the lambs in metabolism cages.

The silage was of good quality with a pH of 4.29 and a moisture content of 209 g/kg. Each kg of dry matter contained; 21.7 g total N; 10.7 g protein - N; 2.1 g ammonia - N; and 28 g water soluble carbohydrate.

Main results are summarised in Table 1. Dry matter intake and live-weight gain were decreased by both casein and urea supplementation, while sucrose had no effect. In rumen fluid, the pH was lowered by sucrose, while ammonia - N concentration was increased equally by both casein and urea supplementation. The rumen VFA were also affected by treatment. In particular, casein increased the proportion of isobutyric and isovaleric acids while sucrose increased the proportion of propionic acid, in both cases in association with a reduced acetate level. Treatments did not affect the blood acid-base balance. Blood glucose concentration was increased by sucrose supplementation and serum urea concentration was increased both by casein and urea supplementation. The results of the nitrogen balance showed that both casein and urea caused an increase in urinary nitrogen excretion and a small non-significant increase in nitrogen retention. Sucrose also affected protein utilization by decreasing urinary nitrogen excretion and increasing nitrogen retention, though not significantly so.

The silage used in this experiment was of good quality and it was surprising to find that both urea and casein supplementation decreased its intake. This may have been a palatability effect but more likely it was a metabolic effect, possibly associated with the high levels of ammonia-N in the rumen and of urea in blood. Casein is known to be rapidly broken in the rumen and it is likely that less soluble proteins would not have the same effect. While sucrose supplementation appeared to improve protein utilization, the fact that protein was probably already adequate for the sheep, resulted in it having no beneficial effect on animal performance. Different responses might well be found with the same animals fed low quality silage, or with animals having a higher protein requirement fed good quality silage.

Table 1. Performance of store lambs on silage treatments (Mean of 12 lambs on each treatment except for the nitrogen balance results.)

	Silage alone	Silage plus casein	Silage plus urea	Silage plus sucrose	SE of means	F-test
DM intake (g/d)	733	643	640	776	27.1	**
Live-wt. gain (g/d)	98	-56	-8	59	24.4	**
DM Digestibility (%)	73.6	72.9	74.4	72.7	0.68	NS
Rumen Fluid (Mean of 3 samples/lamb taken during the day)						
pH	7.48	7.41	7.48	7.43	0.29	**
NH_3N(mg/100ml)	11.4	15.9	22.2	9.7	1.20	***
Volatile fatty acids Molar %:						
Acetic	73.3	70.9	73.0	71.6	0.58	*
Propionic	18.1	18.4	17.9	20.0	0.57	*
Isobutyric	0.9	1.5	0.9	0.5	0.5	*
Butyric	5.9	5.9	6.1	6.5	0.15	*
Isovaleric	1.3	2.1	1.3	0.9	0.17	*
Valeric	0.8	1.2	0.9	0.6	0.08	*
Blood						
pH	7.49	7.50	7.50	7.51	0.004	NS
Glucose (mg/100ml)	40.2	40.6	40.5	46.1	1.23	**
Urea (mg/100ml serum)	40.8	58.7	61.7	33.8	1.70	***
* Nitrogen Balance (g/d)						
Intake	16.2	19.5	21.2	16.9	1·01	***
Faecal output	4.9	4.8	4.3	5.6	0.34	NS
Urinary output	8.4	10.7	11.0	6.7	0.58	***
Balance	3.1	4.0	5.9	4.6	0.85	NS

* *Mean of 8 lambs for the last 10 days of 21 day period.*

Paper No. 15.

METABOLISM OF SILAGE NON-PROTEIN NITROGEN IN THE RUMEN

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Non-protein nitrogen (NPN) accounts for approximately one-half of the crude protein in most ensiled feeds. Analysis of NPN in maize silage produced in Ontario revealed that 10.1% (± 1.6, standard deviation) of the NPN was ammonia-N, 30.4% (± 10.6) was alpha amino-N and 1.2% (±0.7) was amide-N. On occasion, peptide-N has been quantitated and generally contributes an amount of N equivalent to approximately one-half of the amino-N. Remaining NPN has not been identified. Occasional analyses of lucerne and lucerne/grass silages have shown a similar pattern in NPN composition.

Infusion of effluent (collected from vertical silos containing maize) into the rumen of steers demonstrated that maize silage NPN released ammonia in the rumen very gradually relative to urea. Peak ammonia-N concentrations in the rumen following infusion of 20.65 g N from either maize silage NPN or urea, together with 4 kg maize silage, were 23.5 and 9.8 mg/100 ml, respectively. In these same experiments, rate of disappearance of non-ammonia non-protein nitrogen of maize silage was evaluated and found to be equivalent to urea.

Since free amino acids are a major constituent in ensiled feeds, levels of alpha-amino N have been determined in the rumen of cattle and sheep given either a single feed prior to the recording of amino acid levels or with cattle, smaller feedsat regular intervals of 1 h.

In the single feed experiments, sheep were given either 1000 g lucerne silage or 750 g lucerne silage with a supplement of maize grain and urea to provide dry matter and N equivalent to 250 g lucerne silage. Samples of rumen contents were withdrawn at 15 minute intervals for 1 h after feeding and at 2 h and 4 h after feeding. An exponential decrease in alpha-amino N concentration in the rumen fluid was determined. Pattern for this decrease was not affected by the provision of maize and urea. Alpha-amino N declined from a mean value of 37.3 mg/100 ml (±10.3, standard deviation) 20 min after feeding and had a half-life of 52.2 min (±5.3).

A comparable experiment was conducted with cattle fed 5 kg lucerne silage. Alpha-amino N declined from a mean value of 26.7 mg/100 ml (±8.8) 45 min after feeding and had a half-life of 45.1 min (±4.0). Deamination of amino-N to ammonia-N was suggested by positive correlations found between alpha-amino N 30-60 min after feeding and ammonia-N at 180 and 240 min after feeding. Utilization of amino-N within the rumen is suggested since no elevation in peripheral plasma amino-N concentration occurred in concert with rumen amino-N.

With cattle fed at short regular intervals (1.5 kg lucerne silage per hour), mean alpha-amino N concentration in rumen fluid in different experiments varied between 8.28 (±2.73, standard deviation, 7 observations) and 3.21 mg/

100 ml (±2.15, 6 observations). Rumen ammonia-N levels measured in corresponding rumen samples were 17.03 (±1.27) and 19.49 mg/100 ml (±3.13). These results demonstrate that amino-N contributes significantly to nitrogen metabolism in the rumen of animals fed silage-containing diets.

It can be concluded that free amino acids are rapidly deaminated to ammonia or consumed directly by the rumen microflora and that amino acid levels in the rumen of animals fed silage diets can be much greater than the values accepted in the literature for ruminants fed dry diets.

Paper No. 16.

THE VALUE OF SILAGE NITROGEN FOR DAIRY COWS; THE USE OF THE NEW FRENCH EVALUATION SYSTEM

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The new French evaluation system depends on the calculation of the amount of true protein digested in the small intestine (PDI).

The PDI content of a feed consists of two fractions (i) the undegraded dietary true protein which is digested in the small intestine (PDIA) and (ii) the microbial true protein digested in the small intestine (PDIM).

The amount of microbial protein synthesized in the rumen is calculated from either the digestible organic matter content of the diet expressed in terms of ME (PDIME) or from the available N content of the diet (PDIMN), which ever is the limiting factor.

Thus in general

PDI = PDI from feed + PDI from microbial synthesis

But for specific purposes

(a) Where energy is limiting for microbial synthesis

PDI (now called PDIE) = PDI feed (called PDIA) + PDI from microbes (called PDIME)

and (b) where N is limiting for microbial synthesis

PDI (now called PDIN) = PDI feed (called PDIA) + PDI from microbes (called PDIMN)

The requirements for cows have been calculated as follows:

For maintenance 95 + 0.5 W (kg) g PDI where W = liveweight
For milk production 50 g PDI/kg fat corrected milk
For growth 280 g PDI/kg weight gain

Although silages often have a high nitrogen content their true protein value is sometimes low. The aim is now to verify that the calculated values of PDI for silages are in agreement with the needs of the animals and if this system is more appropriate than the DCP system.

In three trials, perennial ryegrass silages with the following mean characteristics were fed to dairy cows.

CP (% DM)	=	13.8
Sol N (% Total N)	=	59.0
OM digestibility	=	74 (0.89 Feed Units/kg DM)
DCP (g/kg DM)	=	90
PDIE (g/kg DM)	=	79
PDIN (g/kg DM)	=	82

The trials were conducted during the declining phase of lactation (2nd to 5th month after calving) with groups of 8 cows receiving low, normal or high levels of PDI. The response of the cows to additional PDI, given in concentrates, was examined. The distribution of silage and concentrate was limited to have isoenergetic rations among the groups of cows. The mean results are presented in Table 1.

Table 1. Feed intake and animal production

	Level of PDI		
	low	medium	high
DM intake (kg/day)			
silage	9.70	9.95	10.00
concentrate	4.34	4.59	4.62
Energy (Daily FU/animal)			
silage	8.63	8.86	8.90
concentrate	5.20	5.30	5.34
PDI (g/day)			
silage	763	783	787
concentrate	540	616	726
CP content of ration (g/kg DM)	141	156	175
Milk production (kg/day)	20.23	20.78	21.56
Fat corrected milk (kg/day)	19.41	20.33	21.21
Fat content (g/kg)	37,3	38,4	38,8
CP content (g/kg)	31,5	32,3	32,0
Liveweight (kg)	556	564	565
Liveweight gain (g/day)	87	111	189
Theoretical needs			
FU/day	13.40	13.92	14.58
PDI g/day	1349	1405	1462
Expressed values of silages			
FU/kg DM	0.840	0.863	0.917
PDI/kg DM	83.4	79.3	73.6

The predicted fat-corrected milk production was 19.22 kg. The agreement between allowance and theoretical needs was therefore good.

Nevertheless the response of the animals was high; 1.8 kg fat corrected milk and 102 g growth per day for 210 g PDI between the low and high levels of feeding. This response indicated that the calculated PDI value of the silage was a little over-estimated especially at the medium and high levels, but it is not possible to calculate the exact value.

In these trials, when calculated by the DCP system, the silages provided the maintenance requirements plus 9.3 kg fat corrected milk. In the PDI system they provided the maintenance requirements plus 8.1 kg (medium level) or 7.1 kg (high level). The difference is small but the silages were of high quality with high digestibility and good preservation. The difference would be higher with silages of lower digestibility and higher soluble N content.

Further work is necessary to confirm these facts with higher levels of PDI and different quantities of silage and to verify if the results are the same for *ad libitum* feeding of silages. Corrections can then be provided for the PDI value of the silages.

SESSION 5 SILAGE INTAKE

PAPERS 17 TO 21

CHAIRMAN - G ALDERMAN ESQ

Paper No. 17.

A FURTHER ANALYSIS OF RELATIONSHIPS BETWEEN SILAGE COMPOSITION AND VOLUNTARY INTAKE BY SHEEP

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Relationships between dry matter intake and composition were examined for 142 silages prepared at the Grassland Research Institute and fed *ad libitum* without supplementary feeds to wether lambs in the period 1968-77. This report complements that of Wilkins *et al* (1971) for silages given to sheep in the period 1961-67. Silages were made from grasses (perennial ryegrass, cocksfoot or tall fescue), cereals (maize and sorghum) or legumes (lucerne and red clover). All crops were precision chopped and made without additive (49 silages), with the addition of 85% formic acid at 1.5 - 11.2 l/t (37), with formalin or paraformaldehyde at 1.8 - 24.4 g HCHO/100 g CP (28) or with formalin + either formic or sulphuric acid (28).

Mean values for the composition and intake of the silages classified according to crop and additive type are given in Table 1. Particular features are: (i)the better preservation of silages made with than without additives as indicated by the contents of ammonia-N, volatile acids and Flieg Index, (ii) the higher intake of legumes than of grasses or cereals and (iii) the higher intake of silages made with formic acid than without additive; intakes of the HCHO-treated silages were intermediate.

Correlation coefficients relating intake with the silage components are given in Table 2. Intakes were depressed, sometimes severely, in silages treated with high rates of HCHO and correlations with intake were generally increased when all HCHO-treated silages were removed from the analysis. There was a consistent negative correlation of ammonia-N with intake. Nitrogen content had positive correlations with intake for all silages and for all silages without HCHO. However, for legumes without HCHO the correlation between nitrogen and intake was negative and significant. Total acid content was negatively correlated with intake both for all silages without HCHO and for legumes without HCHO.

Multiple regressions were examined for the four groups of silages. In all cases when two factors were examined more of the variance in intake was accounted for by regressions involving ammonia-N and nitrogen than by any others (see Table 2). Also, the inclusion of further factors in the multiple regressions led only to small increases in the variance accounted for.

The correlations with ammonia-N and nitrogen are in line with earlier results (Wilkins *et al* 1971). Correlations with other measures of fermentation quality (Flieg Index, acetic acid, lactic acid (% total acids)) were, however, lower than found previously. We consider that despite the high residual variation, analyses for ammonia-N and nitrogen will provide a guide to the likely relative intakes of different silages.

Wilkins, R.J., Hutchinson, K.J., Wilson, R.F. and Harris, C.E. (1971). J. agric. Sci. Camb. Vol 27, 531-7.

Table 1. Composition and intake of silages

	Grasses			Legumes			Cereals	SD
	No additive	Formic acid	Formaldehyde*	No additive	Formic acid	Formaldehyde*	No additive	
No. silages	29	23	41	11	14	15	9	
Dry matter (%)	23.4	20.0	23.5	21.1	20.4	21.4	28.8	5.78
pH	4.36	4.35	4.75	5.15	4.39	5.05	3.85	.381
Composition of DM (%)								
Nitrogen	2.50	2.99	2.86	3.21	3.23	3.22	1.46	.449
Lactic acid	7.19	5.63	2.43	4.02	3.80	1.50	6.68	2.66
Acetic acid	4.05	2.78	0.82	6.05	3.03	1.19	2.37	1.80
Propionic acid	0.25	0.18	0.02	0.38	0.19	0.03	0	0.206
Butyric acid	0.72	0.83	0.05	0.15	0.70	0.05	0	0.834
Ammonia-N (% N)	13.33	9.90	3.75	16.62	8.67	4.58	8.31	5.82
Flieg Index	61.0	54.4	79.5	52.7	53.1	59.2	90.8	8.31
Dry matter intake (g/kg $LW^{0.75}$)	56.2	63.6	60.2	67.0	76.1	72.0	54.8	9.74

** Formaldehyde applied alone and in mixture with acid*

Table 2. Relationships between silage composition and DM intake (g/kg $LW^{0.75}$)

	Overall	Silages with no formaldehyde added		
		All species	Grasses	Legumes
No. silages	142	86	52	25
	Correlation coefficients (r)[ϕ]			
pH	NS	NS	NS	- 0.60 **
Components of DM (%)				
Nitrogen	0.29***	0.34**	NS	- 0.53 **
Butyric acid	- 0.17*	- 0.24*	NS	- 0.44 *
Total acids	NS	- 0.21*	NS	- 0.54 **
Ammonia-N (%N)	- 0.17*	- 0.33**	- 0.42**	- 0.56 **
Lactic acid (% total acids)	NS	NS	NS	- 0.48 *
Flieg Index	NS	NS	NS	0.51 **
	Multiple regression analysis			
Ammonia-N and nitrogen related to DM intake:				
Variance accounted for (%)	11.5	29.9	33.7	64.0
Signs of regression coefficients and significance levels				
Ammonia-N	(-) **	(-)***	(-)***	(-)***
Nitrogen	(+)***	(+)***	(+)***	(-)***

ϕ *Correlation coefficients relating intake to dry matter (%), acetic acid (%) and propionic acid (%) were not significant for any group of silages*

Paper No. 18.

VARIATIONS BETWEEN DAIRY COWS IN VOLUNTARY INTAKE OF SILAGES

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The planning and computation of rations for dairy cows would be facilitated if a method of accurately predicting the voluntary intake of feeds by individual cows was available. To provide more information for this purpose the extent and some causes of variability between milking cows in their voluntary intakes of grass and lucerne silages were examined in a group of Friesian cows. In earlier work the amount of concentrates was given in proportion to the milk yield of the individual cows and it was difficult to separate their effects on forage intake.

In this study each cow was given 8.6 kg of a mainly barley based concentrate (approx 7.2 kg DM). Voluntary intakes were measured when the cows were between 100 and 200 days of lactation. Silage was offered *ad libitum* daily in two meals each of 2.5 hours duration. Grass silage was used for 24 cows for six weeks and then lucerne silage was offered to 21 of the same cows for a similar period. Table 1 gives a brief description of the silages fed.

Table 1. Analyses of grass and lucerne silages.

Silage	Dry matter (g/kg)	Crude protein (g/kg DM)	Cellulose (g/kg DM)	pH	*In-vitro* D
Grass	325	148	282	4.2	0.69
Lucerne	230	186	344	4.9	0.55

The main results of the feeding trials are summarised in Table 2. With both grass and lucerne silages variations between cows in silage intake were associated with differences in milk yield ($r = 0.4$) and liveweight ($r = 0.4$). Intake of silage increased by about 0.1 kg DM per kg milk yield. There were no significant associations between silage intake and change in liveweight and days in milk. About 50% the variation between silage intake could be accounted for by a multiple regression including data on milk yield, liveweight, change in liveweight and days in milk. Measurements of body size revealed little variability between the cows and no relationship with voluntary intake of silage.

Table 2. Silage intake and animal production

Silage	Daily silage intake (kg DM)	Daily milk yield (kg)	Liveweight (kg)	Daily change in liveweight (kg)
Grass	8.7 ± 1.37	18.7 ± 4.48	614 ± 53	0.39 ± 0.34
Lucerne	5.5 ± 0.9	14.4 ± 3.41	634 ± 66	0.44 ± 0.30

The intakes of total feed predicted by equation 22 in Technical Bulletin 33 (MAFF 1975) indicated that with both grass and lucerne silages total intakes should be 17.3 kg dry matter per day. However, the actual mean total intake was 15.9 kg for grass silage and concentrates and 12.7 kg DM for lucerne silage and concentrates. Intakes of grass silage were correlated with intakes of lucerne silage (r = 0.76, n = 21); the correspondent correlation coefficient for milk yield was 0.91.

These results are typical of others obtained at Wye College and more detailed experiments are now in progress to study the variability in eating and ruminating behaviour under different feeding regimes.

Paper No. 19.

SUPPLEMENTATION OF SILAGE WITH SPECIFIC NUTRIENTS AND THEIR EFFECT ON VOLUNTARY INTAKE

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Previous studies on the voluntary intake of silage have generally examined in separate experiments the effects of increased concentrations of individual silage constituents. However, the concentration of silage constituents are unlikely to vary independently. The two experiments reported here were designed, therefore, to examine the interactions resulting from simultaneous addition of two nutrients.

In the first experiment, 12 British Friesian entire male calves, initially 3 months of age, were offered a grass silage low in N (1.63% N in DM). The two basic treatments were silage alone and silage supplemented with fishmeal (50 g/kg silage DM). Each of these two diets was given *ad libitum*, either untreated or treated with lactic acid at 50 g/kg silage DM. The fishmeal was mixed with the silage by hand just prior to feeding, whilst the lactic acid was mixed with the silage in a concrete mixer and allowed to equilibrate overnight. The experiment consisted of two 28-day periods separated by a 14-day change-over period during which lactic acid treatments were reversed within fishmeal treatments. The results are summarised in Table 1.

Table 1 Voluntary intake per day, Experiment 1

Lactic acid addition	Silage 0	Silage 50 g/kg	Silage + fishmeal 0	Silage + fishmeal 50 g/kg	SE of means* a	SE of means* b
DM intake/day						
kg	3.21	2.85	3.47	3.48	0.126	0.051
g/kg liveweight	23.9	21.1	23.2	23.1	0.41	0.37

* *SE a for comparisons at different levels of fishmeal*
b for comparisons within fishmeal treatments

There was a significant interaction ($P < 0.05$) between the effect of lactic acid addition and the inclusion of fishmeal, in that lactic acid depressed the intake of the silage alone diet but this effect was not evident in the presence of fishmeal. The response to fishmeal tended to be more marked when intake was expressed in absolute terms rather than on the basis of liveweight.

In the second experiment 36 British Friesian steers, initially 3 months of age, were offered red clover silage *ad libitum*. The animals were randomly allocated to two basal diets: silage alone or silage supplemented with sucrose (75 g/kg silage DM). Each calf acted as its own control to measure the response to one of three levels of lactic acid (25, 50 or 75 g/kg silage DM). Intakes were recorded over two 14-day periods, each preceded by a 14-day adaptation period. Both lactic acid and sucrose treatments were prepared just prior to feeding. The results are summarised in Table 2.

Table 2. Voluntary intakes per day, Experiment 2

Diet	Voluntary intake/day (g/kg liveweight)		Depression in voluntary intake/day (g/kg liveweight)		
	Period I	Period II	L1*	L2*	L3*
Silage alone	25.1	26.2	0.8	1.8	2.4
Silage + sucrose	22.9	27.1	0.8	1.5	1.6

* *L1 = 25 g lactic acid/kg silage DM*

L2 = 50 g lactic acid/kg silage DM

L3 = 75 g lactic acid/kg silage DM

Voluntary intake was significantly depressed by the addition of lactic acid to silage alone ($P < 0.01$) and to silage plus sucrose ($P < 0.05$). The interaction between inclusion of sucrose and time was significant ($P < 0.05$) in that sucrose appeared to depress intake in the first period but not the second. There was no significant difference in response between the different levels of lactic acid addition.

Paper No. 20.

THE EFFECT OF SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF GRASS SILAGE UPON THE FEEDING BEHAVIOUR AND SILAGE DRY MATTER INTAKE OF SELF-FED DAIRY COWS

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To make the best use of silage dry matter for milk production it is necessary to achieve high silage dry matter intakes. This is reflected in a swing towards the manger feeding of silage on commercial farms, but the low labour requirement and capital investment required to self-feed silage is still attractive to many farmers.

These observation studies of cow feeding behaviour were conducted to help identify the factors limiting silage intake under self-feed management.

In each of 4 years 1974-77, two different silages were self-fed in adjacent silos. Twenty-four cows had access to each silage at a stocking rate of 250 mm/cow controlled by an electrified metal bar suspended 0.5 m in front of the face and 1 m from the floor. All cows calved between October and December and were given a similar flat rate of concentrate feeding and mean silage dry matter intakes were calculated weekly from silage density/ volume measurements.

The observation studies were carried out in January each winter. Each cow which was feeding was identified and recorded at 5 minute intervals during a 24 hour period. From this data a feeding pattern (total feeding time, number of feeds taken and the length of each feed) was established for each silage.

There was a good relationship between total feeding time and silage chop length (Table 1). The shortest chop length i.e., metered chop silage, had the shortest feeding time, 3.9 hours, compared with 5.0 hours for flail cut silage. Silage dry matter intakes however were not affected.

Table 1. The effect of chop length on total feeding time.

Type of harvester	Length of chop (mm)	Total daily feeding time (h/cow)
Metered chop	20	3.92
	40	4.00
Double chop	60	4.02
	80	4.15
Direct cut flail	120	4.50
	140	4.95

Combining the data for all silages fed (8 silages, 192 cows) a pattern of feed activity was established. Activity was greatest before evening milking, 1600 h, and declined to a low at 0200 h. When feeding patterns of individual silages were compared with the norm, it was apparent that some silages did not exhibit the expected pattern of feed activity. The unusual feeding patterns were a result of cows making frequent visits to the silage face, 10 in 24 hours compared with 6 visits in a more normal feeding pattern. Frequent visits were associated with feeds of shorter duration. Chemical analyses of these silages revealed that they all had a high acid content.

Cows eating silages with a high acid content appeared to have the lowest dry matter intakes. Dry matter intakes were highest on silages with a high dry matter content (Table 2). DOMD appeared to have no consistent effect upon silage dry matter intake.

Table 2. The effect of silage dry matter content on dry matter intake

Silage dry matter (g/kg)	190	198	220	238	240	285	300	328
Silage DM intake (kg/d)	7.8	7.8	8.3	10.8	8.4	10.4	9.1	11.1

These results suggest that short chop length, high dry matter and low acid content are the silage characteristics required to achieve high silage dry matter intake under self-feed management.

Footnote: Data presented in the Tables have been obtained from Figures submitted with the text - Editor.

Paper No. 21.

SILAGE ADDITIVE, LEVEL OF PROTEIN SUPPLEMENTATION AND DIGESTIBILITY AS FACTORS INFLUENCING VOLUNTARY INTAKE AND MILK PRODUCTION

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The results from two trials are reported. In the first experiment animals were given wilted grass silages prepared with either no additive (NA) or a mixture of formic acid and formalin (3.5 g HCHO/100 g CP) (FF). The silages were supplemented with either pellets of ground maize (10.4% CP) (LP) or a pelleted mixture of ground maize and soya bean meal (25.4% CP) (HP). Supplements were given at the rate of 85 MJ ME/day to heifers and 100 MJ ME/day to cows. Diets were balanced with urea to provide 1.6 g fermentable N/MJ ME. Each treatment group in the 2 x 2 factorial design consisted of 6 cows and 4 heifers and the experiment was conducted over weeks 4 to 22 of lactation. The results are summarised in Table 1.

Table 1. Silage intake and milk yield, Experiment 1

Supplement	NA		FF		SE of Means
	LP	HP	LP	HP	
Voluntary intake (kg DM/day)					
Silage	8.2	8.3	8.9	9.6	± 0.38
Supplement	6.6	6.9	6.6	6.9	-
Total	14.8	15.2	15.5	16.4	± 0.38
Adjusted milk yield (kg/day)					
Heifers	18.3	16.9	19.3	19.1	± 1.07
Cows	24.1	27.9	26.1	28.1	± 1.14

The formalin additive markedly reduced the content of total fermentation acids in the DM and the proportion of ammonia-N in the total N. In early lactation, cows and heifers consumed 16% more of silage FF than of silage NA ($P < 0.01$) and the animals given silage FF produced more milk than those given silage NA, a trend which achieved significance with heifers ($P < 0.05$). However, in mid lactation the effect of the additive on voluntary intake was not significant and cows given silage FF had a significantly faster rate of milk yield decline than those given silage NA. Thus, over the whole trial period, the use of formalin did not result in an increase in milk production. The protein content of the supplement had no significant effect on voluntary intake but cows receiving the HP supplement produced on average 11.5% more milk than those given the LP concentrate ($P < 0.05$).

In the second experiment, primary growth perennial ryegrass (cv Endura) was cut at either 72D or 62D, wilted and ensiled with a mixture of formic acid and formaldehyde (3.0 g HCHO/100 g CP). The silages were given together with a pelleted supplement consisting of barley and soya bean meal (23% CP) to 2 groups of 12 cows over weeks 4 to 18 of lactation. The supplement was given at the rate of 85 MJ ME/day and urea was added to the diets so that they supplied a minimum of 1.6 g fermentable N/MJ ME. A summary of the results is presented in Table 2.

Table 2. D value, intake and milk yield, Experiment 2

	D-value 72	D-value 62	SE of means
Voluntary intake (kg DM/day)			
Silage	9.9	9.5	± 0.27
Supplement	6.3	6.3	-
Total	16.2	15.8	± 0.27
Adjusted milk yield (kg/day)	27.9	24.7	± 0.69

Digestibility of the silage had no significant effect on voluntary intake but resulted in a significant difference in milk yield of 3.2 kg/day ($P < 0.01$). However, the harvested DM from primary growth cut at 72D was only 54% of the yield at 62D. Experiments are in progress to assess the quantity of supplement needed to equate milk yield/cow from medium D silage with that of high D material.

SESSION 6 ANIMAL PRODUCTION FROM SILAGE

PAPERS 22 TO 25

CHAIRMAN - H A WATERSON ESQ

Paper No. 22.

THE EFFECT OF INTERVAL BETWEEN HARVESTS AND WILTING ON MILK PRODUCTION

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Reducing the interval between harvests, and wilting prior to ensiling have generally both been considered as factors which improve the quality of grass silage. The purpose of the present work was to provide information on the response in milk output to both these aspects.

In Experiment 1 an area of 28 hectares of perennial ryegrass swards, which had previously been harvested for silage during late May, was divided into three sections. Subsequently two sections were each harvested twice after regrowth intervals of 5 weeks. The material from one section was ensiled directly and from the other, allowed wilt prior to ensiling. The third section of land was harvested once after a regrowth interval of 9 weeks and ensiled directly. All silages were harvested by the same machinery and received formic acid (85% w/w) at the rate of 3.0 litres/tonne of grass ensiled. During the following winter the three silages were fed *ad libitum* to 84 January/February calving cows from 1 week post-calving until going to pasture in mid-April. Two levels of concentrate feeding, 7.6 and 11.2 kg/day, were offered within each silage type in a 3 x 2 factorial design experiment. The effects on animal performance are shown in Table 1 below. As there was no interaction between level of concentrate supplementation and silage type on any of the parameters measured, the results given in Table 1 are means for the two levels of concentrate.

Table 1. Silage analysis, intake and animal output, Experiment 1

	Direct cut		Wilted	SE of mean
Interval between harvests (wks)	5	9	5	
Silage analysis				
Dry matter (%)	23	27	35	
pH	3.9	3.8	4.3	
D value	68.2	64.2	68.7	
Mean milk yield (kg/day)	27.6_a	25.1_b	27.5_a	0.41 ***
Silake DM intake (kg/day)	9.4_a	8.5_b	9.7_a	0.27 *
Liveweight at end of expt. (kg)	549	537	545	3.6 NS

Means with the same subscript are not significantly different.

Reducing the interval between harvests from 9 to 5 weeks significantly increased milk output but wilting, although slightly increasing dry matter intake, did not affect milk production.

In Experiment 2 a similar area of perennial ryegrass swards which had previously been harvested for silage during late May was again divided into 3 sections. Subsequently one section was harvested twice at regrowth intervals of 5 weeks, and the other two sections harvested once after regrowth intervals of 7 and 9 weeks. Within each of the three sections half of the area was ensiled directly and half wilted to around 45% dry matter prior to ensiling. All silages were harvested by the same machinery and received formic acid at the rate of 3.0 litres/tonne of grass ensiled. The six resulting silages were fed *ad libitum* the following winter to 72 January/February calving cows from 1 week post-calving until going to pasture in mid April. A randomised block design was used and the effects on animal performance are shown in Table 2.

Table 2. Silage analysis, intake and animal output, Experiment 2

	Direct cut			Wilted			SE of mean
Interval between harvests (wks)	5	7	9	5	7	9	
Silage analysis							
Dry matter (%)	22	26	23	42	51	49	
pH	3.9	3.8	3.9	4.6	4.7	4.4	.
D value	71	68	58	—	—	—	
Mean milk yield (kg/day)	29.0 a	28.2 a	26.3 bc	27.0 c	26.9 c	25.6 b	0.57 **
Silage DM intake (kg/day)	10.4	8.4	7.8	11.3	9.2	9.2	—
Liveweight at end of expt. (kg)	528	530	511	529	524	517	6.2 NS

Means with the same subscript are not significantly different.

In none of the parameters measured was there a significant interaction between frequency of harvesting and wilting. Decreasing the interval between harvests again resulted in a significant increase in milk output with the magnitude of the response in milk output to a change in regrowth interval from 9 to 5 weeks being similar to that reported in Experiment 1. Wilting, while significantly increasing silage dry matter intake, depressed milk output.

In conclusion, while the results presented demonstrate that an increase in milk output can be achieved by harvesting grass more frequently, they have shown no benefits in terms of milk output from wilting prior to ensiling.

Paper No. 23.

THE EFFECT OF GRAIN CONTENT IN MAIZE SILAGE ON MILK YIELD AND COMPOSITION

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Crop production techniques and breeding programmes have been affected markedly by the belief that the quality of maize silage is closely linked to its grain content.

Agronomy trials have indicated that the proportion of plant components has little or no effect on the *in-vitro* DOMD value of forage maize (Table 1). Nevertheless it has been established that the carbohydrate composition of forage maize depends on its grain content. Thus crops containing a large amount of grain have a high starch and low water-soluble-carbohydrate content, while the reverse is true for low grain crops (Table 2).

Table 1. Changes in the *in-vitro* DOMD values, percentage of ear in the whole crop and dry matter content during the growing season (Caldera 535).

Date	*In-vitro* DOMD				% ear in whole crop	Dry matter content (%)
	Leaf	Stem	Ear	Whole crop		
20 August	66	71	82	72	19	16
21 October	61	61	79	71	55	24

In order to examine the effect of maize silage grain content on milk yield and composition, 40 Friesian dairy cows were divided into two groups after a three week covariance period at the start of lactation. During weeks 4 to 17 of lactation each group received an 18% crude protein concentrate and maize silage *ad libitum*. All animals received equal total quantities of the same concentrate as that used in weeks 1 to 3. It was fed during lactation weeks 4 to 8, 9 to 13 and 14.17 at a rate per cow of 5.1, 4.7 and 3.8 kg DM/day respectively.

The maize silages fed (Table 2) to the two groups were produced from Anjou 210, which had been established at either 5 or 15 plants/m^2 to produce silages containing a high or low grain content respectively.

The morphological characteristics of high grain/low plant density and low grain/high plant density for leaf, stem, ear and grain were 10, 22, 68 and 50% and 15, 39, 46 and 26% of the whole crop DM yield for the two crops respectively.

The results of the feeding experiment showed that the cows fed the high grain silage produced significantly more milk but of a significantly lower milk fat content (Table 3). Differences between solids-not-fat, lactose and protein content were not significant, but higher yields of these quality components were obtained from the cows which received the high grain silage. Although these cows had a slightly higher mean DM intake, a further covariance adjustment for these differences still left a positive effect from the high grain silage. Markedly higher liveweight gains were also recorded from the high grain silage.

Table 2. Nutritive value of the high and low grain Anjou 210 crops

	Before ensiling		After ensiling	
	High grain	Low grain	High grain	Low grain
DM yield (t/ha)	7.6	7.9	-	-
DM content (%)	33	26	30	25
Chemical composition (% Toluene DM)				
Total nitrogen	1.32	1.57	1.50	1.67
Acid detergent fibre	19.1	20.9	25.4	31.0
Lignin	1.0	1.0	2.7	3.3
Water soluble-CHO	6.9	20.4	0.4	1.6
Starch	27.4	24.7	24.4	14.7
Cell wall constituents	-	-	40.6	45.2
In-vitro DOMD	75	72	69	67
Organic acids (% in DM)				
Lactic	-	-	5.1	4.9
Acetic	-	-	2.8	4.8
Propionic	-	-	0.1	0.1
Butyric	-	-	0.3	0.2

Table 3. Mean weekly values for silage dry matter intake, liveweight change and milk production per cow during weeks 4-17 of lactation.

	High grain silage	Low Grain silage	Diff.	SE
Silage intake (kg DM/week)	68.8	64.1	4.7	±3.81
Liveweight change (kg/week)	+ 3.24	+ 2.67	0.57	±0.573
Milk yield (kg/week)	127.5	120.3	7.2 *	±3.42
Milk fat (%)	3.29	3.70	-0.41**	±0.131
Milk fat yield (kg/week)	4.10	4.49	-0.39	±0.209
Solids-not-fat (%)	8.79	8.73	0.06	±0.074
Solids-not-fat yield (kg/week)	11.19	10.46	0.73*	±0.308
Lactose (%)	4.87	4.83	0.04	±0.035
Lactose yield (kg/week)	6.21	5.79	0.42*	±0.170
Protein (%)	3.16	3.14	0.02	±0.067
Protein yield (kg/week)	4.02	3.76	0.26	±0.132

* $P < 0.05$ ** $P < 0.01$

Although the *in-vitro* DOMD values of the silages were similar the increased milk yield is not attributed to the differences in intake, but rather to the higher concentration of non-structural carbohydrates and lower levels of cell-wall-constituents and lignin in the high grain silage (Table 2). The lower milk fat content is due probably to the lower fibre values and high grain content of the high grain silage.

In conclusion, there is a definite advantage in terms of milk yield/cow in favour of high grain silage. This does not mean that plant density should be decreased to produce a higher grain content. Instead, genotypes should be used which are tolerant of high densities and density tolerance should be one of the criteria selected for when developing new hybrids for forage maize production.

Paper No. 24.

THE EFFECT OF ENSILING ON THE BEEF PRODUCTION POTENTIAL OF GRASS

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Low voluntary dry matter intake is commonly regarded as a characteristic of silage, particularly unwilted silage. This is frequently cited as the major obstacle to the achievement of high levels of production by animals fed on silage only. Despite this widespread belief there have been few attempts to quantify the magnitude of the silage intake problem and to measure the direct effect of ensiling grass by a good technique on the animal production potential of forage.

The experiment reported was established to quantify the direct effect of ensiling *per se* on the feed value of grass for growing beef cattle. The effect of ensiling in terms of dry matter intake and carcase gain was measured at 2 levels of dry matter content.

During a 15 week experimental period, grass was cut daily and fed either immediately (unwilted grass) or after wilting for 24 hours (wilted grass). Each feed was offered *ad libitum* to a group of 10 individually fed steers. In the middle of each week a sample of the grass fed in that week was cut and harvested for unwilted or wilted silage. All silages were treated with 2.3 l/tonne of 85% formic acid. Sufficient of each silage was made to feed a group of 10 cattle for 1 week. After 14 weeks in storage the silages were fed out in sequence to groups of 10 individually fed cattle, each silage being fed 7 days before moving on to the next. Cattle were similar in all respects in both the grass and silage sections of the experiment. At the end of the feeding periods all animals were slaughtered and carcase weights recorded. Carcase gains were calculated by reference to the carcase weight of groups of animals slaughtered at the beginning of the feeding periods.

Because of the nature of the experiment the dry matter content and digestibility of the feeds varied considerably from week to week. The dry matter contents of unwilted and wilted grass and unwilted and wilted silage averaged 22.9%, 32.4%, 23.3% and 29.2% respectively. Dry matter digestibility of grass and silage was 70.4% and 71.5% respectively. All silages were excellently preserved with an ammoniacal nitrogen level (% total N) of 5.7% and 6.3% in the unwilted and wilted silage respectively.

Results of the animal feeding experiment are given in Table 1. Wilting has not increased dry matter intakes or weight gains on either grass or silage. Dry matter intakes and daily liveweight gains were higher on grass than on silage but daily carcase gains were similar on grass and silage.

Table 1. The effect of ensiling on the feeding value of unwilted and wilted grass for beef cattle

	Unwilted Grass	Unwilted Silage	Wilted Grass	Wilted Silage	G v S	Uw v W
Mean DM content (%)	22.9	23.3	32.4	29.2		
Liveweight gain (g/day)	805	656	791	560	**	NS
Carcase gain (kg)	421	426	427	362	NS	NS
Dry matter intake						
kg/day	9.50	8.82	9.14	8.73	**	NS
g/kg $W^{.75}$	92.6	87.1	89.4	87.2	*	NS
Conversion						
kg DM/kg liveweight gain	12.4	14.2	12.2	18.5	*	NS
kg DM/kg carcase gain	23.8	21.8	22.4	25.1	NS	NS

Efficiency of conversion of dry matter to carcase was similar for grass and silage. The liveweight results have illustrated the risks incurred when treatment effects were measured in liveweight terms only.

The dry matter intakes and the carcase gains were similar to levels normally expected on forage having a dry matter digestibility of 70%. The ensiling of grass by a good technique to prevent the production of a high level of ammonia in the silage has not reduced the feed value of herbage for growing beef cattle.

Paper No. 25.

EFFECTS OF DIFFERENT CONSERVATION SYSTEMS ON THE UTILIZATION OF LUCERNE

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The yields of dry matter (DM), metabolizable energy (ME) and digestible crude protein (DCP) from a grass-lucerne crop (seed mixture: 15 kg lucerne 5 kg timothy and 5 kg meadow fescue per ha) were studied over four successive years. The experiment was undertaken on a farm scale with plots of 5 ha per treatment. The following four treatments were studied:

a) barn dried hay - wilted in the field to 60-70 per cent dry matter.

b) formic acid treated silage stored in towers (direct or freshly cut silage).

c) dehydrated cobs.

d) wilted (35% DM), formic acid treated silage stored in towers.

All treatments were cut simultaneously. Three cuts per season were obtained from treatments b, c and d and two cuts from treatment a. Wilting of the third cut for barn drying is not possible in Sweden.

Field losses were measured as the difference between plots from which fresh crops were taken (b and c) and those which were wilted for hay or silage. The fresh crops gave the average yields per year and hectare as presented in Table 1.

Table 1. Production per hectare

Year	DM (kg)	MJ ME	DCP (kg)
1	7050	62.10^3	930
2 and 3	10 000	97.10^3	1530

Wilting incurred average field losses of 9% DM and 4% DCP for silage and 29% DM and 39% DCP for hay.

The relative yields of DM were for treatment b and c, 100; for d, 91 and for a, 52. The low value for hay was mainly an effect of the climatic situation which limited the number of cuts to two as compared to three in the other conservation systems. Dry matter losses during conservation and storage were on average, 7.3 + 0.7%; 14.0 + 0.5%; 9.5 + 0.8% and 9.9 + 0.6% respectively for four treatments a, b, c and d.

Silage quality was good and the values of some quality parameters are presented in Table 2.

Table 2. Silage analyses

Type of silage	pH	Ammonia-N (% TN)	Lactic acid (% in DM)	Butyric acid (% in DM)
Fresh cut	4.5	9.1	6.0	<0.1
Wilted	4.8	10.8	5.3	0.3

One case of late fermentation occurred in wilted silage just after opening of the silo.

Feeding value was evaluated in metabolic studies with wethers and production experiments with heifers. In the experiments with heifers the daily weight gain was regulated to 600 g/day and the amount of feed needed for this weight gain measured. The relative amounts of DM needed to reach this gain were for hay 115 ± 3, fresh silage 100 ± 3, dehydrated cobs 100 ± 3 and wilted silage 97 ± 6. The metabolic studies on wethers gave the same relation between treatments but the difference between hay and silage was smaller.

SESSION 7 CROPS FOR SILAGE AND CONSERVATION LOSSES

PAPERS 26 TO 28

CHAIRMAN - DR M E CASTLE

Paper No. 26.

STUDIES ON SUNFLOWER SILAGE

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Sunflowers *(Helianthus annuus L.)* variety Fransol, a French F_1 hybrid, have been successfully grown in south-east Scotland. They have provided a useful alternative to maize in this area, where late springs and short, cool summers result in low dry matter yields and immaturity at harvest even of early maturing maize hybrids. Maximum dry matter yield of sunflowers of 18 t/ha compared favourably with two varieties of maize grown at the same site, when dry matter yields of maize were 9.0 and 9.4 t/ha.

In August 1977 the sunflowers were harvested with a maize forage harvester. Site 1 (Dryden) was cut immediately before the "seeds milky ripe" stage of growth and Site 2 (Howgate) at the "flowering" stage of growth. The crops were ensiled directly, without an additive, in a polythene silo and in a bunker respectively. Despite the very high moisture content of the crop the sunflowers ensiled satisfactorily. Details of the composition of the fresh sunflowers and the sunflower silages are given in Table 1.

Table 1. Composition of sunflowers and sunflower silages

	Site 1 Pre-seeds milky ripe		Site 2 Flowering	
	fresh	silage	fresh	silage
Oven dry matter (g/kg)	122	118	138	143
Toluene dry matter (g/kg)	nd	128	nd	145
pH	nd	4.61	6.19	4.00
Composition of DM (g/kg)				
Organic matter	850	854	875	889
Total nitrogen	22.5	19.5	21.4	21.1
Protein nitrogen	16.7	9.8	17.6	13.0
Volatile nitrogen	trace	2.6	trace	1.2
Water soluble carbohydrate	178	trace	188	trace
Ethanol	nd	1.1	nd	1.3
Lactic acid	nd	73	nd	127
Acetic acid	nd	89	nd	28
Butyric acid	nd	0.3	nd	4.3

nd = not determined

Intakes, apparent digestibilities, nitrogen retention and ME values were determined for both silages, and for the fresh sunflowers cut at the pre-milky ripe stage of growth, using 3 Suffolk cross wethers per treatment. Results of the feeding trials are given in Table 2.

Dry matter intakes of the fresh sunflowers were high despite their low dry matter content of 122 g/kg. Mean daily intake of a 50 kg sheep would be 14.75 kg fresh sunflower of which 12.95 kg would be moisture. The exceptionally high dry matter intakes of these low dry matter silages compensated for their relatively low ME content. To achieve the same ME intake from a silage with an ME content of 10.5 MJ/kg, dry matter intakes would require to be in excess of 20 g/kg W.

Table 2. Mean digestibility and intake values for sunflower and sunflower silages

	Site 1 pre-seeds milky ripe		Site 2 flowering	
	fresh	silage	fresh	silage
Dry matter digestibility	0.629	0.611	-	0.649
Organic matter digestibility	0.644	0.638	-	0.686
Nitrogen digestibility	0.706	0.644	-	0.662
Digestible organic matter (g/kg)	547	545	-	610
Digestible crude protein (g/kg)	99	79	-	87
ME (MJ/kg DM)	7.87	7.71	-	7.99
Daily dry matter intake (g/kg W)	36.0	29.6	-	27.0
Estimated MEI, 50 kg sheep (MJ/d)	14.2	11.4	-	10.8

In a separate metabolism experiment, the silage made at the flowering stage of growth was fed to four rumen fistulated wethers of approximately 60 kg liveweight. The sheep were fed twice daily and access to the silage was limited to two, two-hour periods. Dry matter intakes were lower, at 15.4 g/kg W, and apparent digestibilities and ME values were higher, than those found in the feeding trial. Rumen contents were sampled at pre-feeding then at four, one-hourly intervals and two, two-hourly intervals. Values of rumenal total and individual VFA's are given in Table 3.

Table 3. Mean rumenal pH, ammonia and VFA's for sunflower silage

Time of sampling	Pre-feeding		+ 1h postfeeding		+ 2h postfeeding	
Rumenal	Mean	SE	Mean	SE	Mean	SE
pH	7.45	0.039	6.55	0.039	6.54	0.087
TVFA (mmol/l)	39	4.4	98	7.0	107	8.8
Acetic acid (mmol/mol)	690	9.1	539	5.8	547	5.7
Propionic acid (mmol/mol)	169	3.4	381	8.2	366	4.4
Butyric acid (mmol/mol)	77	3.9	41	3.0	47	2.8
Ammonia-N (mg/l)	122	15.9	180	18.2	216	6.6

In conclusion, in south-east Scotland sunflowers have given good yields of dry matter and have ensiled satisfactorily. The silage has been readily accepted by sheep and rumen fermentation patterns have indicated a high production potential for growing animals.

Paper No. 27.

A COMPARISON BETWEEN TWO DIFFERENT METHODS OF ESTIMATING LOSSES IN ENSILING EXPERIMENTS

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In most cases losses during ensiling have been determined as the difference between the amount of specific nutrients or compounds in the grass being ensiled and those in the resulting silage. Besides measuring the losses as the difference between input and output, they may also be measured as the sum of the losses via gas and effluent. These two methods are referred to as the Difference - and the Sum Method, respectively.

Today the ensiling plant at Hellerud experimental station consists of 26 identical silos. The silos are airtight and have facilities for absorbing the CO_2 produced during the experiment. KOH is used as absorbent.

Results from 54 silos with untreated and 204 silos with formic acid treated silage were used to compare the Difference and the Sum Methods of estimating losses during ensiling (Table 1).

When estimating the losses of dry matter and organic matter according to the Sum Method, the amount of CO_2 produced was calculated to equivalent amounts of glucose by use of the factor 0.68. The CO_2 production was 5.6% of the dry matter when ensiled without additive and 3.3% when using formic acid.

Table 1. The losses during ensiling estimated according to the Difference and Sum Methods (% of amount of herbage ensiled).

	The Difference Method		The Sum Method	
	Without additive	With formic acid	Without additive	With formic acid
Total weight	6.9	10.7	7.0	10.5
Dry matter	8.2	7.5	5.5	5.0
Ash	1.8	7.2	4.9	9.1
Organic matter	8.8	7.5	5.5	4.6

The calculation of the loss of total weight showed only a slight variation between the two methods, which could be accounted for by small weighing inaccuracies. For all the nutrients, except ash, the losses were smaller when calculated according to the Sum Method than according to the Difference Method.

The balances between input and output of different components were calculated according to the following equation:

$$G = S + E + CO_2 - x$$

where G = kg grass, S = kg silage, E = kg effluent, CO_2 = kg CO_2 recalculated by use of the factor 0.68 and x = kg deviation. The results are presented in Table 2.

Table 2. The balances between input and output of different components (% of the amounts ensiled).

	Without additive		With formic acid	
	Deviation from zero	Standard deviation	Deviation from zero	Standard deviation
Total weight	0.09	0.84	0.22	1.47
Dry matter	2.77	5.17	2.48	4.63
Ash	-3.13	5.98	-1.93	5.41
Organic matter	3.36	7.94	2.72	5.45

The weighings were made without systematical biases and the relatively small standard deviations on total weight have indicated that the weighings were recorded with adequate accuracy.

More dry matter was filled into the silos than taken out of them and it was reasonable to believe that this was caused by systematical biases when sampling and biases involved in the dry matter determination. Biases when converting CO_2 to sugar or gaseous losses other than CO_2 may also be of some magnitude.

More ash was taken out of the silos than was put in, and the standard deviations were relatively large. The ash content was determined by ignition to constant weight. During this process some carbonate may be formed where the carbon originates from organic materials. If this reaction takes place to a different extent when igniting grass, silage and effluent, systematical deviations may occur.

When calculating the amount of organic matter in the same way, both the effect and the variation of the balances of dry matter and ash will influence the results.

Prior to reaching the stage where adequate methods exist for determining energy losses during ensiling, the losses of dry matter and organic matter will continue to be of great importance. The Sum Method for calculating these losses seems to be more accurate than the Difference Method as the latter includes some sources of error which may lead to systematical biases, i.e. difficulties during sampling and dry matter determination of silage. The Sum Method, on the other hand, is more laborious.

Paper No. 28.

THE EFFECT OF SODIUM BENTONITE ON EFFLUENT PRODUCTION FROM GRASS SILAGE

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Effluent is a problem associated with the ensilage of low dry matter (DM) crops and it can be prevented by pre-wilting. However, in wet weather pre-wilting is not always possible. An alternative means of prevention is to incorporate moisture absorbants into the crop at ensiling and several materials have been tried, such as dried grass, chopped straw and newsprint. These materials have low absorptive capacities (2 to 3 units of water per unit DM of absorbant) and for effective reduction of effluent flow the rate of incorporation of absorbant DM with crop DM needs to be high. Sodium bentonite (Wyoming grade), a colloidal clay has an absorptive capacity of 6.5. Two trials were conducted to assess the potential of sodium bentonite as an effluent absorbant.

In the first trial the effect of level of bentonite and pressure on effluent production was examined. Perennial ryegrass (10.5% DM) was ensiled in 6 kg fresh weight quantities in 76 cm x 15.2 cm diameter plastic silos after treatment with bentonite at 0, 1.25, 2.5 and 5.0% of the fresh weight and subjected to a pressure of 34.8 g/cm^2. In addition, material was ensiled with 0 and 2.5% bentonite and subjected to a pressure of 54.6 g/cm^2.

In the second trial similar quantities of perennial ryegrass (15.6% DM) were ensiled and subjected to a surface pressure of 54.6 g/cm^2 following treatment with bentonite at the lower levels of 0, 0.5 and 1.0% of the fresh weight and with and without the addition of 85% formic acid at 0.25% of fresh weight. Each silage treatment was triplicated. The volume of effluent was measured over storage periods of 150 and 92 days for the first and second trials respectively. Changes in DM and chemical composition of the silages and of the effluent were also monitored.

Treatment with bentonite reduced both the total quantity and the rate of effluent production at the 5% level of addition in Trial 1 (Table 1). With all treatments the volumes of effluents produced were less than those expected. It was thought likely that the pressure applied was insufficient to facilitate complete discharge of the effluent. Thus the higher pressure alone was used in the second trial and resulted in an increase in effluent discharge. The reduction in effluent/g bentonite added ranged between 11.7 and 4.5 ml and no trend with respect to treatment was noted. The ammonia-N content of the silages ranged between 0.5 and 0.29% of the DM and tended to be lower in the bentonite treated silages than in the control silages.

The effluent data for the second trial are in Table 2. Addition of bentonite at 0.5% had little effect in stemming the flow of effluent whereas at the 1.0% addition, effluent production was reduced by 32 and 25% in the silages made with and without formic acid, respectively. Treatment of the crop with formic acid increased the maximum rate of effluent flow ($P<0.01$) and tended to increase the production of effluent (P>0.05). The reduction in effluent/g bentonite was greater in the treatments containing 1% than with 0.5% bentonite. Mean ammonia-N contents ranged between 0.24 and 0.47% of the DM with no pattern with respect to treatment.

Sodium bentonite has potential as an additive for reducing the discharge of effluent from crops ensiled at low contents of DM, but to achieve complete prevention of effluent production the rate of addition would have to be greater than 5% of the crop fresh weight.

Table 1 Effects of bentonite and pressure on the production of effluent from ryegrass ensiled at 10.5% dry matter content (Trial 1)

Treatment		Total volume of effluent (ml)	Reduction of effluent by bentonite (%)	Max. rate of effluent prodn. (ml/day)	Increase in effluent due to consolidation (%)	Reduction in effluent/g bentonite (ml)
Bentonite (% fresh wt)	Consolidation (g/cm^2)					
0	34.8	1926	-	402	-	-
1.25	"	1049	45.4	170	-	11.7
2.5	"	1245	35.4	61	-	4.5
5.0	"	526	72.7	35	-	4.7
0	54.6	2406	-	290	19.9	-
2.5	"	1486	38.2	43	16.2	6.1

Table 2 Effects of bentonite and formic acid on the production of effluent from ryegrass ensiled at 15.6% dry matter content (Trial 2)

Treatment		Total volume of effluent (ml)	Reduction of effluent by bentonite (%)	Max. rate of effluent prodn. (ml/day)	Increase in effluent due to formic acid (%)	Reduction in effluent/g bentonite (ml)
Bentonite (% fresh wt)	Formic acid (% fresh wt)					
0	0	1361	-	234	-	-
0.5	0	1327	2.5	114	-	1.1
1.0	0	1014	25.5	81	-	5.8
0	0.25	1599	-	278	14.9	-
0.5	0.25	1588	0.7	196	16.4	0.4
1.0	0.25	1095	31.7	90	7.4	8.4
SED		203.0		41.0		

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