# FOURTH SILAGE CONFERENCE

THE GRASSLAND RESEARCH INSTITUTE

22 - 23 SEPTEMBER 1976

A B S T R A C T S

O F

P A P E R S

# Fourth Silage Conference

## The Grassland Research Institute, Hurley

## 22 and 23 September 1976

| | |
|---|---|
| Tuesday 21 September | 1800-1900 Dinner at Wells Hall University of Reading |
| | Registration at Wells Hall University of Reading 1900-2100 |
| Wednesday 22 September | SESSION 1 Silage:fermentation and aerobic deterioration |
| | Chairman - Dr M E Castle |
| 0930-0940 | Welcome and Introduction - Dr R J Wilkins |
| 0940-1000 | Paper 1 Professor E Zimmer 'Silage research around maize in Germany, with special attention to Vӧlkenrode experiments'. |
| 1000-1020 | Paper 2 Dr M K Woolford 'Microbiology of the aerobic deterioration of silage' |
| 1020-1035 | Paper 3 Mr M Hastings 'Aspects of harvesting, storage and unloading in practical silage systems'. |
| 1035-1100 | Discussion |
| 1100-1120 | Coffee |
| | SESSION 2 Energy value of silage |
| | Chairman - Dr J H D Prescott |
| 1120-1135 | Paper 4 Mr J S Smith, Dr F W Wainman and Mr P J S Dewey 'The energy value to sheep of three Aberdeenshire grass silages'. |
| 1135-1150 | Paper 5 Dr N C Kelly 'Some aspects of the energy utilisation of high quality silages' |
| 1150-1210 | Paper 6 Ir H A Boekholt 'Results of some energy balance trials with dairy cows fed rations containing maize' |
| 1210-1225 | Paper 7 Mr W P Barber, Mr G Alderman and Mr W Lessells 'Prediction of the metabolisable energy of silages' |
| 1225-1255 | Discussion |
| 1255-1345 | Lunch |

## SESSION 3 Use of enzymes and alkalis in ensiling

Chairman - Dr P McDonald

| | | |
|---|---|---|
| 1345-1400 | Paper 8 | Mr R F Wilson 'Effect of enzymes on the fermentation of lucerne' |
| 1400-1415 | Paper 9 | Dr H H Theune 'Experiments using cellulolytic and delignifying agents' |
| 1415-1430 | Paper 10 | Dr A R Henderson and Dr C T Whittemore 'Cellulase-treated silages for pigs' |
| 1430-1450 | Paper 11 | Dr J M Wilkinson and Mr R Gonzalez 'Effect of type and level of alkalis on the composition of ensiled barley straw' |
| 1450-1520 | Discussion | |
| 1520-1540 | Tea | |

## SESSION 4 Digestion and metabolism of silage

Chairman - Dr J L'Estrange

| | | |
|---|---|---|
| 1540-1555 | Paper 12 | Mr J M Ewart 'In vitro rumen studies with silage' |
| 1555-1610 | Paper 13 | Mr C R Lonsdale, Dr D Beever and Dr D J Thomson 'The effect of formaldehyde on the digestion of the energy and protein components of silage diets by cattle' |
| 1610-1625 | Paper 14 | Dr L Syrjälä 'Effect of preservation method on the utilisation of protein of silage' |
| 1625-1700 | Discussion | |
| 1700 | Close | |
| 1930 | Reception and Buffet Dinner at The Riviera Hotel, Maidenhead | |

Thursday 23 September

## SESSION 5 Silage intake

Chairman - Mr R Crawshaw

| | | |
|---|---|---|
| 0930-0945 | Paper 15 | Dr J L'Estrange and Mr R W Mayes 'Effects of organic acids and ammonium salts on voluntary intake of sheep' |
| 0945-1000 | Paper 16 | Ir A Deswysen and Professor M Vanbelle 'The effect of chopping before and after ensiling on the voluntary intake of silage by sheep and heifers' |

| | | |
|---|---|---|
| 1000-1015 | Paper 17 | Dr T N Barry, Dr R J Wilkins and Mr J E Cook 'Intake and nitrogen retention by sheep fed lucerne silages differing in composition and effects of intraperitoneal infusions of methionine' |
| 1015-1030 | Paper 18 | Mr M S Smith and Mr R Crawshaw 'Silage intake by dairy herds under commercial self feeding conditions' |
| 1030-1100 | Discussion | |
| 1100-1120 | Coffee | |

SESSION 6 Silage for milk production

Chairman - Dr J C Tayler

| | | |
|---|---|---|
| 1120-1140 | Paper 19 | Professor J P Dulphy 'Intake of grass silage and its use in the feeding of dairy cows' |
| 1140-1155 | Paper 20 | Dr M E Castle, Mr J N Watson and Mr W C Retter 'Supplementation of high-digestibility grass silage for milk production' |
| 1155-1205 | Paper 21 | Dr F J Gordon (to be presented by Dr A W McIlmoyle) 'An evaluation of high digestibility silage for dairy cows and the effect of the protein content of the supplement on milk production' |
| 1205-1235 | Discussion | |
| 1235-1400 | Lunch and Discussion | |

SESSION 7 Farm production and feeding of silage

Chairman - Ir S Schukking

| | | |
|---|---|---|
| 1400-1415 | Paper 22 | Mr C Ibbotson 'Some observations on the effectiveness of silage additives on commercial farms' |
| 1415-1430 | Paper 23 | Mr J W G Parker 'A comparison between a single and two cut silage system for dairy cows' |
| 1430-1445 | Paper 24 | Mr A Adamson and Mr D Brooke 'A theoretical study of different strategies for cutting grass for ensiling and feeding to dairy cows' |
| 1445-1505 | Discussion | |

SESSION 8 Closing Session

| | | |
|---|---|---|
| 1505-1520 | Paper 25 | Dr R J Wilkins 'Silage research and development ?' |
| 1520-1600 | Discussion | |
| 1600 | Tea and conference close | |
| 1800-1900 | Dinner at Wells Hall | |

IV Silage Conference

The Grassland Research Institute, Hurley

22nd and 23rd September, 1976

List of Delegates

Mr A Adamson, ADAS, Leeds
Mrs J F B Altman, Rothamsted
Mr W P Barber, ADAS, Drayton
Mr R Bee, ADAS, Drayton
Ir H A Boekholt, Holland
Dr J G Buchannan-Smith, Guelph
Mr B S Capper, TPI, London
Dr M E Castle, Hannah
Mr J E Cook, GRI
Mr R Crawshaw, ADAS, Bangor
Ir a Deswysen, Belgium
Mr P J S Dewey, Rowett
Dr E Donaldson, ESA
Prof J P Dulphy, France
Mr J P Elrick, ESA
Mr A V Flynn, Grange
Mr A G Francis, ADAS, Cambridge
Mr R Gonzalez, GRI
Dr F Gross, Germany
Dr R D Harkess, WSAC
Mr M Hastings, ADAS, Liscombe
Dr A R Henderson, ESA
Mr I V Hunt, WSAC
Mr C Ibbotson, ADAS, Newcastle
Mr J Johnson, GRI
Dr D I H Jones, WPBS
Mr A G Kaiser, GRI
Dr N Kelly, Hannah
Dr J L L'Estrange, Univ Coll Dublin
Dr M Lewis, ESA
Dr P Lingvall, Sweden
Mr C R Lonsdale, GRI
Mr I I McCullough, Greenmount
Dr P McDonald, ESA
Dr W A McIlmoyle, Hillsborough
Mr H J M Messer, NIAE
Dr R W Mayes, Univ Coll Dublin
Dr T B Miller, ASA
Mr J W G Parker, ADAS, Great House
Dr J D Prescott, ESA
Mr W F Raymond, MAFF, London
Mr W C Retter, Hannah
Mr G M Robertson, ESA
Mr W R Rosser, ADAS, Shardlow
Mr I B Ruxton, Bansted
Ir S Schukking, Holland
Mr J S Smith, Rowett
Mr M S Smith, ADAS, Wolverhampton
Mr R W J Steen, Hillsborough
Dr L Syrjäla, Finland
Mr R G Tate, ESA
Dr J C Tayler, GRI
Mr R A Terry, GRI
Dr H-H Theune, Germany
Dr C Thomas, GRI
Mr I M Thomson, ESA
Mr E F Unsworth, AFCRD, Belfast
Professor M Vanbelle, Belgium
Dr R J Wilkins, GRI
Dr J M Wilkinson, GRI
Dr R K Wilson, Dunsinea
Mr R F Wilson, GRI
Dr M K Woolford, GRI
Dr J Young, ASA
Prof E Zimmer, Germany

Fourth Silage Conference

The Grassland Research Institute, Hurley

22 and 23 September 1976

Session 1,

Paper 1.

E. Zimmer: Silage research around maize in Germany with special attention to Völkenrode experiments.

Within the past 10 years maize has become an important crop in Germany (Fig. 1)*)

Climatic conditions are allowing varieties with

- FAO index 190 - 240 for grain, to be harvested within 40 - 25 % moisture content, followed up by drying, ensiling or acid treatment;
- FAO index 200 - 280, in some regions - 330, for whole-plant silage to be harvested within 30 - 18 % drymatter, depending on years.

Regarding these conditions research around maize conservation has to deal with certain problems. These are initiated from point of view of

1. conservation, its biological and technical aspects with respect to fermentation, conservation losses, and affecting factors, use of NPN or other additives, causality and prevention of heating;

*) note: figures will be made available by imprint.

2. maize-breeding for testing fermentability and feeding value of new types;
3. animal nutrition for better estimating feeding value of maize grown under different agronomic conditions, of different rations including maize.

Ensiling high-moisture grain or ear-corn two main factors as drymatter content and aeration will effect height of losses and risk of heating. Because dry-matter depends on year the filling procedure, air-tightness of silo, and use of Fungicides are the instruments:

- DM-losses are decreasing significantly with increasing drymatter; cracking lowers losses too; (Fig. 2, 3)
- Anaerobic conditions will stabilize fermentation compared to conventional silos; (Fig. 4)
- Even small aeration increases risk of heating with additional losses of 2 - 3 % DM;
- Fungicides as Propionic, Acetic, Kofa can prevent or diminish heating (Fig. 5).

Ensiling whole-crop maize conservation losses are affecting feeding value and economics as well. Conclusions from particular experiments are

- reduction of net-energy has to be calculated around 30 - 50 SE/kg DM compared to fresh material (Fig. 6);

- digestibility decreases around 2 - 5 units;
- DM-losses are in the range of 10 - 15 %;
- a close relation exists between type of fermentation, height of losses and reduction of net-energy content (Fig. 7).

A most pressing problem is heating. Starting factor on a given epiphytic flora is influence of air. Results can be summarized as follows:

- instability causes additional energy reduction of 30 - 75 SE units/kg DM and energy loss up to 25 % (Fig. 8, 9);
- technique of unloading, especially trenches or bunkers can alterate risk of heating definitely.

Positive effect of chopping to particel size 10 - 20 mm is well known. Modern technique now allows higher fineness, but

- increasing fineness from 14 mm to 4 mm and using a recutter doesn't influence fermentation significant;
- there is no better utilization of silo capacity;
- energy requirement runs up to more than 200 %;
- use of recutter can minimize the loss of untouched; undigested cernels in faeces if mature material has to be harvested (Fig. 10).

Adding NPN not only improves feeding value but also stabilizes fermentation and lowers risk of heating. Particular experiments showed nearly same results between PROSIL and UREA (Fig. 11, 12, 13)

Farmers and extension service are highly interested in quick and precise prediction of feeding value. Different functions are in discussion regarding

- the background of agronomic factors involved,
- demand for quick and simple determination of important parameter.

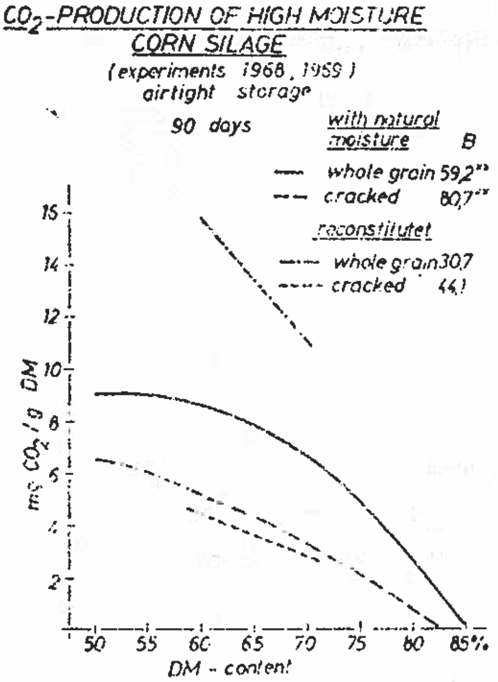



Fig. 2

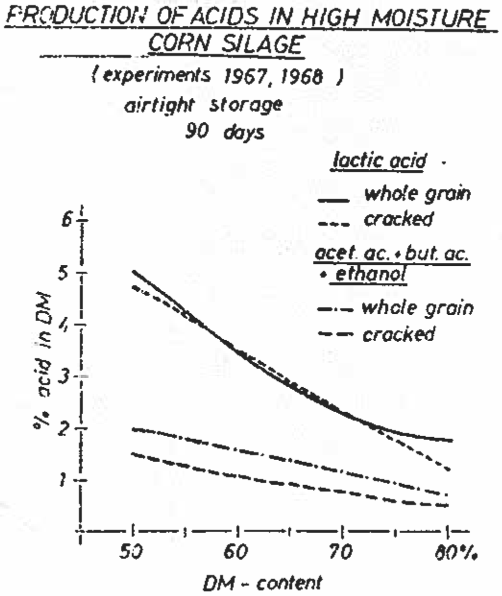
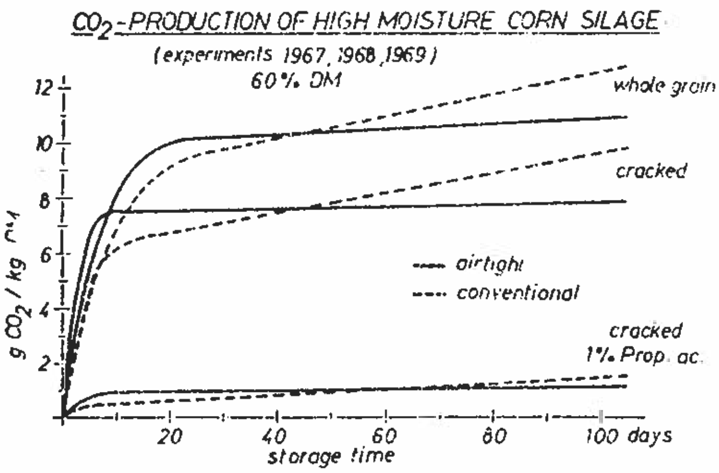



Fig. 3

Fig. 4



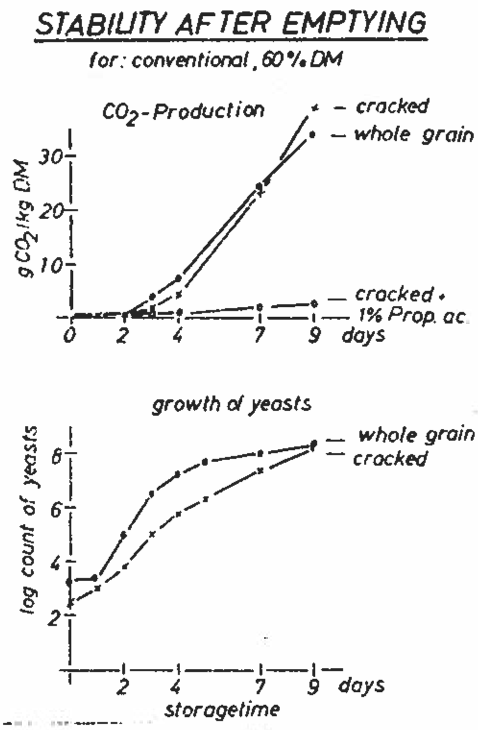




Fig. 5

Authority:

Fig. 2 - 5 HONIG, H.; ZIMMER, E.; 1973, Umsetzungen bei Körner- und Maisschrotsilagen unter verschiedenen siliertechnischen Bedingungen. in: Conservation des Grains récoltés humids; INRA Symposium International, Paris, p489-497.

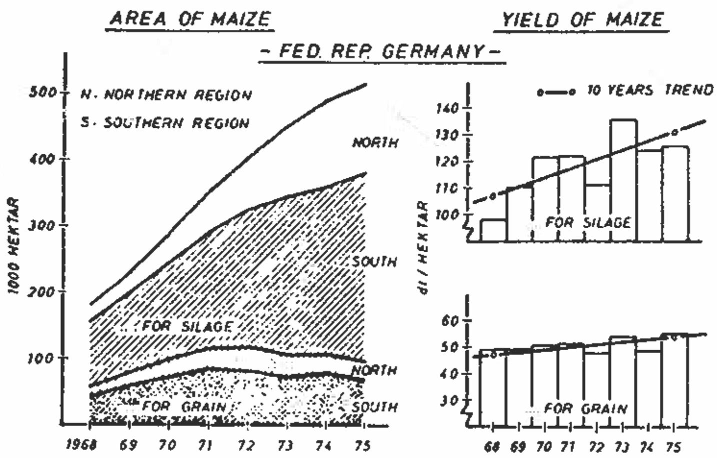
see also
ZIMMER et al., 1973, Das wirtschaftseigene Futter 19, p.204-221.
and work of
BECK, Th; Gross, F., WEISE, F.

Fourth Silage Conference, Hurley, September 1976

Session 1, Paper 1

E. Zimmer: Silage research around maize in Germany with special attention to Völkenrode experiments

Subject: Ensiling high moisture maize




Authority:

Fig. 1 ZIMMER, E., 1976, Use of Maize for livestock feeding in Fed. Rep. Germany. ECE Symposium Novi Sad, June 1976, (in press).

Fourth Silage Conference, Hurley, September 1976

Session 1, Paper 1

E. Zimmer: <u>Silage research around maize in Germany with special attention to Völkenrode experiments</u>

Supject: Losses, Feeding value, heating

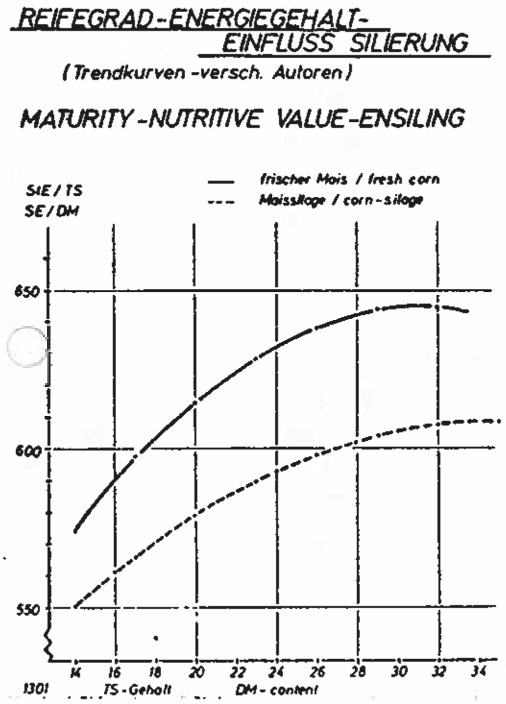



Fig. 6

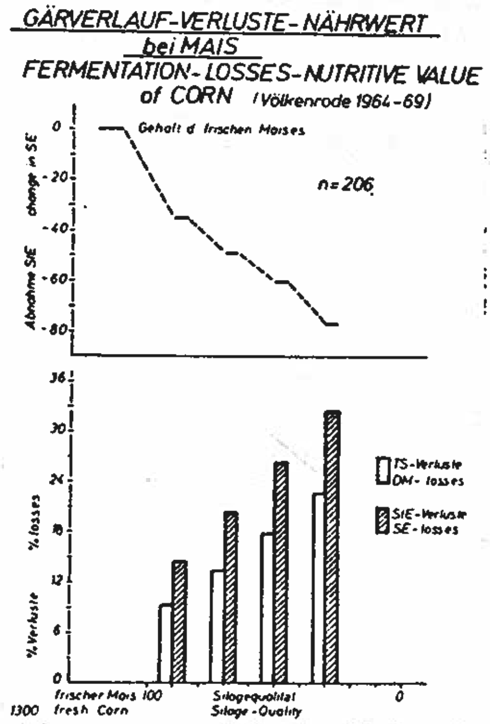



Fig. 7

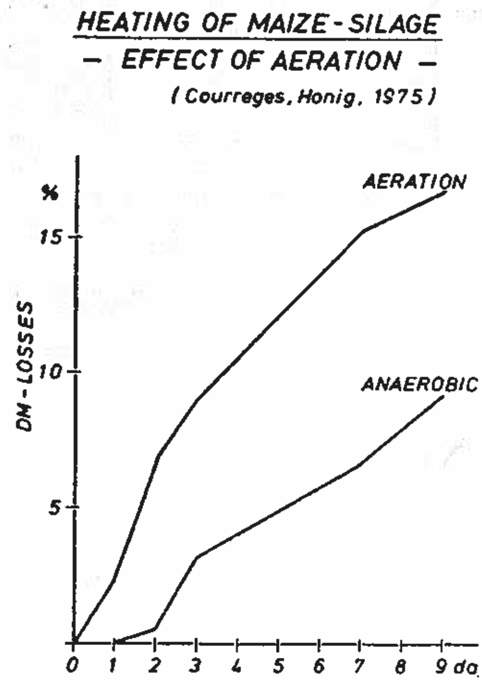



Fig. 8

Authority:

Fig. 6,7 : ZIMMER, E. 1976 Efficiency of harvesting and conservation of maize ECE Symposium Nivi Sad, (in press)

Fig. 8, 9: HONIG, H. 1975, Umsetzungen und Verlus bei der Nachgärung. Das wirtschafts-eigene Futter <u>21</u>, p. 25 - 31

see als : BECK, TH., GROSS, F., WEISE, F.

*Losses of drymatter and energy during secondary fermentation*

| coditions of fermentation | energy content when un-loading | energy content 9 days later | drymatter losses % | energy losses % |
|---|---|---|---|---|
| poor | 451 | 374 | 14.2 | 28 |
| ↓ | 509 | 452 | 2.5 | 13 |
| good | 505 | 470 | 1.1 | 8 |

Fig. 9

Fourth Silage Conference, Hurley, September 1976

Session 1, Paper 1

E. Zimmer: Silage research around maize in Germany with special attention to Völkenrode experiments

Subject: Chopping treatment, NPN as Prosil

## Effect of chopping treatment on maize

— Honig, Völkenrode 1975 —

| Treatment | Density [1] | Org. Acids | | Losses | | Instability [2] | | Cernel [3] | | Energy requirement | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VFA | Lactic | $CO_2$ | Energy | 4 day | 8 day | in silage | in faeces | | |
| | relative | % of Tot | % DM | % DM | % Tot. | relative | relative | % DM | % DM intake | KWh/t | relative |
| 14 mm | 100 | 36 | 6,0 | 3,7 | 7,6 | 91 | 105 | 19,0 | · | · | · |
| 7 mm | 106 | 36 | 5,5 | 3,7 | 7,2 | 109 | 109 | 15,0 | 5,8 | 1,6 | 100 |
| 4 mm | 114 | 36 | 5,9 | 3,4 | 8,3 | 121 | 107 | 12,5 | · | 2,1 | 136 |
| Recutter | 125 | 34 | 6,5 | 3,1 | 7,4 | 79 | 79 | 5,5 | 2,2 | 3,5 | 223 |

1) Density: kg DM/cbm of treatment 14 mm = 100,

2) Instability: mean of 4 resp 8 day losses = 100,

3) Cernel: untouched cernel in faeces as % of DM intake

Fig. 10 Authority:

HONIG, H. 1975, under experimentation

## $CO_2$ PRODUCTION during fermentation

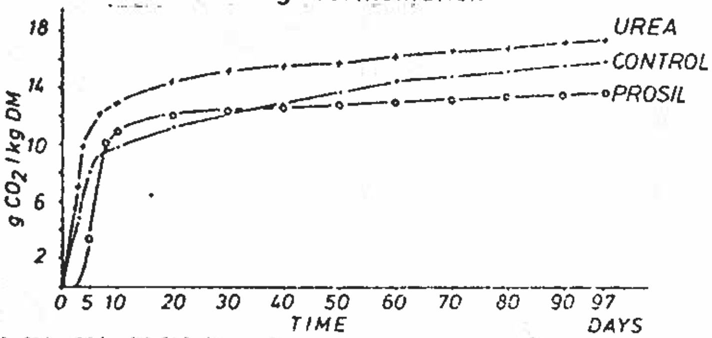



Fig. 11 Authority:

HONIG, H. ZIMMER, E. 1975. Experiments on use of PROSIL as an NPN Additive for maize silages. Sec. Ann. Silage Symposium, Ann. Arbor. Michigan 1975 Manuscript of Ruminant Nitrogen Prod. Co. Okomos, Michigan.

## Losses of DM and energy

Material: Maize, 27% DM
Fermentationperiod: 97 days

| Treatments | $CO_2$ production $gCO_2$/100gDM | DM Losses % acc. to $CO_2$ prod. | DM Balance | SE-Losses % |
|---|---|---|---|---|
| Control | 1.60 | 2.0 | 1.8 | 6.3 |
| Urea | 1.74 | 2.2 | 2.3 | 6.1 |
| Prosil | 1.37 | 1.8 | 1.3 | 5.6 |

1) Faktor for nearly absolut anaerobic conditions (98%) = 28% DM Losses per g $CO_2$ prod./100g DM

2) Mean of 8 buried bags. Differences not significant

Fig. 12

## Secondary fermentation losses in maize silages with NPN-additives

(Laborsilos, aerob)

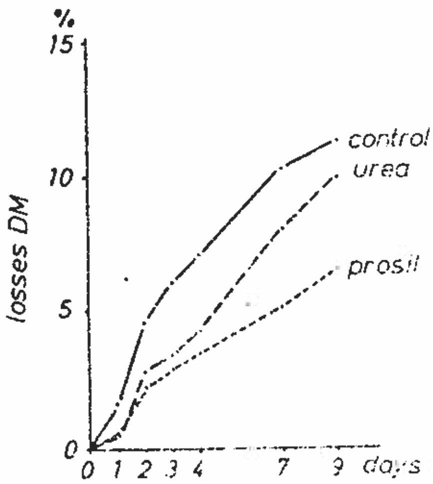



Fig. 13 see also

GROSS, F. et.al 1969, Harnstoff in Maisgärfutter, Das wirtschaftseigene Futter 15, 210 - 227.

FOURTH SILAGE CONFERENCE

THE GRASSLAND RESEARCH INSTITUTE, HURLEY

22 - 23 SEPTEMBER 1976

SESSION NUMBER 1

PAPER NUMBER 2

M K WOOLFORD

# MICROBIOLOGY OF THE AEROBIC DETERIORATION OF SILAGE

The aerobic deterioration of silage is characterized by a rise in temperature and pH and loss of dry matter (DM). Aerobic deterioration is an increasing problem with the use of additives to restrict fermentation, the increasing practice of pre-wilting and the ensilage of crops naturally high in DM such as maize. This deterioration has been attributed solely to the activities of yeasts and other fungi although there is little direct evidence to support this view. Three experiments have been conducted with both maize and grass silages stored in air under controlled conditions in order to establish the relative importance of different groups of micro-organisms to the aerobic deterioration process. To this end the silages were treated with antibiotics which are specifically antimycotic or antibacterial. The influence of micro-organisms of aerial origin and of air entry into the silo during fermentation has also been assessed.

In the first experiment 500 g quantities of maize silage (26% DM) were subjected to the following treatments: antimycotic (pimaricin), antibacterial (chlortetracycline, chloramphenicol, streptomycin B, bacitracin, polymyxin B and rose bengal), combined antimycotic/antibacterial treatment and control. Each quantity of treated silage was stored at a constant temperature (20$^{o}$C) and subjected to a constant flow of bacteriologically filtered air, unfiltered laboratory air or outside air. Temperature changes were recorded at intervals and a monitor of $CO_2$ production was kept. At intervals a unit quantity of silage from each treatment was destructively sampled for microbiological analyses (for lactic acid bacteria, proteolytic bacteria, coliforms, yeasts and fungi), for chemical analyses (water soluble carbohydrates, total nitrogen, volatile fatty acids, lactic acid, ammonia), fresh weight and pH determinations.

In both the second and third experiments direct cut (16% DM) and pre-wilted (48% DM) grass silage was used. The only differences between the two types of silage used in each of these experiments were those which might arise as a result of passing air into the silo during fermentation. The second experiment was conducted with silage made in a sealed silo and the third experiment with "aerated" silage. The material used in both experiments was harvested on the same day and the nominal quantities used and the procedures followed were the same as in the first experiment.

The results strongly suggest that bacteria play a significant role in the aerobic deterioration of both maize and grass silages. It appears that bacteria initiate deterioration and that proteolytic bacteria are the principal organisms involved. The lactic acid bacteria also proliferate in aerobically deteriorating silage but the extent of their growth is not sufficient to suggest a large involvement. Yeasts tend to follow in the wake of bacteria; other fungi, however, appear to have a minor role. No influence on deterioration by micro-organisms of aerial origin was noted as one would have expected higher recoveries of filamentous fungi. The results obtained show that with grass silage air entry into the silo during fermentation lessens the subsequent aerobic stability.

Work is continuing to establish the identity of the micro-organisms involved.

FOURTH SILAGE CONFERENCE, THE GRASSLAND RESEARCH INSTITUTE, HURLEY
Session No 1 paper No 3 (Summary)

Author: M Hastings, Liscombe EHF

ASPECT OF HARVESTING, STORAGE AND UNLOADING IN PRACTICAL SILAGE SYSTEMS.

An experiment over three seasons compared silage from a drum mown swath which was harvested by flail forager or meter chopper. A standard rate of 2.3 litres formic acid per tonne of grass was applied with both harvesters. Silage was stored in 150 tonne bunker silos. The meter chopped silage was consistently of better quality and gave 0.17 kg (yearlings) and 0.10 kg (2 year fatteners) higher daily growth rates than flailed silage.

The results suggested that a chop length x additive rate interaction occurred and that harvesters which gave little chopping or bruising required higher rates of additive than short chopping harvesters.

Over two seasons silage made in 150 tonne bunkers by flail forager, self loading forage wagon, double chop and meter chop harvesters with respective formic acid additive rates of 3.4, 3.4, 2.2 and 1.4 litres/tonne produced very similar silages. Meter chopped and double chopped silages showed slight advantages (+ 1.0%) in crude protein percentage, forage wagon silage was visibly variable and showed higher (+ 1.4%) MAD fibre. Flail forager silage showed higher (+ 0.5%) insoluble ash, attributed to soil contamination from flail pick-up. pH of forage wagon silage was 4.0, 0.2 units higher than silages from the other three machines.

Feeding trials were conducted over a 6 month winter during 2 seasons, to both yearlings on diets of silage alone and 2 year fattening beef animals on diets of silage with 1.8 and 3.2 kg barley. The shorter chopped silages gave slight improvements in gain, carcase weight and averaged £6 greater sale value per beast.

In-silo losses were almost identical with all four machines. Forage wagon silages exhibited slightly greater visible waste. In a general consideration of in-silo losses conventional 150 tonne silos covered with a polythene top sheet showed 80% recovery of edible dry matter, this compared with 88% recovery where thorough wrapping of the silage with polythene was carried out and repeated filling occurred during the season. In a gas tight zipped and evacuable butyl bag 95% recovery was obtained. With the Silopress system recovery of 92% was obtained when the pack was consumed within three weeks. When unloading extended to three months the recovery was only 81%

Studies of in-silo loss were made with observations of the surface weighting of silos and unloading by cutting out $\frac{3}{4}$ tonne blocks of silage.

Surface pressures of 0, 25, 50, 100 and 200 kg/m$^2$ were compared on six silage surfaces which were covered with 75 micron polythene sheet. Average depth of rotted silage was 47 mm, 8 mm, and 8 mm for surface weights of 0, 25 and 50 kg/m$^2$. Depth of visibly poor silage with a pH value above 4.6 was 79mm, 38mm, 33mm and 12mm for surface weights of 0, 25, 50 and 100 kg/m$^2$. With surface weights of 200 kg/m$^2$ good silage occurred to the surface of the polythene sheet.

In unloading studies approximately 2000 tonnes has been unloaded over two seasons with both fore mounted and rear mounted block cutters capable of cutting blocks which are approximately $\frac{3}{4}$m$^3$ and weigh $\frac{3}{4}$ tonne. Cutting time has ranged from 1 to 6 minutes and the blocks have shown no deterioration for three weeks, thus allowing considerable feed flexibility. After one month the blocks had lost approximately 5% by weight but visible spoilage was estimated to be only 2% and this was readily eaten by cattle. During the two years this system of unloading and feeding has been practiced total in-silo losses have averaged 22%. In comparison during the previous three years when using fore-loader and hand unloading systems losses averaged 29%.

In these commercial scale studies an improvement in silage quality and a reduction in in-silo losses was obtained by matching harvester type and additive rate; effective surface weighting and unloading with block cutters.

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FOURTH SILAGE CONFERENCE, THE GRASSLAND RESEARCH INSTITUTE, HURLEY
22nd and 23rd September 1976

Session No 1 Paper No 3

Author: M Hastings, Liscombe EHF.

# ASPECTS OF HARVESTING, STORAGE AND UNLOADING IN PRACTICAL SILAGE SYSTEMS.

I should like to mention some aspects of harvesting, storage and unloading which we have examined in 150 tonne bunker silos.

Several years ago the interest in sophisticated harvesters in the South West Region suggested that we should examine the effect of chop length of herbage upon both silage quality and beef animal performance. An experiment, which covered three seasons, has been reported to the B.S.A.P. Briefly it was a factorial 2 x 2 trial comparing the silage produced when a drum mown swath was harvested by flail forager or meter chopper. A standard rate of 2.3 litres of formic acid per tonne was used.

TABLE 1

SILAGE FROM CONTRASTING MACHINES
2.3 litres formic acid/tonne

| | | Flail forager | Meter chopper |
|---|---|---|---|
| SILAGE | DM% | 20.5 | 21.7 |
| on DM | ( Crude protein | 15.0 | 16.5 |
| | ( MAD fibre | 38.0 | 35.7 |
| | ( Insol ash | 1.4 | 0.9 |
| | pH | 4.6 | 4.0 |
| | DOMD | 66.5 | 69.9 |
| ANIMALS (kg/gain) | Yearlings | 0.49 | 0.66 |
| | Fatteners | 0.92 | 1.02 |

The meter chopped silage was consistently of better quality and gave higher growth rates.

Each year there was a clear indication that the shorter chopped material produced a superior fermentation and that the long material would have required higher rates of additive to achieve a similar degree of preservation. We extended this work to consider the other important harvester types in our Region, the self loading forage wagon and the double chop harvester.

The range in particle size and the degree of bruising both affect the speed of fermentation and additive requirement. The average chop length over two seasons are given in the table.

TABLE 2

RANGE IN PARTICLE SIZE AND BRUISING FROM HARVESTERS
(mean 2 years)

| | % WEIGHT IN EACH FRACTION | | | |
|---|---|---|---|---|
| | Flail forager | Forage wagon | Double chop | Meter chop |
| Short < 40 mm | 2 | 4 | 11 | 54 |
| Medium < 160 mm | 39 | 35 | 64 | 43 |
| Long 160 mm + | 59 | 61 | 25 | 3 |
| Bruising (1 = low, 5 = high) | (2) | (1) | (3) | (2) |
| Likely additive requirement | High | High | Medium | Low |

Flail and forage wagon are similarly long with little bruising, the double chopper is intermediate in length but gives considerable bruising and the meter chopper, under commercial use, chops half the herbage to under 40 mm length.

We set out to match each harvester type with an appropriate amount of additive and so get the best from each machine. This trial is now in its third year and mean results for 2 years are presented.

TABLE 3

ADDITIVE RATES MATCHED TO MACHINES

Formic acid - litres/tonne grass

| Flail forager | Forage wagon | Double chop | Meter chop |
|---|---|---|---|
| 3.4 | 3.4 | 2.2 | 1.4 |

The flail and forage wagon were given 3.4 litres of acid/tonne, the double chop 2.2 litres and the meter chop 1.4 litres/tonne.

Additive was applied in the chopping chamber of the harvesters and via two polyjets over the pick up table of the 12 knife forage wagon.

TABLE 4

MEAN SILAGE ANALYSIS 2 YEARS

| | | Variations from the mean |
|---|---|---|
| DM % | 24 | |
| Crude protein | 14 | (+ 1.0 for meter chopped) |
| MAD fibre | 30 | (+ 1.4 for forage wagon) |
| Insol ash | 0.9 | (+ 0.5 for flail) |
| pH | 3.8 | (+ 0.2 for forage wagon) |
| DOMD | 70 | |

All the silages produced each year appeared very similar. The dry matter percentage was 24. Crude protein was 14, but 1% higher with meter chopping. MAD fibre was 30, but 31.5% for forage wagon and insoluble ash was 0.9% but 0.5% higher with the flail, due to soil contamination. All silages showed a pH of 3.8 except the forage wagon which was pH 4.0

The similarity of the silages was confirmed when manger fed to yearlings as their sole feed and to 2 year fatteners in diets with 1.8 to 3.2 kg barley.

TABLE 5

MEAN ANIMAL PERFORMANCE kg/day

| | | Flail forager | Forage wagon | Double chop | Meter chop |
|---|---|---|---|---|---|
| Yearlings | (gain) | 0.33 | 0.37 | 0.37 | 0.38 |
| Fatteners | (gain) | 0.80 | 0.83 | 0.86 | 0.90 |
| | (carcase weight) | 252 | 252 | 256 | 255 |
| | (sale value £) | + 1.3 | 0 | + 8.8 | + 5.4 |

Each year the shorter chopped material, double chop and meter chop, produced slight improvements in the cattle in terms of gain, carcase weight and sale value.

The carcase weights showed slight improvements due to shorter chopping and this was also reflected in improved sale value for the double chop and meter chop fed animals. It can be concluded that improvements in feeding value due to chopping can be nearly matched by increased additive rates on long material.

With all four machines very similar <u>in-silo losses</u> were observed, but the forage wagon showed slightly greater visibly rotted waste.

In general terms a consideration of losses in ensilage with a wide variety of harvesters over the last two years (at 24-30% DM) shows the relative importance of good sealing and consolidation and the magnitude of unloading losses.

TABLE 6

% LOSSES IN ENSILAGE

| | % Edible silage | % Rotted waste |
|---|---|---|
| Conventional 150 tonne bunkers with top sheet | 80 | 2 |
| Thoroughly wrapped in polythene and repeated filling | 88 | 2 |
| Gas tight butyl zip bag | 95 | - |
| Silopress quick use - 3 weeks | 92 | - |
| slow use - 3 months | 81 | 5 |

The various silages from the four harvesting machines put in conventional bunkers with a weighted top sheet gave 80% recovery.

Thorough wrapping in polythene and repeated filling through the season improved recovery to 88%. This was further improved to 95% in a gas tight zipped butyl bag.

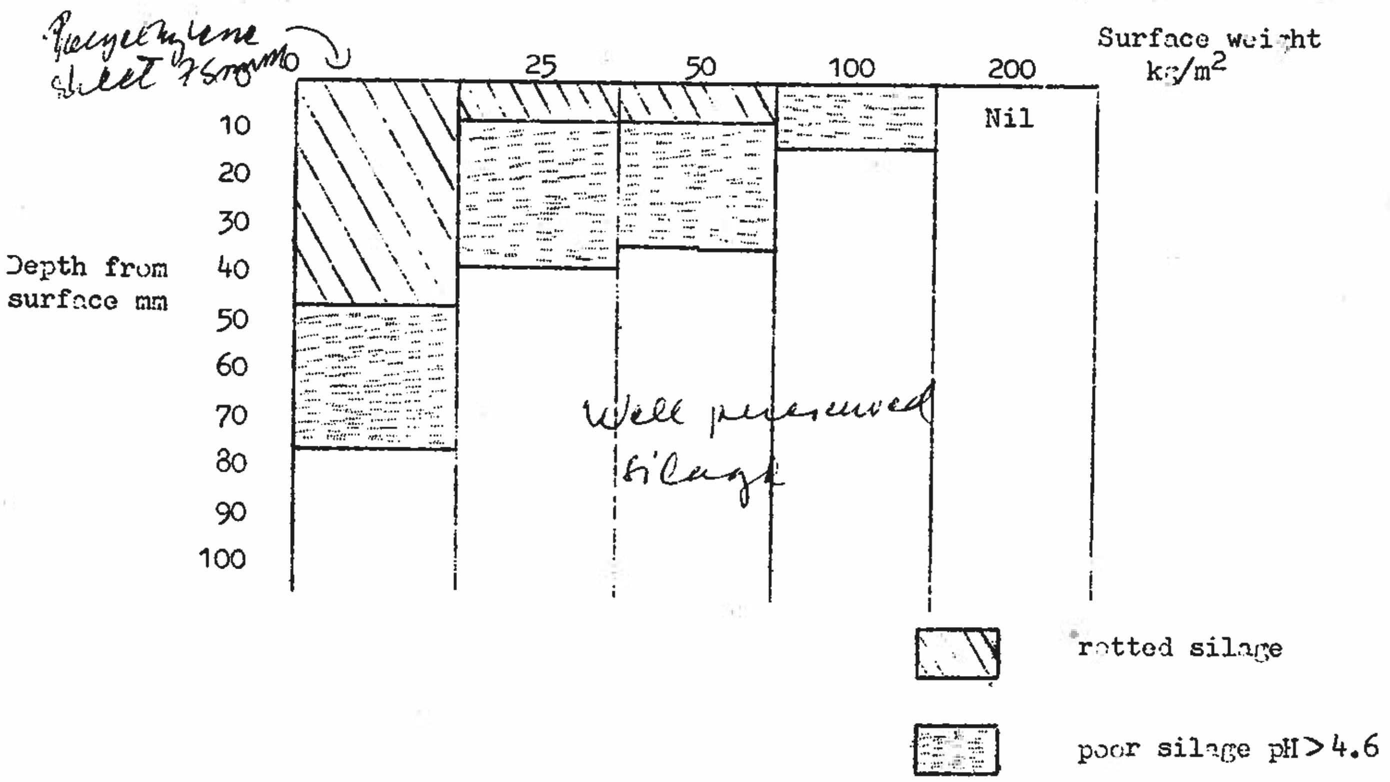
In comparison the Silopress system which relies on compression rather than a gas tight seal, gave 92% recovery when the 80 tonnes were used over a period of three weeks. If emptying was delayed then recovery dropped to only 81% with excessive rotted waste.

Two observations have investigated these silo losses. The first has compared surface pressures on silo covers, for farmers have repeatedly asked for information on the minimum weight of material they can use to hold down silo covers with no visible waste occurring.

A range of surface weights from nil to 200 kg/m$^2$ have been observed on six silages of 22 - 24% DM which were covered with 75 micron polythene sheet.

TABLE 7

MEAN REDUCTION IN WASTE WITH SURFACE PRESSURE (6 silages)



Surface weights of 25 to 50 kg/m$^2$ reduced rotted silage to less than 10 mm, but 100 kg/m$^2$ was generally needed to prevent any visible rotted silage occurring. Two materials frequently used in practice are used car tyres which exert 25 kg/m$^2$ and a layer of straw bales which generally average 50 kg/m$^2$. Of course surface wastes can also be reduced by using thicker (250 micron) polythene. On its own this exerts only 0.25 kg/m$^2$ but frequently prevents any visible surface spoilage. These observations are continuing with comparisons of surface weight and sheet thickness.

More insidious is the spoilage and loss occurring during the long winter unloading operation on commercial farms.

TABLE 8

UNLOADING AND FEEDING WITH BLOCK CUTTERS

| | | |
|---|---|---|
| Cutting time | 1-6 minutes | |
| Block size | $\frac{3}{4}$ m$^3$, $\frac{3}{4}$ tonne | |
| Silage density | 800-1000 kg/m$^3$ | |
| Block life | 3-4 weeks | |
| In-silo losses | - with block cutters | 22% (silage 24% DM) |
| | with foreloading and hand loading | 29% (silage 20% DM) |

Use of block cutters, both front and rear mounted has shown further interesting light on unloading losses. The cutters remove blocks of approximately $\frac{3}{4}$ m$^3$ from silos 2.5 m height, the density of the silage has ranged from 800 kg/m$^3$ in the top metre to 1000 kg/m$^3$ in the bottom metre of the silo. The blocks have shown no deterioration after being cut out for three weeks and this allows considerable feed flexibility. After one month 5% loss in weight had occurred, the visible waste was estimated to be only 2% and even this material was still eaten. Perhaps most significant is that during the two years we have used a block cutter and pallet feeding system total in-silo losses have averaged 22% (with 24% DM silage). In comparison the previous three years when using both foreloader and hand unloading systems losses averaged 29% (with 20% DM silage). Obviously some improvement in silage recovery was due to rather drier silage, but some credit is also due to the smooth dense silage face left by block cutting machines.

In these commercial scale studies there is clear indication that, matching harvester type and additive rates, effective sealing and efficient unloading are all important in ensuring that a greater proportion of what we harvest is available to feed and that the silage we produce is of high quality.

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SESSION 2 PAPER 4

# THE ENERGY VALUE TO SHEEP OF THREE ABERDEENSHIRE SILAGES

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There have been few calorimetric measurements of the net energy value of grass silages produced in the United Kingdom. In conjunction with the work of the Feed Evaluation Unit on the metabolizability of silages, the net energy values of three grass silages have been determined. Two of these silages were prepared from 1st harvest grass and the other from third harvest grass; all three were wilted to some degree, while two of them were treated with additive on ensiling.

The *ad libitum* D.M. intakes of sheep fed the three silages ranged from 1.5 to 1.8 times maintenance requirement.

The mean daily energy balances of the sheep at the high level of intake for the three silages are shown below. All data have been reduced to metabolic body size ($W^{0.75}$).

HIGH LEVEL OF FEEDING

| | | | |
|---|---|---|---|
| Silage | 1 | 2 | 3 |
| Harvest | 1st | 1st | 3rd |
| D.M. Intake (x maintenance)/day | 1.60 | 1.56 | 1.39 |
| M.E. Intake (kJ)/day | 604.9 | 549.4 | 538.6 |
| Metabolizability (Q) | 0.57 | 0.63 | 0.56 |
| Retention (kJ)/day | +107.4 | +117.8 | +47.7 |
| Efficiency of utilization of M.E. above maintenance (kf) | 0.49 | 0.54 | 0.31 |
| Net energy (above maintenance) (kJ/gm D.M.) | 5.29 | 7.10 | 3.51 |

The decline in the ratio N.E. : M.E. previously observed between 1st and 3rd harvest artificially dried grasses would also appear to apply to this silage comparison.

The A.R.C. (1965) and Blaxter (1973) equations predict efficiencies of utilization of M.E. and thus net energy with the following results:

| SILAGE | HARVEST | METABOLIZABILITY (EXPERIMENTAL) | NET ENERGY ABOVE MAINTENANCE (kJ/gm D.M.) | | |
|---|---|---|---|---|---|
| | | | ARC (1965) | BLAXTER (1973) | ACTUAL |
| 1 | 1st | 0.57 | 5.51(+4%) | 5.22(-1%) | 5.29 |
| 2 | 1st | 0.62 | 6.40(-10%) | 6.52(-8%) | 7.10 |
| 3 | 3rd | 0.56 | 5.21(+48%) | 4.35(+23%) | 3.51 |

(% age difference from actual values in brackets)

The efforts of the Feed Evaluation Unit are directed towards improving the prediction of metabolizable energy from chemical composition, and it is plain that the prediction of net energy values from M.E. can also be improved, however, as both the A.R.C. (1965) and Blaxter (1973) equations were computed from data on classes of feeds which did not include silages the predicted net energy values, particularly those from Blaxter (1973) are close to experimental values.

## REFERENCES

Agricultural Research Council (1965): The Nutrient Requirement of Farm Livestock. No. 2 Ruminants. H.M.S.O. London.

Blaxter, K. L. (1974). Nutrition Conference for Feed Manufacturers, 7. University of Nottingham.

FOURTH SILAGE CONFERENCE

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SESSION 2 PAPER 5

# 'SOME ASPECTS OF THE ENERGY UTILISATION OF HIGH QUALITY SILAGES'

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As part of an overall assessment of the nutritive value of high quality silage, the technique of closed circuit respiration calorimetry was used to determine the efficiency of utilisation of diets of silage and silage plus barley.

The silages studied were prepared either in the spring (1 silage) or in the autumn (2 silages) from a predominantly ryegrass sward (Lolium perenne) and ensiled either in a 250 t capacity concrete bunker or in 3 t capacity polythene bag silos. Formic acid was applied to all silages at the rate of 2.3 $l.t^{-1}$.

All silages were well preserved with low concentrations of volatile-N (5 to 10% of total N), a low pH (3.7 to 4.2) and a lactic acid content ranging from 4 to 12% of the dry matter. Their digestible organic matter contents ranged from 65 to 72% of the dry matter.

The utilisation of each silage was studied in wether sheep at levels of feeding designed to provide sufficient energy for maintenance and for about 1.4 x Maintenance. For the spring silage and the later cut autumn silage the effect of supplementation with barley at the lower level of feeding was also investigated.

Details of the gross energy (GE) of the silages, of the proportions of this energy lost in faeces, urine and methane, and available as ME are given in Table 1.

TABLE 1. The gross energy content (MJ/kg dry matter), the percentage of gross energy lost in faeces, in urine and as methane, and available as ME and the ratio of $ME/_{DE}$ in three silages given at two levels of feeding.

| SILAGE | SPRING | | EARLY AUTUMN | | LATE AUTUMN | |
|---|---|---|---|---|---|---|
| Level of feeding | L | H SED | L | H SED | L | H SED |
| Gross Energy | 18.73 | | 18.83 | | 19.15 | |
| Losses in: | | | | | | |
| Faeces | 30.8 | 33.0±1.3 | 22.1 | 25.4±0.6 | 32.6 | 31.5±0.6 |
| Urine | 5.4 | 3.3±0.5 | 4.5 | 4.5±0.4 | 4.1 | 3.6±0.2 |
| Methane | 6.0 | 5.8±0.3 | 6.8 | 6.4±0.1 | 7.4 | 7.1±0.1 |
| Metabolisable Energy | 57.8 | 57.7±1.4 | 66.6 | 63.6±0.7 | 56.0 | 57.8±0.8 |
| $ME/_{DE}$ (%) | 83.6 | 86.2±0.8 | 85.5 | 85.3±0.6 | 83.1 | 84.4±0.5 |

The efficiency of utilisation of ME for maintenance ($k_m$) was 68% for the spring silage and 73 and 72% for the autumn silages, values in good agreement with those predicted from the ratio of $ME/_{GE}$ in the diet (ARC, 1965). Similar agreement was also obtained with the efficiency of utilisation of ME above maintenance ($k_f$) with the autumn silages. The efficiency was estimated as 57% for the first cut and 62% for the later cut material but in contrast to these efficiencies the $k_f$ for the spring silage was exceptionally low, 23%.

This low efficiency has yet to be explained but it is linked in some way with the ingestion of high levels of the spring silage since, when the lower level of silage was supplemented with barley, the $k_f$ of the barley calculated by difference was 65%. The most marked difference in the composition of the silages is in the lactic acid concentrations. The spring silage contained 11.6% lactic acid while the autumn silages each contained 4%. Furthermore, L(+) lactic acid accounted for 71% of the total lactic acid in the autumn silage but only 58% in the spring silage. This means that the animals receiving the high level of the spring silage were ingesting about 52 g D(-) lactic acid/d. The presence of D(-) lactic acid in the blood has been noted in animals which have become engorged with grain and it is known that this acid is only slowly metabolised by the tissues, the majority being excreted in the urine (Dunlop and Hammond, 1965; McKenzie, 1967).

At present, experiments are in progress to investigate the extent of D(-) lactic acid absorption in animals receiving silage diets and to determine the effect of dietary lactic acid on intermediary metabolism.

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

Dunlop, R.H. and Hammond, P.B. (1965). Ann. N.Y. Acad. Sci. 119, 1109-1132.

MacKenzie, D.D.S. (1967) J. Dairy Sci. 50, 1772.

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Fourth Silage Conference
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Boekholt, H.A.[1], Y. van der Honing[2] and A.J.H. van Es[1,2]

# Results of some energy balance trials with dairy cows fed rations containing maize silage

## Introduction

The nutritive value of a feed for a certain combination of maintenance and production depends on its content of metabolizable energy ($M_E$) and the efficiency or the utilization of this $M_E$ for maintenance ($k_m$) and production ($k_l$ for lactation).

We carried out 27 energy balance trials with lactating cattle producing 13 to 27 kg milk and consuming 2.6 kg, 1.7 kg or no hay, 6 to 10 kg maize silage dry matter and 1 to 6 kg concentrates. It should be mentioned that most figures of the experiments relate to rations and not to maize silage only.

## The $M_E$ content of maize silage

The gross energy of the silage used was on average 4.43 Mcal per kg dry matter (DM) or 4.67 Mcal per kg organic matter (OM). This compares very well with the figure of 4.34 Mcal per kg DM of Leahay et al. (1973) and with the figure of 4.65 Mcal per kg OM of Demarquilly and Andrieu (1975) for green maize. Moe and Tyrrell (1972) found a slightly higher figure in silage: 4.66 Mcal per kg DM. The conversion of gross energy to $M_E$ is influenced by three main factors: 1. stage of growth of the maize; 2. animal species (cattle or sheep); 3. level of feeding. With advancing stage of growth the change in digestibility is only small as the decreasing digestibility of stems and leaves is compensated for by the increase in grain content of high digestibility. Cattle chew maize grains less well than sheep, resulting in a greater amount of grains in the duodenum. The higher feeding level in cows and the lower digestibility of grains and grainparticles can result in differences of up to 5 units in OM digestibility between high yielding cows and sheep.

The $M_E$ content of feedstuffs is predicted from its content of digestible organic matter ($D_O$) for sheep fed at or slightly above maintenance feeding level. In the case of protein poor roughages the prediction equation used is:

$$M_E \text{ (kcal/kg)} = 3.6\ D_O \text{ (g/kg)}.$$

There is some indication that for corn silage a value of 3.7 $D_O$ may be better. However, at this moment we have not enough data from experiments with sheep and cows to provide evidence for this value. In the cow trials (with a lower $D_O$) the average $M_E/D_O$ was 3.96.

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In table 1 some results of our trials are compared with data from the literature.

Table 1:

| reference | $d_E$ % | $U_E$ % of $I_E$ | $G_E$ % of $I_E$ | $M_E$ % of $I_E$ | $M_E$ % of $D_E$ | milk kg | ration |
|---|---|---|---|---|---|---|---|
| Wageningen | 68.2 | 3.2 | 6.5 | 58.6 | 85.9 | 20 | (hay +) silage + conc. |
| (5) | 66.5 | 2.8 | 6.4 | 56.9 | 86.1 | 22 | 70% silage + conc. |
| | 67.2 | 2.4 | 5.1 | 59.5 | 88.9 | 19 | 40% silage + conc. |
| (4) | 68.4 | 3.6 | 7.2 | 57.3 | 83.9 | 8 | 60% silage + conc. (16% XP) |
| | 63.0 | 2.3 | 6.5 | 53.9 | 85.8 | 11 | + conc. (11% XP) |
| (3) | 68.7 | 3.6 | 6.7 | 57.9 | 84.3 | 0 | 100% urea-treated silage |
| (1) | 66.8 | | | 55.1 | 82.5 | 0 | 85% silage + conc. |

E = energy, d = digestibility, U = urinary, G = methane, M = metabolizable, I = intake, XP = crude protein.

## The utilization of $M_E$ in rations with silage

There is a limited amount of information on the utilization of the $M_E$ for maintenance and production. The 27 Dutch trials gave efficiencies for milk of 53-66% with an average of 60%.

Table 2: $N_E = k \cdot M_E - N_{E,m} = k(M_E - M_{E,m})$

| reference | efficiency of utilization of $M_E$ k | calculated maintenance requirement in kcal/kg$^{\frac{3}{4}}$ $N_{E,m}$ | $M_{E,m}$ |
|---|---|---|---|
| Wageningen | 0.60 | 70 | 117 |
| (5) | 0.61 | 68 | 111 |
| | 0.54 | 51 | 95 |
| (4) | 0.59 | 65 | 110 |
| | 0.60 | 67 | 112 |
| (3) | 0.80 | 98 | 122 |
| (1) | 0.60 | 90 | 150 |

$N_{E,m}$ = net energy for maintenance

From table 2 it can be seen that the improbably high figure of 80% for growth, found by Leahey et al. (1973), is coupled with a high maintenance requirement and that the low figure (54%) of Tyrrell and Moe (1972) is coupled with a low maintenance requirement. Most figures of table 2 suggest an efficiency of 60% with a maintenance of 70 kcal $N_E$/kg$^{\frac{3}{4}}$. This agrees well with the formula that was calculated from more than 1000 balance trials with lactating cows fed different rations: $R_E^* + L_E^* = (0.60 + 0.0024\ (q-57))\ M_E^* - 70$ $\quad * = /\text{kg}^{\frac{3}{4}}$

or the more simple formula: $R_E^* + L_E^* = 0.60\ M_E^* - 70$ $\quad q = M_E/I_E$ ; R=retention L=milk

A comparison of the results from the 27 Dutch balance trials with the first formula shows differences from -24 to +17 kcal/kg$^{\frac{3}{4}}$ at an average $M_E$ intake of 327 kcal/kg$^{\frac{3}{4}}$. There are no reasons to assume that the utilization of the $M_E$ in rations with maize silage is different from that of other rations.

References: 1. Burlacu Gh., 1975. Private communication.
2. Demarquilly, D. and J. Andrieu, 1975. Private communication.
3. Leahey, J.M., J.B. Holter and W.E. Urban, 1973. J. Dairy Sci. 56: /587-591
4. Moe, P.W. and H.F. Tyrrell, 1972. J.Dairy.Sci.55:318-324
5. Tyrrell, H.F. and P.W. Moe, 1972. J.Dairy.Sci.55:1106-1111

Fourth Silage Conference

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Session Number 2

Paper Number 7

W.P. Barber[1], G. Alderman[2], and Mrs J.F.B. Altman[3]

## Predicting the metabolisable energy content of silages

Two preliminary reports have already been presented. The first dealing with the results of 21 silages was given at the 1969 Winter meeting of the British Grassland Society in London, and was published in 1970. The second concerning 45 silages was given at the Edinburgh Silage Conference held September 1974.

The present paper must be again considered as a preliminary report on 51 silages, the main characteristics of which are summarised below.

| Nature of crop | No. of samples | Species present | No. of samples |
|---|---|---|---|
| Temporary grass or mixtures | 29 | Mainly perennial ryegrass | 33 |
| Permanent pasture | 22 | Mainly timothy/meadow fescue | 10 |
| | | Complex mixtures | 5 |
| | | Inferior indigenous species | 3 |

### Method of ensiling and additive used

| Additive | Tower | Clamp good seal | Clamp moderate seal |
|---|---|---|---|
| None | 3 | 17 | 16 |
| Formic acid type | - | 5 | 6 |
| Formalin type | - | - | 4 |

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3. Statistics Department, Rothamsted Experimental Station.

Before considering the correlations and regression equations, it is important to appreciate the variations and ranges of chemical composition and energy values in the population of silages used. The use of any regression cannot be justifiably extended beyond these ranges. Details are given in the following table.

Chemical composition and energy value of 51 grass silages (oven dry matter basis)

| | Mean | Range |
|---|---|---|
| % Oven dry matter (DM) | 24.1 | 15.6 - 44.0 |
| pH | 4.3 | 3.8 - 5.2 |
| % Crude protein (CP) | 16.9 | 10.9 - 25.9 |
| % Crude fibre (CF) | 29.5 | 22.5 - 35.8 |
| % Total ash (TA) | 9.9 | 6.4 - 14.6 |
| % DOMD, in vitro (IVD) | 62.3 | 47.9 - 69.1 |
| % Modified acid detergent fibre (MADF) | 33.2 | 23.8 - 40.8 |
| % DOMD, in vivo (DOMD) | 64.3 | 51.5 - 71.9 |
| Energy value MJ/kg (EV) | 19.8 | 18.1 - 21.9 |
| Digestible energy MJ/kg (DE) | 13.7 | 11.3 - 16.3 |
| Metabolisable energy MJ/kg (ME) | 11.1 | 9.2 - 13.2 |

Metabolisable energy values were calculated from the digestible energy values as proposed by Armstrong (1964). ME = 0.81 x DE

Correlation coefficients were calculated between the values obtained for each chemical constituent and the metabolisable energy content. Where relatively high correlations were obtained simple linear regression equations were calculated. Further multiple regressions were calculated for groups of constituents.

There was little to choose between the single variables, and none were highly significant. Of the multiple regressions the most useful was:-

ME = 2.16 + 0.186 IVD + 0.128 CP - 0.027 DM (Accountable Variance 53.2%)

Not all laboratories are equipped however to deal with the In vitro DOMD determination. The most useful equation for this situation was:-

ME = 14.61 + 0.075 CP - 0.123 MADF - 0.030 DM (Accountable Variance 38.2%)

The data was subdivided into classes to see if improved relationships could be found. The first subdivision into treated and untreated silages resulted in significant changes in the importance of certain variables in each class. Most notable was the increase in the importance of the In vitro DOMD and the MADF values for untreated silages at the expense of their importance for treated silages.

The data on the untreated silages was also subdivided into first cuts and re-growths. This resulted in a further increase in the significance of the In vitro DOMD and the MADF values for the first cut silages at the expense of the regrowth materials. The most useful equations for the 19 first cut untreated silages were:-

ME = 2.04 + 0.137 IVD + 0.123 CP - 0.052 DM (Accountable Variance 64.8%)

ME = 18.89 + 0.0453 CP - 0.203 MADF - 0.060 DM (Accountable Variance 53.9%)

An alternative approach to the analysis of the data has been to try to predict the digestibility coefficient of the energy value. The most promising simple regressions obtained so far are:-

Y = 0.995 - 0.00916 MADF (Accountable Variance 41.0%)

Y = 0.128 + 0.0081 In vitro OMD (Accountable Variance 69.5%)

where Y represents the digestibility coefficient of the energy value.

REFERENCES

Alderman G, Collins F C and Dougall H W, (1970) J. Brit. Grass Soc., 26, 109.
Armstrong D G, (1964) J. Agric. Sci., 62, 399.

## APPENDIX

### CORRELATION OF DE/ME WITH VARIOUS PARAMETERS, VALUES FOR 'r'

| | n | DM | IVD | CP | EE | MADF | T. Ash |
|---|---|---|---|---|---|---|---|
| All silages | 51 | -.221 | .470 | .490 | .464 | -.494 | .441 |
| Untreated | 36 | -.144 | .530 | .487 | .397 | -.566 | .487 |
| Formics + Formalins | 15 | -.662 | .239 | .525 | .725 | -.217 | .300 |
| Formics only | 11 | -.635 | .249 | .525 | .816 | -.204 | .406 |
| Untreated 1st cuts | 19 | -.278 | .577 | .499 | .520 | -.629 | .494 |
| Untreated regrowths | 16 | -.024 | .459 | .585 | .407 | -.474 | .497 |

### SELECTED REGRESSIONS

| All silages | Accountable Variance % |
|---|---|
| ME = 0.0971 IVD + 5.036 | 20.5 |
| ME = 0.125 CP + 8.94 | 22.5 |
| ME = 0.494 EE + 9.154 | 20.0 |
| ME = 15.52 - 0.1334 MADF | 22.8 |
| ME = 14.61 + 0.0754 CP - 0.123 MADF - 0.0302 DM | 38.2 |
| ME = 0.1864 IVD + 0.1279 CP + 2.1576 - 0.0268 DM | 53.2 |

Untreated silages

| | |
|---|---|
| ME = 0.119 IVD + 3.69 | 26.0 |
| ME = 16.71 - 0.1675 MADF | 30.0 |
| ME = 17.09 + 0.0461 CP - 0.172 MADF - 0.0394 DM | 39.8 |
| ME = 0.750 + 0.141 IVD + 0.138 CP - 0.0300 DM | 56.7 |

Untreated first cut silages

| | |
|---|---|
| ME = 0.120 IVD + 3.58 | 29.3 |
| ME = 17.60 - 0.193 MADF | 36.0 |
| ME = 18.89 + 0.0453 CP - 0.203 MADF - 0.0600 DM | 53.9 |
| ME = 2.04 + 0.137 IVD + 0.123 CP - 0.052 DM | 64.8 |

FOURTH SILAGE CONFERENCE

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# EFFECT OF ENZYMES ON THE FERMENTATION OF LUCERNE

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Cellulolytic enzymes have been used experimentally to increase the digestibility of forages by breaking down some of the structural carbohydrates. As this process liberates simple carbohydrates it was considered that enzyme preparations might be applied to silage making particularly with crops such as lucerne which are naturally low in fermentable carbohydrate and therefore difficult to ensile without an additive. Preliminary experiments have therefore been undertaken in test-tube silos to assess the potential of some commercially available enzymes.

In the first experiment lucerne of 18.9% dry matter was ensiled without an additive and after the addition of cellulase and hemicellulase at 0.25% of the fresh crop weight. The silos were opened after 100 days. The untreated material was poorly preserved with a pH of 5.9, containing a negligible amount of lactic acid, over 5% of the dry matter as butyric acid and 0.75% of the dry matter as ammonia-N, indicating considerable clostridial activity. The hemicellulase treated silage had a pH of 4.85 and contained 2.7% of lactic acid and 0.5% of ammonia-N. There was complete absence of butyric acid. The cellulase preparation gave a further improvement in quality, reducing the pH to 4.56 and increasing the lactic acid content to 4.3%.

In the second experiment the levels of enzyme were reduced and an additional cellulase preparation derived from *Trichoderma viride* was also employed. The rates of application in each case were 0.05, 0.10, 0.15 and 0.2% of the fresh crop weight. Lucerne of 17% dry matter was again ensiled in test-tube silos. The control silage on this occasion was surprisingly well preserved having a pH value of 4.65 and containing over 10% of lactic acid. Hemicellulase at the lowest level of application gave rise to a silage of similar composition. With increase in application rate there was a steady fall in pH to 4.24 with increase in lactic acid to over 16%. The original cellulase preparation at the lowest application rate produced a silage with pH of 4.2 with lactic acid content of 15%. By the highest rate of application the pH had fallen to 4.02 and lactic acid had risen to almost 20% of the dry matter. With the *Trichoderma viride* cellulase the pH at the lowest application rate was 4.05 and the lactic acid content almost 20%. At the higher rate the pH was 3.90 but the lactic acid content had fallen to almost 17%. All treated silages had an ammonia-N content of around 0.5% of the dry matter, similar to that of the untreated silage.

In view of these promising results a third experiment was set up in 1976 to study the effects of the enzymes when applied at lower rates than in the second experiment. It is anticipated that preliminary results of this experiment will be presented at the conference.

Fourth Silage Conference

The Grassland Research Institute, Hurley

22. and 23 September 1976

Session 3,

Paper 9.

H.H. Theune: Experiments using cellulolytic and delignifying agents.

1. Introduction:

Experiments were startet, to extend the optimum time for cutting by eliminating the negative effect of overproportional increase of cellwalls and lignin incrustation and the decrease of soluble carbohydrate content during the generative phase, to be accomplished by use of disintegrating additives for the fermentation process.

Two different ways were taken:

- hydrolysation of the cellwalls - cellulose and hemicellulose - through technical cellulase
- dissolution and soaking of the cellwalls and lignin by chemical oxidative reactions caused by technical Na $ClO_2$.

Both treatments should cause a better suitability for fermentation and a better digestibility especially for older plant material by the effect of increased cellwall decomposition and in consequence better availability of soluble carbohydrates.

2. Experiments and methods

Fig. 1 shows the experimental design and the way of evaluation. To allow an exact comparison, the analytic data were converted by multiple linear or square regressions to the values for DM content and doses on the base of DM given in fig. 1. This first report can only give tendencies as the statistical evaluation has not been finished yet.

## 3. Results - Specific influences of dose, prewilting and growth stage on losses and selected plant constituents.

### 3.1. Influence on organic and digestible organic matter losses.

#### 3.1.1. Cellulase treatment.

With increasing dose of cellulase OM-losses decreased for direct-cut silage from 18.0 to 6.5 % and reached the niveau of prewilted material. In prewilted material cellulases did not show any effect.

The influence of dose and growth stage is presented as an example by the data for direct-cut silage. For prewilted silage we found here basicly the same tendencies, but at a lover level.

In the first growth stage cellulase treatment resulted in an increase of OM-losses. For the third growth stage showed the highest influence of an increased dose with a reduction of OM-losses from 18.5 to 6.0 %.

The losses for DOM for direct-cut silage in the first experiment decreased parallelly to the OM losses. The increase of DOM-losses in the case of both prewilting stages and the high doses was caused by an in vitro DOM reduction of 1.3 and 2.0 units compared to controls.

The rather small increase for the DOM-losses in the first and second growth stage is caused by the insignificant reduction of the in vitro DOM by 2.0 and 3.0 units. For the third growth stage this DOM reduction is overcompensated by the decrease of OM-losses.

1974 as well as 1975 the in vitro DOM values showed an insignificant downward tendency with increasing cellulase doses. The reason for this seems to be the overproportional reduction of the cellwall digestibility.

#### 3.1.2. $NaClO_2$ treatment

After $NaClO_2$ treatment was of no influence for direct-cut silage in any dose. With prewilting the losses grew, because the oxidative effect increased here according to the concentration. DOM-losses showed an opposite tendency as the OM-losses. This can be explained by the fact, that the in vitro DOM values increased in the sequence of the DM stages by max. 8.5, 10.5 and 11.4 units compared to the controls.

As by the $NaClO_2$ effect the in vitro DOM increased in the sequence of the growth stage by max. 7.0, 10.0 and 15.0 units, DOM-losses were reduced to mean values of 14.0 or 2.0 %. $NaClO_2$ produced the best effect in connection with the oldest material.

## 3.2. Reduction of the cellwall elements.

### 3.2.1. Cellulase treatment

The changes of the cellwall constituents have been balanced. They were expressed in % of ensiled OM.

In the first and second growth stage no measurable quantities of cellulose were hydrolised up to the dose of 1.25 % cellulase. Whereas for the control of the third growth stage a decomposition of 2.5 % was found. With ascending doses 6.0 or 4.0 % of cellulose were hydrolised in the first and second growth stage. For the third stage no changes were observed.

Three conclusions can be drawn from there results:

- cellulase activity of the plants incresed with advanced age,
- as a consequence of advanced growth stage the polymerisation grade of cellulose and the lignification were increased. So possibly an ascending resistence against cellulases added from outside could be brought about, or
- the activities of the type of cellulase used are not strong enough for the degradation of the older plant material.

### 3.2.2. $NaClO_2$ treatment

Whereas by the ensiling process by itself up to 0.6 % lignin were lost, with ascending $NaClO_2$ doses this value increased to 1.3 % and for cellulose to 3.0 % independent of the prewilting.

The lignin reduction reached its maximum rate of 2.0 % in the third growth stage. For cellulose the decomposition rate grew in relationship to the dose and advancing growth stage from 3.0 to 6.0 %.

## 3.3. Silage quality

### 3.3.1. Cellulase treatment

The known effect of prewilting on acid production is confirmed. In relation to cellulase doses the greatest effect was found for direct-cut silage. Lactic acid production increased markedly, acetic acid to a smaller extent, whereas butyric acid formation was strongly decreased. Prewilted silage was practically not influenced.

In the first growth stage the fermentation pattern was positively influenced by an increasing cellulase dose. Lactic and acetic acid content increased and butyric acid content decreased. The high level of losses points at a possible luxury consumption of soluble carbohydrates, get free by cellulase activity.

In second growth stage cellulase adivity effected the acid formation to a smaller extent. The reason for this may be found in the comparatively favourite fermentation conditions at the beginning.However, the decreasing tendency of OM-losses points at an optimum influence of the cellulase.

For the third growth stage we found a high, but only slightly differentiated level of acid formation. Lactic acid contents were high, acetic values were relatively low and butyric acid was only found in traces. Also the constant pH level of 4.0 showed that the fermantation took place under optimum conditions for all doses. However cellulase did not produce an additional effect with ascending doses for the cellwall reduction. Nevertheless the OM-losses decreased from 18.5 to 6.5 %.

This specific effect can only be explained by the fact.

- that a substance group, which has not been analysed yet - as soluble or non structured carbohydrates - are protected from decomposition and are fermented very economically or
- that our analytic methods are not differentiated enough to determine the relatively small differencesin these result.

Reduction of protein was not significantly influenced by the cellulase treatment.

3.3.2. $NaClO_2$ treatment

The effect of the $NaClO_2$ treatment and its increased doses resulted in a massive disturbance of the microbial flora and acted in the direction of non fermented conservation. Ethanol, volatile acids and lactic acid decreased highly significant in all prewilting and growth stages, whereas pH values in consequence of Na-application increase.

The protein reduction was high, caused by the high oxidation effect of the $NaClO_2$. For highest dose the relative crude protein losses amounted to 14.0 % in the mean for the prewilting stages and to 15.0, 25.0 or 36.0 % respectively in the sequence of the growth stages.

The positve effect of $NaClO_2$ is to be found neither in the minimizing of the OM-losses nor in the optimizing of the fermentation process, but in the disintegration of the cell-walls and thus in the improvement of the digestibility. How far this will honoured by the animal can only be evaluated by in vivo experiments.

Fig.1

## Experiments and evaluations

| experiment | material | harvest, cut and growth stage | DM content exper. % | DM content evalu. % | additives | doses exper. % FM | doses evalu. % DM | parameters of quality |
|---|---|---|---|---|---|---|---|---|
| 1974 | grass | 6. harvest | 28 | 20 | | | | **Losses:** |
| | chop ~ | cut october | | | cellulase [illegible] | 0,0 | 0,0 | OM |
| | 2,0cm | equal to (2. growth | 44 | 40 | (Röhm) | 0,25 | 1,25 | DOM |
| | | stage 1975) | 53 | 50 | pH-optim. 4-5 | 0,50 | 2,50 | (Tilley a. Terry) |
| | | | | | Temp.optim. 40°C | 1,00 | 5,00 | cellwall reduction |
| | | | | | | | | Lignin |
| | | | | | | | | cellulose |
| 1975 | grass | 1. harvest | | | Sodium chlorite | 1,0 | 2,50 | (van Soest-scheme) |
| | chop | cut after | | | (techn.) | 3,0 | 5,00 | quality of silage: |
| | 2,0cm | 52 veg.days: shoot. | 18 | | ($NaClO_2$) | 5,0 | 15,00 | volume - DM |
| | | 66 " " : head. | 15 | 20 | | | | ph |
| | | 86 " " : flower. | 22 | | | | | $NH_3$-N i. tot.-N |
| | | | | | | | | ethanol |
| | | | | | | | | volatile acids |
| | | | | | | | | lactic acid |

Remarks: Ensiling: 1,5 Lit. jars, anaerobic conditions; 20°C for 90 days, 2 or 3 replications

Application: doses based on fresh material; dissolved in water amounting to [illegible] matter

Evaluation: for exakt comparison analytic data were converted by multiple linear or spare regressions to the evaluation values for DM content and dose.

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Authors:- Dr. A.R. Henderson and Dr. C.T. Whittemore

A series of experiments investigated the potential of grass silage in the diet of pigs. In the first experiment, young, growing pigs (40 kg) refused to eat sufficient silage, when it was fed with barley, to allow a satisfactory difference calculation. It was concluded that the young pig is not a suitable subject for assessing the nutritive value of silage, nor for receiving it as part of its diet. Subsequent experiments were carried out with sows and when these were fed silages, untreated, treated with formic acid and formalin, and wilted, DM digestibilities ranged from 0.62 to 0.68 and CP digestibilities from 0.63 to 0.82.

In an attempt to increase the digestibility of grass silage for pigs, preliminary experiments were carried out in test-tube silos in which cellulase was added to the grass to hydrolyse the cellulose to free sugar during ensilage. Fermentation inhibitors were applied to conserve this sugar. In the first experiment, a commercial cellulase preparation prepared from Aspergillus niger ($C_1$) was added to grass at the rate of 4 g kg$^{-1}$. The addition of cellulase improved the preservation of the control silage and the silages treated with sodium metabisulphite and zinc bacitracin. The silages treated with formalin and formic (ADD-F) and caproic acids had high residual WSC contents and these were increased further by the addition of cellulase. Loss of cellulose after 133 days was highest (419 g kg$^{-1}$) in the fresh silage treated with formic acid and cellulase and in subsequent experiments formic acid was included as a treatment. In the second experiment, two levels of application of the same cellulytic preparation ($C_1$) were examined. Only after 61 days at the higher level of application (4 g kg$^{-1}$) was there a major breakdown of cellulose. In the third experiment, the effect of four different cellulase preparations was studied at two levels of application (1.0 and 4.0 g kg$^{-1}$). Under the conditions of the experiment, those prepared from Trichoderma viride ($C_2$ and $C_3$) gave better results than those prepared from Aspergillus niger ($C_1$, $C_4$). After 175 days, the greatest loss of cellulose (388 g kg$^{-1}$) and highest increase in WSC (1660 g kg$^{-1}$) occurred in the silage treated with formic acid (5.4 g kg$^{-1}$ fresh grass) and cellulase $C_3$ (4.0 g kg$^{-1}$ fresh grass).

To study the effect of the breakdown of cellulose during ensilage on the digestibility of silage by the pig, three silages were prepared with the following treatments:- fresh, fresh treated with 5.4 g formic acid kg$^{-1}$; fresh treated with 5.4 g formic acid kg$^{-1}$ followed by 4 g kg$^{-1}$ of an active cellulase preparation ($C_2$). The silages were found to have digestibilities to sows of 0.63 for DM, 0.73 for N, 0.60 for GE, 0.60 for cellulose and 0.51 for fibre. The addition of the cellulase enzyme preparation to the grass prior to ensiling decreased the cellulose content of the silage by 39 g kg$^{-1}$ DM and increased the WSC content by 154 g kg$^{-1}$ DM, but did not influence the digestibility of the silage. It is concluded that grass silage could play an important rôle in the nutrition of the pregnant sow.

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FOURTH SILAGE CONFERENCE

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# EFFECT OF TYPE AND LEVEL OF ALKALIS ON THE COMPOSITION OF ENSILED BARLEY STRAW

J M WILKINSON and R GONZALEZ SANTILLANA

Barley straw (cv. Proctor) was chopped (5 cm average length) and ensiled in glass jars which contained 300g fresh weight after addition of either water (c) or alkalis in an incomplete factorial design viz: two types of alkali ($Ca(OH)_2$ or KOH), three proportions of NaOH (0, 50 or 100%), and three levels of addition of total alkali by weight (2.5, 5 or 10 g alkali/100g straw dry matter (DM)). KOH and NaOH in aqueous solution and $Ca(OH)_2$ in powder form were mixed with the straw in a small concrete mixer. A constant volume of liquid (120 ml/100g straw DM) was added to all treatments to give a mean DM content of 43%. Replicates (4 for treatment C, 2 for other treatments) were ensiled for 90 days. In vitro digestibility of organic matter (OMD) for treatment C was 49.0% at Day 0, and 47.6% at Day 90. The main effect of type of alkali at Day 0 was an increase in OMD to 61.9% with KOH, but no increase occurred with $Ca(OH)_2$. By Day 90, however, OMD of straw treated with $Ca(OH)_2$ had increased to 58.7%, compared to 59.8% for KOH. The main effect of proportion of NaOH at Day 0 was an increase in OMD from 55.3% at zero NaOH, to 59.4% at 50% NaOH and 69.2% at 100% NaOH. At Day 90 the corresponding values were 59.2%, 62.2% and 64.8% for 0, 50 and 100% NaOH, respectively. There was a significant interaction at Day 90 between type of alkali and proportion of NaOH in that, with $Ca(OH)_2$, OMD increased by only 1.6% units between 0 and 50% NaOH, whilst between 50 and 100% NaOH, OMD increased by a further 4.5% units. With KOH, on the other hand, OMD only increased between 0 and 50% NaOH (by 4.3% units).

OMD increased with level of alkali at Day 0 and at Day 90. Values after ensiling were 52.5%, 61.8% and 70.2% OMD for 2.5, 5 and 10g alkali/100g straw DM respectively. There was no effect of type of alkali or proportion of NaOH on OMD at 2.5g/100g straw DM, but at 5g the effect of $Ca(OH)_2$ was slightly greater than that of KOH. At 10g of alkali, however, KOH gave higher levels of OMD than $Ca(OH)_2$. With 50% NaOH in the mixture, the effect of KOH was greater than that of $Ca(OH)_2$ at both 5 and 10g alkali addition. Values for OMD of individual treatments are shown in table 1.

Addition of alkalis was associated with a decrease in the content of cell walls in the straw. This decrease was largely due to a decrease in the content of hemicellulose, since values for acid detergent fibre (cellulose + lignin) showed little variation between treatments (table 1). Level of alkali had a marked influence on the content of hemicellulose, and the effects of type of alkali or proportion of NaOH on hemicellulose content were small.

There was a decrease in pH of the straws during storage, which was greater for treatment C than for alkali-treated material, and greater for $Ca(OH)_2$ than for KOH. However, average initial pH was slightly lower for $Ca(OH)_2$ than for KOH (table 1). Increasing level of alkali was reflected in a reduction in the change in pH between Day 0 and Day 90.

In conclusion, NaOH gave greater increases in OMD than other alkalis used alone at levels of addition above 2.5g/100g straw DM. However, partial replacement of NaOH by KOH gave similar responses in OMD to those from NaOH alone. Partial replacement of NaOH by $Ca(OH)_2$ gave responses in OMD which were only slightly higher than those from $Ca(OH)_2$ alone. $Ca(OH)_2$ is a safer and cheaper alkali for use in upgrading straw than is NaOH. There is evidence that animal performance is likely to be relatively greater from diets containing crop by-products treated with $Ca(OH)_2$ than from those containing an equivalent weight of NaOH. Further research is therefore required to determine the effect of the moisture content of straw on the response in OMD to the addition of $Ca(OH)_2$ in powder form. Also, work is required to determine the nutritive value *in vivo* of ensiled straws which have been treated with different quantities of $Ca(OH)_2$.

TABLE 1. Effect of type and level of alkali on the composition of barley straw after 90 days of ensiling

| Proportion of NaOH/% | 0 | | | | | | 50 | | | | | | 100 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of alkali | $Ca(OH)_2$ | | | KOH | | | $Ca(OH)_2$ + NaOH | | | KOH + NaOH | | | NaOH | | | Contr |
| Level of addition (g/100g straw DM) | 2.5 | 5 | 10 | 2.5 | 5 | 10 | 2.5 | 5 | 10 | 2.5 | 5 | 10 | 2.5 | 5 | 10 | |
| in vitro OMD% | 50.8 | 60.7 | 64.5 | 52.2 | 57.3 | 69.7 | 52.9 | 60.5 | 67.4 | 53.7 | 64.8 | 73.8 | 52.8 | 65.9 | 75.7 | 47.6 |
| Cell walls[1] % of DM | 81.3 | 74.9 | 63.4 | 80.0 | 77.2 | 64.2 | 79.1 | 75.7 | 59.0 | 79.9 | 73.5 | 61.3 | 79.5 | 67.4 | 58.3 | 82.5 |
| Hemicellulose[2] % of DM | 33.2 | 26.7 | 14.9 | 30.1 | 27.8 | 16.2 | 31.1 | 26.9 | 13.4 | 29.8 | 25.1 | 14.3 | 29.2 | 18.6 | 12.3 | 34.8 |
| Cellulose + lignin[3] % of DM | 48.1 | 48.2 | 48.5 | 49.9 | 49.4 | 48.0 | 48.0 | 48.8 | 45.6 | 50.1 | 48.4 | 47.0 | 50.2 | 48.8 | 46.0 | 47.7 |
| pH before ensiling | 8.83 | 8.43 | 11.9 | 9.20 | 9.54 | 11.3 | 9.18 | 10.6 | 12.1 | 9.13 | 10.0 | 12.1 | 9.23 | 10.5 | 12.2 | 6.3 |
| pH after 90 days | 6.91 | 6.86 | 10.6 | 8.06 | 8.22 | 10.2 | 7.58 | 7.91 | 11.8 | 7.97 | 8.12 | 11.3 | 7.88 | 8.92 | 12.0 | 4.3 |

(1) Neutral detergent fibre (NDF) (2) NDF-ADF (3) Acid detergent fibre (ADF)

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Session 4

Paper 12

J M Ewart

This paper deals with the potential antimicrobial action of silage additives, in the rumen. Present knowledge of antimicrobial compounds which have been evaluated in the rumen is briefly discussed and in particular the possible modes of action of short and long chain fatty acids are considered.

An experiment is described in which "in vitro" ruminal cultures, maintained at steady-state on an additive-free silage diet in the "Rumenstat" apparatus, were infused with increasing concentrations of formaldehyde and the sodium salts of formic acid, acetic acid and propionic acid.

Results of these experiments show that the salts acted as inhibitors of VFA production and thereby brought about an apparent "energy deficit" for the microflora, resulting in an increase in ruminal $NH_3$-N concentration. The microbiological effects of these infusions were, however, limited; total numbers of organisms were maintained at high infusate concentrations.

Even with low concentrations of infused formaldehyde the effects on VFA production, $NH_3$-N concentration and microbial numbers were considerable suggesting a non-selective toxic action and differing from the catabolite repression effects apparently brought about by the organic acid salts.

The implications of these results in terms of both the modes of action of ruminal inhibitors and the additive treatment of silages, are discussed.

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Paper Number 13

C.R. Lonsdale, D.E. Beever and D.J. Thomson

# The effect of preserving grass with formaldehyde on the efficiency of herbage utilization by young cattle

The use of young cattle in comparative slaughter studies at the G.R.I. has clearly demonstrated that the ensilage of grass by fermentation results in poor utilization of the crude protein in the herbage for protein synthesis by the animal. Consequently a large proportion of the energy retained when such diets are offered is in the form of fat. At a daily empty-weight gain of about 500g per day, young cattle given silage deposited 130g ether extract and 55g crude protein daily, whilst the corresponding depositions by comparable animals given dried grass were 50g and 110g respectively.

The explanation offered for these observations is that the high content of soluble nitrogen in the silage results in most of that nitrogen being converted to ammonia in the rumen. The ruminally available energy is insufficient to allow very much of this to be incorporated into microbial protein. Thus, the supply of amino acid to the small intestine is low and relatively little amino acid is absorbed in relation to the total nitrogen consumed. In such circumstances the animal, unable to synthesize protein, retains surplus energy in the form of fat. Studies using sheep fitted with re-entrant cannulae have shown that heat-drying decreases ruminal protein degradation and increases total flow of amino acids at the duodenum.

Formaldehyde has been shown to reduce proteolysis in the silo and protect protein from ruminal degradation. With this in mind, two experiments were conducted. The first was to assess, by comparative slaughter, the levels of fat and protein deposition in young cattle given grass preserved either by fermentation or by the application of formalin. The second experiment was conducted to study the digestion by young cattle given the same diets.

Grass was ensiled with either 2l of formic acid (C) or 4.5l of formalin and 4.5l of formic acid (F) per tonne of fresh crop.

In experiment 1, five diets were studied: silage C, silage F, silage F plus 2g urea/100g DM (Fu), Fu with 10% of the DM as barley (Fu10) and Fu with 20% of the DM as barley (Fu20). Each was offered at 16, 20 or 24g DM/kg LW to 3-month-old Friesian steers for about 100 days. Empty-weight gain (EWG, kg/head per day) was related to DM intake (DMI, kg/head per day) by the following equation

$$EWG = 0.341\ DMI - 0.427, \quad r = 0.961^{***}, \quad RSD = 0.061$$

No diet deviated significantly from this relationship. However, an initial examination of the composition of the animals at the end of the feeding period showed that those given silage C contained significantly more fat than those given diets containing silage F, when compared at similar empty weights.

For experiment 2, six calves, comparable with those used in experiment 1, were fitted with rumen cannulae and re-entrant cannulae at the proximal duodenum between 2 and 3 months of age. At 3½ months of age they were allocated to 2, 3 x 3 Latin squares in which animals were columns and periods were rows. Diets C, F and Fu, given at 16g DM/kg LW comprised the three treatments and they were allocated to the animal x period combinations.

Preliminary calculations of flow rate, not corrected for the recovery of the marker, indicated that when silage C was offered, the total daily flow of protein at the duodenum was 138g of which 67% was of microbial origin. When silage F was given, with or without urea, the corresponding total flow of protein was 171g, but only 49% was of microbial origin. The amount of microbial protein synthesized per 100g OM digested in the rumen was similar for all three diets (20-22g/100g).

The results show that formaldehyde improves herbage protein utilization by reducing proteolysis in the silo and in the rumen. However, its use reduces voluntary intake by young cattle, thus its practical application appears questionable. Urea may return intake to the level associated with fermented silage, but its nitrogen appears to have no value because it does not increase microbial protein synthesis.

The data illustrates the effects that the form of dietary nitrogen may have on the nature of the end products of digestion. A knowledge of these phenomena may help to develop methods of conservation which will allow more efficient use of herbage protein, particularly by classes of ruminant livestock with a high daily requirement for amino acid.

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Session 4, Paper 14

# EFFECT OF PRESERVATION METHOD ON THE UTILIZATION OF SILAGE PROTEIN

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Many investigations have shown that silage carefully prepared from grass at a relatively early stage of growth and produced at a high nitrogen fertilizer level provides good protein feed for cattle and sheep. Nevertheless, it has become apparent that the productive effect of silage protein has not come up to expectation. Differences in the utilization of the protein have varied. The main reason for this probably lies in changes in the chemical composition occurring during silage fermentation.

## Changes in the crude protein and sugars during silage fermentation

The crude protein concentration of the dry matter of fresh grass of the corresponding silage are generally of the same magnitude. Between the compositions of their crude protein fractions there can, however, be great differences. The proportion of true protein in the crude protein of grass at so-called silage stage is usually 70-75 %. Its proportion in the corresponding silage is much lower, at amount depending on the silage method used and the success of the ensilage process. In grass silages, the proportion of true protein is usually 40-50 % of crude protein.

The solubility of the crude protein and especially the ammonia content of the silage are widely used as criteria of its quality. Alone they are insufficient when the utilization of protein by ruminants is considered. The situation is not even mitigated by the fact that the utilization of the nitrogenous compounds by ruminants depends to a large extent on their solubility. The utilization of soluble crude protein by ruminant depends also on the content of soluble carbohydrates in the diet.

In silage fermentation, also the soluble carbohydrates of the raw material are degraded. Frequently the sugar concentration of grass silage is less than two percent although in the raw material dry matter it is 10-15 % or even more. The amount of sugars remaining in the silage, as also the solubility of crude protein, depends upon the ensilage method used.

## Fermentation level of the silage, and sucrose or starch supplements in protein utilization

The effect of the fermentation level on the utilization of silage is shown in an experiment with growing lambs (SYRJÄLÄ 1975). In the silage prepared without any preservatives, the fermentation was allowed to continue much further than in the silage preserved with formic acid. In the silage without preservative the sugar content was only about one fifth of that in the formic acid silage. The lactic acid content was, however, over 2½ times higher in the former than in the latter silage, whereas the amounts of volatile fatty acids were of about the same magnitude in both silages. The degradation of crude protein went further in the non-preserved silage than in the formic acid silage.

When the lambs received these silages as their only feed, their live weight gain (g/day) was significantly better on formic acid silage diet than on the silage without preservative. This was due not only to a better intake (3.0 kg — 2.7 kg/animal/day) but also to the more effective utilization (kg silage DM/kg live weight gain) on the formic acid silage compared with the silage without preservative.

When small amounts sucrose or starch, amounting to 15 % of the dry matter of the daily ration, were given together with silage, the growth rates of lambs were increased on the non-preserved silage by an average of 67 % and on the formic acid silage by 12 %. The reason why the sucrose and starch supplements had a more favourable effect when given with the non-preserved silage than with the formic acid silage is probably associated with differences in the fermentation levels of these silage.

The importance of lactic acid formed during silage fermentation as an energy source for rumen microbes has seemingly not been investigated. There are, nevertheless, some grounds for believing that lactic acid could have effect similar to those of sugars. In this experiment, the high lactic acid content of silage made without preservative, did not, however, compensate for the disadvantage derived from its low sugar content.

<u>Silage preservatives and protein utilization</u>

In Finland, we use as silage preservatives both acid mixtures (AIV solutions) and also mixtures of acids and formalin (Viher solution and Viher acid).

Investigations conserning the effects of different silage preservatives on protein utilization were made with rumen fistulated adult rams (SYRJÄLÄ 1972). The animals were fed on silage alone or on silage with carbohydrate supplements (15 % or 30 % sucrose, starch or cellulose).

The ammonia concentration of the rumen fluid was lower on the Viher solution silage diets than on the AIV I and formic acid silages. The digestibility of the crude protein was also significantly lower in Viher solution silage than in the other silages. The N balance, however, did not differ significantly among the different silage diets. Measurements of the amount and volume of the rumen microbiota did not reveal any differences between different silage diets (SYRJÄLÄ et al. 1976).

In this experiment the proportion of formaldehyde was about 0.8 % of the dry matter of the fresh grass, this amount being similar to that used in practise when Viher solution is used as a silage additive. It seems that this amount of formaldehyde is too low to protect the grass crude protein to have any noticeable effect on protein utilization by the animal.

SYRJÄLÄ, L. 1972. Ann. Agric. Fenn. 11: 199–276.
– 1975. Ann. Agric. Fenn. 14: 338–348.
– , SALONIEMI, H., LAALAHTI, L. 1976. J. Sci. Agric. Fenn. 48: 138–153.

Fourth Silage Conference
The Grassland Research Institute, Hurley
22 and 23 September 1976
Session Number 5
Paper Number 15

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# Effects of organic acids and ammonium salts on voluntary food intake of sheep.

The voluntary consumption of silage by ruminants is usually lower than than of the fresh or dried crop from which it was made. A series of experiments was carried out to investigate the effects of organic acids and of simple ammonium compounds usually present in silage upon the intake of dry grassmeal pellets.

Five cattle and five sheep were fed grass pellets alone or supplemented with lactic acid at 500 or 700 mmol/kg DM or HCl at 300 or 500 mmol/kg DM. Whereas HCl significantly reduced food intake and induced metabolic acidosis, lactic acid had little effect except for a small reduction in the intake of the sheep at the high level.

The effect of lactic acid on intake of sheep was examined further by adding it to the grass pellets or by infusing it intraruminally. In two experiments lactic acid added to the grass pellets at levels up to 1500 mmol/kg did not significantly reduce intake. However, when infused intraruminally at levels up to 1000mmol/kg DM eaten, it reduced food intake considerably but had little effect on pH of rumen fluid, acid base balance and blood levels of D- and L- lactate.

The effects on sheep of the volatile acids, formic, acetic and propionic were studied by adding them to grass pellets at 900 mmol/kg DM. None of the acids significantly affected food intake or acid-base balance of the sheep.

The effects of ammonium salts and butyric acid on sheep were studied by adding ammonium chloride, ammonium lactate, ammonium butyrate, a mixture of Ca, Na, K butyrate and butyric acid to grass pellets at about 500 mmol/kg DM. Ammonium chloride caused a significant reduction in food intake and induced metabolic acidosis, but the other salts and butyric acid did not significantly affect food intake or acid-base balance.

The results of the above experiments suggest that the organic acids and simple ammonium compounds in silage are individually not responsible for low intake of the silage by ruminants.

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# THE EFFECT OF CHOPPING BEFORE AND AFTER ENSILING ON THE VOLUNTARY INTAKE OF SILAGE BY SHEEP AND HEIFERS.

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Session : 5 SILAGE INTAKE
Paper : 16

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The grass silage intake is generally less than that of the corresponding fresh grass.
Wilting und using chemical additives ( H C O O H ... ) improve the intake ; chopping may also have some effect.
The purpose of this paper is to describe some experiments made on the effects of chopping shortly grass silage on intake, digestibility and behaviour of sheep and cattle.

## EXPERIMENT 1.

6 sheep of 30 - 35 kg were fed ad libitum, in a cross over design, on following treatments :

- S short chopped silage ( 1,8 cm ),
- L long chopped silage ( 5,3 cm ),
- L S long chopped silage, chopped shortly before feeding (1,8 cm).

Digestibility, intake and behaviour were measured for periods of 4 days and are shown in the table.

## EXPERIMENT 2.

4 sheep of 30 - 35 kg and 8 heifers of 450 - 500 kg were fed ad libitum, in a cross over design, on following treatments :

- L long chopped silage ( 8,3 cm )
- L S long chopped silage, chopped shortly before feeding ( 1,2 cm).

The effects of chopping the silage for the two species are shown in the table.

Digestibility, dry matter intake, eating and ruminating behaviour of sheep and heifers given short, long or long short chopped silage (average values).

| | SHEEP ( n = 6 ) silage without HCOOH | | | SHEEP ( n = 6 ) silage + 0,4 % HCOOH | | | SHEEP ( n = 4 ) | | Heifers ( n = 4 ) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S | L | LS | S | L | LS | L | LS | L | LS |
| D.M. digestibility (%) | 67,22 | 68,80 | 68,25 | 66,38 | 68,48 | 68,57 | - | - | - | - |
| D.M. intake (gr D.M./kg $W^{0,75}$/day) | 41,19 | 35,13 | 38,04 | 47,79 | 38,60 | 42,55 | 30,58 | 38,01 | 78,84 | 85,41 |
| Unitary eating time (Mn/gr D.M./kg $W^{0,75}$) | 6,91 | 9,87 | 7,67 | 4,72 | 7,91 | 5,69 | 8,96 | 4,64 | 5,27 | 4,34 |
| Unitary ruminating time (Mn/gr D.M./kg $W^{0,75}$) | 14,28 | 14,52 | 14,16 | 12,60 | 13,77 | 13,35 | 12,95 | 12,22 | 6,93 | 6,79 |
| Pseudo-Rumination ( % Boli per day ) | 3,97 | 16,98 | 6,53 | 3,04 | 16,92 | 4,34 | 46,45 | 6,63 | 0,00 | 0,00 |
| Mean duration for one Bolus (Mn) | - | - | - | - | - | - | 0,60 | 0,74 | 0,79 | 0,87 |
| Latency time (Mn) (Morning) | 30,00 | 62,30 | 49,00 | 32,84 | 48,26 | 37,94 | 92,98 | 65,48 | 44,53 | 23,25 |

Conclusions

Chopping shorthy the silage before or after ensiling increased the intake in experiment 1 by 17,3 - 23,8 % or 8,3 - 10,2 %, and in experiment 2 by 24,3 % (sheep) or 8,3 % (heifers).
The better silage conservation and the more normal behaviour with shortly chopped silage may explain the observed higher intake.

Fourth Silage Conference

The Grassland Research Institute, Hurley

22 and 23 September 1976

Session 5

Paper 17

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# Intake and nitrogen retention by sheep fed lucerne silages differing in composition and effects of intraperitoneal infusion of methionine

Unwilted lucerne was made into 10 silages; 5 being made with a flail harvester and five with a precision-chop harvester. Within each harvester type the herbage was ensiled without additive, with 8 l/t formaldehyde (35% w/w) and 1.5, 3.0 and 6.0 l/t formic acid (85% w/w). The resulting 10 silages were deep frozen and later fed to young sheep kept in metabolism cages, with and without intraperitoneal injections of DL-methionine.

The untreated silages were characterised by extensive protein degradation, high levels of ammonia and acetic acid and low contents of lactic acid. Aspartic acid, serine, threonine, glutamic acid, tyrosine, lysine, histidine and arginine were destroyed in untreated silages in excess of 70% when a flail harvester was used and in excess of 50% when a precision-chop harvester was used. Glycine, leucine, iso-leucine, valine and methionine showed net losses or increases of up to 10%, whilst proline, cysteine and phenylalanine were intermediate between these two categories. Net synthesis of alanine and $\alpha$ and $\gamma$ amino butyric acids occurred in the untreated silages.

Formaldehyde addition markedly reduced protein degradation and the extent of carbohydrate fermentation and caused a large reduction in nitrogen digestibility. All these effects were of much greater magnitude when the formaldehyde was applied from the precision-chop harvester than from the flail harvester. Formaldehyde treatment reduced amino acid degradation, apart from apparently high losses of lysine, histidine and tyrosine, but it was concluded that these arose through problems in estimating these amino acids in formaldehyde-treated silages following HCl hydrolysis. Voluntary intake and nitrogen retention were higher in formaldehyde-treated than untreated silages.

Increasing rates of formic acid addition reduced the overall extent of carbohydrate fermentation, decreased the proportion of fermentation products which could be attributed to clostridial activity, and decreased the degradation of true protein though not to the same extent as with formaldehyde. Extensive amino acid degradation was reduced and increases in alanine and $\alpha$ and $\gamma$ amino butyric acids were minimised. With the precision-chop harvester, formic acid addition increased both voluntary intake and nitrogen retention. Intakes were low on the three flail harvested silages made with formic acid as these were unfortunately heavily contaminated with soil; however the additive improved nitrogen utilization and within this group intake increased with increasing rate of formic acid application.

On the seven silages with normal ash contents, methionine supplementation had no effect on voluntary intake, but caused a small and consistent improvement in nitrogen utilization. Methionine supplementation depressed nitrogen utilization in the three silages of high ash content although intake was not affected.

Interrelationships between silage chemical composition and nutritive value were studied, using regression and simple and partial correlation procedures. Voluntary intake, apparent BV and nitrogen retention all decreased linearly with increasing protein degradation and acetic acid formation. These measures of nutritive value were, however, correlated more closely with the concentrations of alanine, threonine and $\gamma$ amino butyric acids in the silage than with ammonia-N or acetic acid. Intake regressions for precision-chopped silages were parallel to those for flail silages but were greater by a constant displacement of 20g OM/kg $W^{0.75}$/day. Data from silages made by the two harvesting methods fitted the same regression for nitrogen retention, which decreased by 0.3 g/day for each 1% increase in ammonia (% total N). It was deduced that in this experiment restriction of amino acid degradation by clostridial bacteria had a greater effect on improving nutritive value than did restricting the degradation of plant proteins to free amino acids and that the prevention of the decarboxylation of amino acids was of greatest importance.

FOURTH SILAGE CONFERENCE

The Grassland Research Institute, Hurley

22 and 23 September 1976

Session 5

Paper 18

Mr M S Smith and Mr R Crawshaw

Agricultural Development and Advisory Service
Woodthorne, Wolverhampton and Bryn Adda, Bangor

# SILAGE INTAKE BY DAIRY HERDS UNDER COMMERCIAL SELF-FEEDING CONDITIONS

Self-feeding remains the predominant system of feeding silage to commercial dairy herds in England and Wales. In ration formulation under this system, reasonably accurate prediction of silage intake is important because of the difficulty of check weighing during feeding. In the investigation to be described, we have examined intakes of self-feed silage measured in a sample of 100 commercial farm sites. We have sought to identify sources of variation in voluntary intake, first in terms of factors amenable to routine advisory investigation, and second with regard to current information on factors known to influence silage intake under experimental conditions.

The investigation combines data from 3 recent studies with dairy cows by ADAS Nutrition Chemists employing largely identical techniques. Mean silage intake was estimated over a 1 month period by a tested procedure based on measurements of volume and density. Silages were analysed by methods routinely employed for advisory samples, and a wide range of background information was recorded. In collating the data, we applied constraints to standardise breed of cow (Friesian), calving pattern (predominantly autumn), access to silage (minimal restraint) and supplementary hay or straw (trivial amounts). Forty sites provided technically satisfactory observations which met the above conditions, and their data were combined for study.

| CODE | Silage | Satisfactory fermentation MEAN | RANGE | Poor fermentation MEAN | RANGE |
|---|---|---|---|---|---|
| DM | Oven dry matter % | 22.6 | 17.3-33.7 | 20.1 | 17.6-24.8 |
| - | pH | 4.2 | 3.6-4.8 | 4.9 | 4.7-5.2 |
| - | Total crude protein % DM | 14.4 | 9.6-19.0 | 16.7 | 13.4-21.7 |
| MADF | MAD Fibre % DM | 39.6 | 36.0-47.9 | 42.2 | 35.7-45.7 |
| - | Average yield, kg/cow in milk | 15.2 | 9.8-21.1 | 14.1 | 10.2-22.9 |
| CDMR | Concentrated feed dry matter intake, kg/kg milk | 0.329 | 0.20-0.47 | 0.339 | 0.18-0.62 |
| SDMI | Silage DM intake, kg/cow/d | 7.45 | 4.9-10.5 | 6.29 | 4.9-9.3 |

Over the full range of variation in silage quality, voluntary silage intake (SDMI) was positively correlated with DM ($r = 0.50$ ***), negatively with MADF ($r = -0.64$ ***) and concentrate feeding rate (CDMR; $r = -0.53$ ***). Well fermented silages were consumed at a higher average level ($P<0.05$) than poorly fermented silages, but at equal DM concentration and with adjustment for concentrate feeding rate the difference narrowed to 0.73 kg silage dry matter. Among well fermented silages, the generally lower intakes at low DM could not be explained in terms of high acidity.

In its relationship with silage intake, MAD Fibre (expressed on oven dry matter) behaved with interesting complexity. Added to any direct relationship associated with digestibility, the fibre term appeared to accumulate indirect effects, also negative on intake, from low silage DM and poor fermentation quality through associated elevations of fibre concentration.

In multiple regression analysis of the 40 sets of observations, 58% of variation in SDMI was accounted for by the model:

$$\text{SDMI} = 14.9 + 0.108\ \text{DM} - 0.192\ \text{MADF} - 7.19\ \text{CDMR} \qquad (\text{RSD} = 1.07)$$

Partial regression coefficients, calculated for different categories of silage, suggest that the elasticity of voluntary silage intake to change in concentrate feeding rate is very much greater with dry well-fermented silages than with wet silages of poor fermentation quality.

*** Signifies $P<0.001$; RSD = residual standard deviation.

FOURTH SILAGE CONFERENCE

The Grassland Research Institute, HURLEY

22 and 23 September, HURLEY

Session 6 - Paper 19

J.P. DULPHY

# INTAKE OF GRASS SILAGE AND ITS USE IN THE FEEDING OF DAIRY COWS.

Each year since 1971, we have studied the use of grass silage with dairy cows. For the preparation of the silages, in addition to normal precautions, we employed three techniques which gave considerable improvement :

- fine chopping (1-3 cm),
- addition of an efficient preservative (formic acid),
- covering with good quality plastic sheeting t( insure impermeability of the silos.

We shall present principally the results concerning silages conserved by the above me.hod (n = 12) immediatly after cutting in 100 m3 trench silos 3 in high.

## MATERIALS AND METHODS

The trials were made, without hay-feeding, during the phase of reducing lactation (2rd to 5 th month after calving) with groups of 8-12 cows of Frisian and Montbéliard race weighing 590 kg (22 % being in first lactation). The cows had calved in November-December and the quantity of concentrates fed was predetermined before the experimental period (6-7 th week after calving) in relation with the maximal milk production and the intake of silage in this period. The duration of each trial permitted measurement of variations in animal weight.

## RESULTS

The 12 silages used (rye-grass, timothy, red clover and red clover-timothy) were well preserved and had high OM digestibility. The quantities of dry matter ingested as silage a as concentrates were respectively 2·10 and 0.51 p.100 of the live weight for cows producing on average 18,3 kg of milk with 4 % fat. With grass silage the intake increased from 1.9 to 2.4 % of the live weight when the forage digestibility increased from 68 to 79. Although the red clover and the mixtures had much lower digestibility (about 64) their intake was satisfactory : 2.2 % of the live weight. The intake of silage by dairy cows can be considered as 95 % of that of green forage. A difference of 1 kg DM of concentrate within a limit of 1-4 kg per day gave à reverse variation of the silage intake of 0.62 kg. According to our trials and those carried out at other research centers, the intake of dry matter by cows is increased by 10-20 % with fine chopped compared with long fragment silage and by 5-10 % with silage containing formic acid compared with the same silage without preservative.The average weight gain of the animals in our trials was 80 g/day.

The energy provided by the silage was sufficient to cover the maintenance needs of the animals and the production of 10.6 kg of milk with the % fat (11.1 kg for the cows after the first lactation, being 10 kg for clover based silage and 7 to 17 kg with grass silage). Variation in the level of concentrates did not have any considerable effect on milk production : +0.35 kg of milk per supplementary kg of concentrate, but the live weight gain was increased by +136 g.

# FOURTH SILAGE CONFERENCE

The Grassland Research Institute, Hurley

22 and 23 September, 1976

Session Number 6
Paper Number 20

Authors: M.E. CASTLE, J.N. WATSON and W.C. RETTER

D-value a 70

## 'SUPPLEMENTATION OF HIGH-DIGESTIBILITY GRASS SILAGE FOR MILK PRODUCTION'

Silages made from perennial ryegrass, and with D-values of 68-70, were offered ad lib to Ayrshire dairy cows either with or without supplements. When silage was given as the sole feed, the average intake of dry matter was 2.34% of the liveweight of the cows, and the average milk yield was 14.6 kg/cow per day. The cows had a mean loss in liveweight of 0.70 kg/day and thus the silage provided nutrients for maintenance and the production of 10.8 kg milk/cow per day.

Supplements of either crushed barley or cubed dried grass with a D-value of 71 offered twice per day at milking time decreased the voluntary intakes of silage but increased the total daily intakes of dry matter. The response to these supplements was 0.39 and 1.02 kg milk per 1 kg dry matter for the barley and dried grass respectively.

A supplement of groundnut cake containing 54% crude protein in the dry matter did not depress the voluntary intake of silage and gave a response of 1.63 kg milk per 1 kg dry matter. A cube containing 82% ground nut plus molasses and minerals, and given at rates of 0.8, 1.4 and 2.0 kg/10 kg milk did not affect the intake of silage, and gave mean daily milk yields of 16.5, 18.2 and 18.4 kg/cow per day.

From these results a "balancer" cube containing mainly ground nut and with 33.5% crude protein in the dry matter has been developed and used in a feeding experiment on a commercial farm. Silage with a D-value of 67 was supplemented with either a low-protein barley mix at 4.0 kg/10 kg milk, or with the high-protein cubes at 1.5 kg/10 kg milk. Over an 18-week period the mean daily yields of milk were 18.9 and 19.4 kg/cow on the barley and the "balancer" cubes respectively and were not significantly different.

It is concluded that with grass silage of high digestibility there are sound reasons for having a more flexible approach to the feeding of supplements if maximum use is to be made of the silage.

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Paper Number 21

Author F.J. Gordon (to be presented by W.A. McIlmoyle)

Two experiments are described. In the first forty British Friesian cows were used in a randomised block design experiment to evaluate a high quality grass silage for milk production. The high quality silage, made from a perennial ryegrass sward cut at intervals of 37 days, wilted to 50 per cent dry matter, finely chopped and ensiled using 2.2 litre/tonne of formic acid as an additive, was fed *ad libitum* in addition to 3.8 kg of concentrates. A medium quality silage, of lower digestibility and dry matter content, was also fed *ad libitum* in addition to either 3.8, 5.7 or 7.6 kg concentrates. The animals used had a mean calving date of January 28. The feeding treatments were commenced immediately after calving and were terminated on April 9 giving a mean period of 72 days on the treatments. Over the total experimental period the animals on the high quality silage diet consumed 15 per cent more silage dry matter and produced 8 per cent more milk than those on the medium quality silage with the same level of concentrate supplementation. It was estimated that 1.7 kg of additional concentrates would have been required with the medium quality silage to give an equivalent milk output to that achieved with the high quality silage. No difference in milk composition or liveweight change was obtained between silage qualities.

In the second experiment 60 cows, mainly in their first lactation were used in a randomised block design experiment to assess the effect of the protein content of the concentrate given as a supplement to high quality grass silage on milk output. The silage was cut from perennial ryegrass swards during the 3rd week in May, wilted for 24 hours, ensiled using a mixture of sulphuric acid and formaldehyde as an additive and had a dry matter digestibility of 71.8 per cent. This was fed ad libitum to cows for the first 75 days post calving in addition to supplements containing either 9, 13, 17 or 21 per cent crude protein on a fresh basis. The level of supplementation was similar on all treatments being 10 and 8 kg for cows and first calving heifers respectively. There was a significant linear increase in total milk output over the experimental period being 1349, 1451, 1533 and 1628 kg for the 9, 13, 17 and 21 per cent protein supplements respectively. No significant effect on either milk composition or liveweight change was recorded between treatments. There was a non-significant trend towards an increase in both total silage intake and dry matter digestibility with increasing level of protein being 514, 524, 548 and 545 kg 74.2, 74.6, 77.6 and 72.2% for silage intake and dry matter digestibility for the 9, 13, 17 and 21 per cent protein diets respectively.

Fourth Silage Conference, The Grassland Research Institute, Hurley, 22 and 23 September 1976.
Session 7. Paper 22. C Ibbotson.

# Some observations on the effectiveness of silage additives on commercial farms. Silage Additive Studies 1972-1975

C Ibbotson, Nutrition Chemistry Department, ADAS, Newcastle upon Tyne

These studies were carried out on farms in the Northern Region during the 4 years 1972-1975. The total number of farm sites was 113. The aim was to study the effectiveness of silage additives under commercial farm conditions and to make comparisons between additive-treated and untreated silages.

The 3 additives studied were Add-F, Kylage Extra and Sylade and application rates were claimed to be approximately those recommended by the manufacturers, ie for Add-F and Sylade ½ gallon (2.3 kg) and Kylage Extra 3½ lb (1.6 kg) per ton of grass ensiled.

In comparing the results, a separation has been made between "wet" and "dry" silages. The low dry matter groups, 25% dry matter and less, consisting of silages made predominantly from unwilted material, and the high dry matter groups, over 25% dry matter, of mainly wilted silages.

The number of silo sites in these groups were:-

| | Wet Silages ≤25.0% DM | | | | Dry Silages >25.0% DM | |
|---|---|---|---|---|---|---|
| | 0 | F | S | K | 0 | AA |
| Number of Silos | 23 | 14 | 12 | 10 | 44 | 10 |

Key: 0 = No additive, F = Add-F, S = Sylade, K = Kylage Extra
AA = All additives in the dry silage group (because of the small numbers involved, additives were not compared separately)

In 1972, 1973 and 1974 the studies were restricted to silage made from primary cuts of grass cut in May and June. In 1975 silages made from late grass cut in September and October were included.

The results are summarised in the following table:-

Analyses of grass (G) and silage (S) samples

| | LOW DRY MATTER SILAGE GROUP | | | | | | | | HIGH DRY MATTER SILAGE GROUP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment and No of sites | 0 (23) | | F (14) | | S (12) | | K (10) | | 0 (44) | | AA (10) | |
| | G | S | G | S | G | S | G | S | G | S | G | S |
| DM % | 21.2 | 21.3 | 19.5 | 21.8 | 19.7 | 21.4 | 20.7 | 21.9 | 28.8 | 30.1 | 27.9 | 28.4 |
| CP % | 12.7 | 11.6 | 13.8 | 12.7 | 14.4 | 12.1 | 13.8 | 11.9 | 12.5 | 11.6 | 12.5 | 11.7 |
| CF % | 30.3 | 35.5 | 29.1 | 35.6 | 29.9 | 36.1 | 30.0 | 35.4 | 30.0 | 33.1 | 29.5 | 33.2 |
| "D" % | 61.1 | 56.6 | 63.6 | 59.9 | 61.5 | 57.6 | 62.4 | 59.5 | 61.0 | 59.6 | 61.3 | 60.2 |
| DM % Loss | | 14.9 | | 18.2 | | 17.1 | | 15.3 | | 9.3** | | 10.0** |
| pH | | 4.57 | | 4.12** | | 4.55 | | 4.27 | | 4.28** | | 4.17** |
| PB % | | 21.0 | | 11.3** | | 21.8 | | 18.3 | | 12.5** | | 13.2** |
| Score (max 10) | | 5.6 | | 7.1* | | 5.4 | | 6.5 | | 7.4** | | 6.7** |
| Drop in "D" (G to S) | | 4.5 | | 3.7 | | 3.9 | | 2.9 | | 1.4** | | 1.1** |

Significance compared with no additive (O) Low Dry Matter Group

*Significant at P = 0.05
** " " P = 0.01

DM = dry matter CP = crude protein determined on dried samples
CF = crude fibre determined by trichloracetic acid method
"D" = digestible organic matter in dry matter (in-vitro)
PB = protein breakdown (volatile nitrogen/total nitrogen x 100)
DM Loss = fermentation dry matter loss determined by "fibre rise" =

$$\left(100 - \frac{\text{CF grass}}{\text{CF silage}} \times 100\right)$$

Fermentation Score:
- 10 Very good
- 8 Good
- 6 Satisfactory
- 4 Fair (slight butyric)
- 2 Bad (strong butyric)
- 0 Very bad

## WET SILAGES

In this wet group the mean silage dry matters were similar for all groups - between 21.3 and 21.9% - but the grass dry matter of the Add-F and Sylade treated silages were considerably lower than the dry matter of the untreated controls. This difference could account for the slightly higher dry matter losses recorded for these additive treated silages. The Add-F treated silages were also made from grass of significantly higher "D" value and so the potential for loss in this group was higher. However, dry matter loss differences within this wet group are not significant.

pH values were relatively high for the untreated and Sylade silages. The low pH value for the Add-F silage is significantly lower than the "untreated" pH at the 5% level and the fairly low pH value for the Kylage silages approaches significance at the 5% level.

Within this wet group only Add-F had markedly reduced protein breakdown.

Both Add-F and Kylage treated silages had better fermentation scores (see table for scoring system) than either the untreated or the Sylade treated silages.

The drop in "D" value between grass and silage (grass "D"-silage "D") was highest in the untreated silages and relatively low for Kylage Extra but none of these differences are significant.

## DRY SILAGES

There are no conspicuous or statistically significant differences between the dry silages made with or without additives. Comparisons with the wet silages show that the wilted silages had reduced dry matter losses, pH values similar to the Add-F and Kylage treated silages and relatively low protein breakdown values which are comparable to those of the Add-F silages. Fermentation scores are high and also comparable to the score for wet Add-F silages.

For these dry silages the drop in "D" value between grass and silage is more than 2 units lower than for all the wet silages.

The results of this study suggest that for direct cut and poorly wilted grass of low dry matter Add-F gave the best results, Kylage Extra gave some improvement but Sylade had no apparent beneficial effect. For wilted grass, additives had no beneficial effect. Wilting gave significant improvements in fermentation assessments, reduced dry matter losses and minimal reductions in "D" value.

August 1976

Fourth Silage Conference
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Paper Number 23
Author J W G Parker

A comparison between a single and two cut silage system for dairy cows.

Upland farms have a short growing season and generally a high annual rainfall, so multi-cut silage systems are often regarded as a doubtful proposition. Great House EHF is in such an area where late cut grass for hay making is the traditional method of conservation. Despite a swing to silage making during recent years many farmers have persisted with a single mid-season cut to provide all their conservation needs. Others have adopted a two or three cut system enabling grass to be cut at a higher digestibility; however, in high rainfall areas a three cut system increases the risk of crop spoilage by bad weather.

The object of this experiment was to compare the performance of dairy cows self feeding silage made either by a one cut system (1CS) or a two cut system (2CS). Equal areas of similar grass were direct cut with a flail forage harvester. Cutting took place during the first week of July for the 1CS and during the first weeks of June and August for the 2CS. Formic acid additive was applied at each cut to avoid the risk of fermentation failure at any one cut. The grass ensiled on the 1CS had a DM of 30% with a crude protein content and calculated digestibility of 10.6 and 64.5% in DM respectively. The mean DM content of grass cut on the 2CS was 21.6%, the crude protein and calculated 'D' value in DM were 16.2% and 67.2% respectively. A satisfactory fermentation was achieved on both treatments. On chemical analysis the 2CS had the higher potential feeding value with a crude protein content of 16.3% compared with 11.5% on the 1CS and a calculated digestibility of 66.8 compared with 63.5% for the 1CS.

Silage density was measured each week during the feeding period. These were 624 and 744 kg/m$^3$ for the 1CS and 2CS respectively from which in silo DM losses and daily DM intakes by the cows were calculated.

Each silage was simultaneously self-fed to 24 Friesian dairy cows and their milk yields and weight changes recorded weekly. Corrected milk yields from week 3-23 of lactation show that cows on the 2CS gave significantly more milk ($P < 0.01$). Feeding 1.8 kg/day extra concentrate to the cows eating 1CS silage only produced an extra 1.5 kg of milk/day. During the same period cows on 1CS lost 20 kg in liveweight while cows on 2CS maintained liveweight.

Extrapolation of whole lactation yields from this data suggests that a 2CS silage will support up to 680 kg more milk yield, which would realise an extra £50/cow/lactation, on the other hand, extra harvesting costs and fertilizer inputs for the 2CS adopted in this experiment amounted to only £5/cow.

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# A THEORETICAL STUDY OF DIFFERENT STRATEGIES FOR CUTTING GRASS FOR ENSILING AND FEEDING TO DAIRY COWS

It is commonly accepted that grass which is conserved for feeding to lactating dairy cows should have a high digestibility since this is often associated with improved productivity however this is measured. Due to the changing economic circumstances it seemed opportune to examine the relative merits of conserving grass of different digestibilities.

Grass yield data relating to different cutting regimes was taken from 2 different sources, the Grassland Research Institute (GRI) and the ADAS/GRI co-ordinated Grassland Manuring Trials. The GRI data covered the 5 years and was related to irrigated plots of S23 ryegrass receiving approximately 390 kg nitrogen per ha per annum cut to give herbage of 70, 67, 64 or 61 DOMD for the first and second cuts (very early, early, medium and late cut). Subsequent cuts were timed to yield herbage of 65-68 DOMD. The GM trials refer to mean yields from plots receiving 270 kg nitrogen per ha per annum over a period of 4 years. Yield data refer to either 6-7 cut systems (very early) or 4-5 cut systems (late) for S23 from 13 sites in different parts of the country. Intermediate values (medium) were obtained by interpolation of the data from the very early and late cutting systems.

The difference between total seasonal dry matter yield between the very early and late cutting systems were 62% (GRI data) or 88% (GM data). In each case the total seasonal yield of DOM/ha increased progressively as the date of the first cuts were delayed but the proportion of first cuts making up the total seasonal yield was less in the early cutting system (only 20% of grass of D 70 in the GM series of trials and 51% in the GRI data).

The metabolisable energy of the silage was calculated on the basis of a constant calorific value of the digestible organic matter and a constant efficiency of conversion of digestible energy into metabolisable energy (ME = 0.81 x DE). Winter rations were calculated for both 4,500 kg (900 gallon) and 5,500 kg (1,200 gallon) cows calving in mid September and the total quantities of silage, barley or dairy compound required for the winter feeding period. Rations were based on a restricted silage intake of either 6 or 10 kg of dry matter per day or on silage fed to appetite.

The reduced quantity of concentrate which was necessary to supplement the best quality silage resulted in the expected progressive reduction in gross margin per cow as forage quality decreased. However, the later cutting systems, where high yields of DOM/ha were obtained, enabled an increase in stock density. Stock density is a more important factor influencing margin per hectare than a saving in supplementary feed costs by adopting an earlier cutting silage system for milk production at current input/output prices.

The individual farm policy needs to be assessed with due regard to the overall effect on the farming system. Where an increase in the dairy herd is the alternative opportunity after due allowance for the increase in fixed cost and interest charges and additional capital, the later cutting silage systems would generally be more profitable. However where the alternative opportunity is another low gross margin enterprise then an early (higher quality) silage system would generally be more profitable.