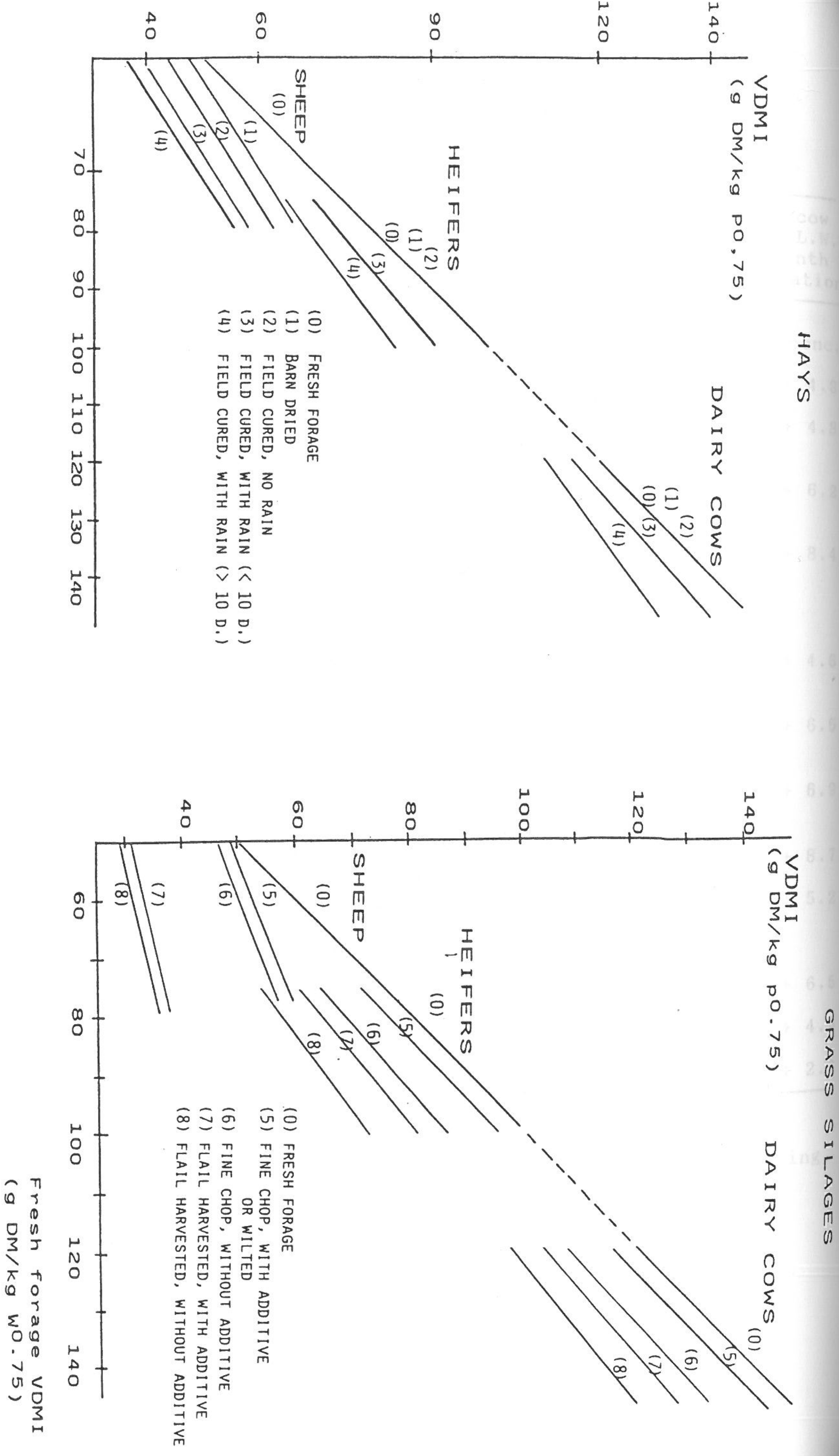

Figure 2 : Relationship between VDMI (Voluntary Dry Matter Intake) of conserved forages and VDMI of initial fresh forages.

EFFECT OF FORAGE QUALITY ON MILK AND MEAT

K. Rohr

Institute of Animal Nutrition, Federal Research Centre
of Agriculture (FAL), Bundesallee 50, 3300 Braunschweig, Germany

Introduction

Expansion of production combined with a static market have led to surpluses in milk and meat in the EEC. Under these conditions, an adequate profit can only be realized when the average cost per unit of animal product is minimized. As feed costs constitute the greatest portion of total cost in ruminant production, this in turn means making maximum use of the cheapest source of food. Consequently, replacement of some of the concentrate feeds with lower cost forages is an essential requirement on farms with a sufficient area of fodder crops. Forage quantity and quality therefore becomes a vital concern.

In this paper a consideration will be given to the effects of forage quality on animal response.

Fresh herbage

The amount of milk produced from grazed pastures or from cut herbage depends on the potential of the animal and its intake of nutrients. The main herbage quality factors affecting herbage intake are digestibility, dry matter (DM) content and contamination with soil or dung. A more or less linear increase in intake with increasing digestibility (up to 82 %) has been documented by numerous authors (CORBETT et al., 1963; MINSON et al., 1964; OSBOURN et al., 1966; ROHR, 1972; STEHR and KIRCHGESSNER, 1975). On the other hand, herbage consumption is reduced with DM contents below 16 - 18 % (VÉRITÉ and JOURNET, 1970; ROHR, 1972). This depression in intake has been claimed to be a palatability effect (LEAVER, 1985). The negative effect of dung contamination on herbage intake is a well-known phenomenon and becomes increasingly important with increasing stocking rates (BOSWELL, 1971).

On high-quality pastures, herbage allowance is the dominating factor affecting intake and thus milk yield. In unrestricted grazing or zero grazing conditions, DM intakes from spring and early summer pasture alone will support up to 25 kg /d of milk (GORDON, 1976; LE DU and HUTCHINSON, 1982; MEIJS, 1983).

However, a certain superiority of legumes in comparison with grasses must be kept in mind. As an example, data on yield and composition of milk from early lactating Friesian cows grazing either perennial ryegrass or white clover (THOMSON et al., 1985) are given in table 1. In spite of mobilizing considerable amounts of body tissue, grass-fed cows produced significantly less milk and milk protein than animals grazed on white clover.

Table 1: Data on food composition and dairy cow performance[1] in a comparative study with ryegrass and white clover (THOMSON et al., 1985)

	Perennial ryegrass	White clover
Food composition (g/kg DM):		
Organic matter, OM	913	907
Crude protein	216	271
Neutral detergent fibre, NDF	394	235
Acid detergent fibre, ADF	229	215
Digest.organic matter, DOM	711	688
Performance data:		
Milk yield (kg/d)	22.2	25.0
Milk fat (%)	4.15	3.89
" (kg/d)	0.92	0.97
Milk protein (%)	2.98	3.09
" (kg/d)	0.66	0.77
Live weight change (kg/d)	- 0.21	0.01

1) weeks 4 to 18 of lactation

With little or no supplementary feed, milk production on pasture declines at well over 2 % per week (LE DU et al., 1981; LEAVER, 1982). Apart from a moderate decrease in herbage nutritive value (LE DU et al., 1981), this decline must mainly be attributed to a reduction in DM and energy intakes as the season progresses. Herbage consumption by grazing cows in autumn was shown to be 10 - 20 % lower than in spring (CORBETT et al., 1986; STEHR and KIRCHGESSNER, 1976). Cows with daily milk yields above 20 - 25 kg in the spring and 10 - 15 kg in the autumn need supplementary feed. Due to a displacement of herbage by concentrates, however, the supplement does not result in a proportional supply of nutrients. Substitution rates vary in relation to herbage allowance and concentrate composition (MEIJS, 1984, 1986).

Turning out to pasture is usually associated with a depression in milk fat and a slight increase in milk protein. The drop in milk fat is more pronounced

with animals fed a well-balanced diet during the preceding winter period (HODEN et al., 1985). Milk fat from herbage-fed cows contains lower portions of short- and medium-chain fatty acids and higher portions of long-chain/unsaturated fatty acids compared with milk from animals fed typical winter diets (table 2).

Table 2: Milk fat composition (molar %) during grazing and indoor feeding (PRECHT et al., 1985)

	Grazing	Indoor feeding
C 4 - C 10	19.7	22.5
C 11 - C 15	13.6	18.7
C 16:0	22.8	30.1
C 16:1	1.8	1.6
C 17	1.8	1.5
C 18:0	8.4	5.6
C 18:1	26.8	16.7
C 18:2	2.7	1.8
C 18:3	1.8	1.0
>C 18	0.6	0.5

As to the fractional composition of milk protein, BANKS et al. (1986) found the relative portion of casein to be similar in milk produced with typical summer and winter feeding. GRADISON et al. (1986) compared milks of two groups of dairy cows grazing either white clover or ryegrass swards. The clover milks contained more α_s- and β-casein and a greater portion of small micelles than grass milks. It must be stressed, however, that the legume-fed animals had a considerably higher energy intake (THOMSON et al., 1986).

High-quality pastures support high levels of live weight gain in growing-fattening cattle without concentrate supplementation. In recent experiments with finishing Friesian bulls (VON BOTHMER, 1987) and Simmental-cross bulls (DURGIAI, 1989), live weight gains of 1.1 kg/d could be achieved with no additional feed. The level of performance will largely be affected by the preceding winter feeding and by the type (quality) of pasture. This has been demonstrated by WRIGHT et al. (1989) with Charolais-cross steers and heifers (table 3).

Table 3: Effects of winter feeding level and of type of pasture on level of performance (WRIGHT et al., 1989)

		Winter feeding		
		Low	Medium	High
		Sown ryegrass pasture[1]		
Initial live weight	(kg)	252	299	337
Final live weight	(kg)	384	405	424
Live-weight gain	(kg/d)	1.07	0.86	0.71
Backfat area at end	(cm^2)	4.03	4.42	4.14
		Hill reseed[2]		
Initial live weight	(kg)	260	305	320
Final live weight	(kg)	403	421	409
Live-weight gain	(kg/d)	1.16	0.94	0.72
Backfat area at end	(cm^2)	2.85	4.03	3.20
		Unimproved hill[3]		
Initial live weight	(kg)	264	317	324
Final live weight	(kg)	360	384	387
Live-weight gain	(kg/d)	0.78	0.54	0.51
Backfat area at end	(cm^2)	2.40	2.67	3.17

1) OM-Digestibility, OMD:77.3-83.7%, 2) OMD: 73.6-75.8%, 3) OMD:61.8-70.4%

Grazing systems must be designed to ensure an adequate daily allowance of herbage, taking into account the increasing weight of the cattle as the season progresses. Where herbage availability cannot be brought into line with the increasing nutrient requirements of the animals, a satisfactory dressing percentage and carcass quality will only be achieved with additional concentrates (VON BOTHMER, 1987).

Conserved forages

Contingent on lower intakes, conserved forages will usually supply the animal with less nutrients then fresh herbage. However, the extent of depression varies considerably with the type and quality of forage, the conservation method and the animal species (DEMARQUILLY, 1973; DULPHY et al., 1984; DULPHY and ROUEL, 1988). In most cases, hay is consumed in larger amounts then silage (WALDO, 1977). This difference in intake, however, is not reflected in animal response.

Depending on quality, DM intakes in dairy cows of 22 - 26 g/kg live weight

can be expected if silage is fed as the sole diet (LEAVER, 1988). This corresponds to about maintenance plus 10 - 20 kg milk. In recent experiments conducted by RAE et al. (1987a) cows in early lactation produced 21 - 23 kg/d of milk with high-quality grass silage (> 11 MJ ME/kg DM) as the sole feed (table 4).

Table 4: Silage as a sole feed for dairy cows[1] (RAE et al., 1987a)

Site		A			B	
Experiment No.		1	2	3	4	5
DM-content of silage	(%)	35.5	33.5	24.6	21.2	22.2
ME-content of silage	(MJ/kg DM)	11.5	11.3	11.5	11.2	10.6
DM intake	(kg/day)	13.6	13.0	13.1	11.5	11.6
Milk yield[2]	(kg/day)	23.1	21.7	21.8	21.3	19.4
Milk fat	(%)	4.05	4.07	3.93	4.00	3.62
Milk protein	(%)	3.18	3.12	2.99	2.93	2.72
Live weight change	(kg/day)	-0.52	-0.43	-0.41	-0.49	-0.65

1) weeks 1-13 of lactation 2) cows only, no heifers

This level of production, however, was achieved at the expense of considerable body tissue.

Although concentrates are unrenouncable in dairy cows, every effort should be made to increase the contribution of forage to the animal's nutrient supply by optimizing the date of cut and by modifying and restricting fermentation through wilting or the use of additives. Increasing digestibility by earlier cutting will generally increase milk output, the average response being more pronounced with low/medium portions of concentrates (BERTILSSON and BURSTEDT, 1983; PHIPPS et al., 1987). Differences between early and late cut forages (time intervall: 2-3 weeks) are illustrated by a number of examples given in table 5.
Feeding early cut forages is also advantageous with regard to the milk protein content (see Table 5). As far as the effect of season of harvest is concerned, first-harvest silage resulted in higher DM-intakes and a higher milk yield than silage harvested from the same sward in autumn (CASTLE and WATSON, 1970; PEOPLES and GORDON, 1989).

Table 5: Effects of early or late cut forages on intake and dairy cow performance

Forage type	Harvest time	Duration of exp. period (weeks)	Forage OM digestibility (%)	DM intake (kg/d) concentrates	DM intake (kg/d) Forage	Milk yield (kg/d)	Milk fat (%)	Milk protein (%)
		Data from BERTILSSON and BURSTEDT (1983)						
Hay	Early	15	76.1	7.5	12.1	24.4	4.36	3.48
	Late	15	72.4	7.5	11.2	22.1	4.44	3.56
Hay	Early	15	74.7	6.2	14.4	24.3	4.49	3.56
	Late	15	63.9	6.3	12.4	23.4	4.19	3.20
		Data from THOMAS et al. (1981)						
Silage (wilted)	Early[1]	15	81.2	6.3	9.9	28.0	3.61	3.15
	Late[1]	15	69.8	6.3	9.5	24.7	4.10	2.94
		Data from KRISTENSEN et al. (1979)						
Silage (wilted)	Early	9	84.0	6.5	11.2	22.7	3.81	3.15
	Late	9	69.6	6.5	9.1	19.0	3.65	2.99
		Data from TAYLOR and LEAVER (1984)						
Silage	Early	25	72.9	7.8	8.7	24.1	4.06	3.38
	Late	25	64.8	7.8	7.6	22.1	4.10	3.31
		Data from RAE et al. (1987)						
Silage (low moisture)	Early	23	78.2	5.3	11.6	23.5	4.32	3.19
	Late	23	67.6	5.3	9.4	19.5	4.23	2.88

1) time interval: 31 days

Wilting is an efficient means to reduce fermentation losses in the silo and to increase DM intake. In most experiments, however, the higher intake in comparison to unwilted silage did not result in higher milk yields (ROHR and THOMAS, 1984; PEOPLES and GORDON, 1989). As this descrepancy can only partly be explained by a somewhat lower digestibility of the wilted material, a lower efficiency of energy utilization has frequently been suggested. However, with the same DM intake from unwilted and wilted material, a large-scale experiment at our resarch centre showed no difference in dairy cow performance (table 6).

Table 6: Performance of dairy cows[1] fed equal amounts of unwilted or wilted silage (HONIG et al., 1984)

		Unwilted silage (3.6 kg formic acid/t) n = 59	Wilted silage (no additive) n = 60
DM content of silage[2]	(g/kg)	221	445
OM digestibility	(%)	75.7	71.6
Intake	(kg DM/day):		
Silage		9.14	9.04
Concentrates		7.40	7.40
Milk yield	(kg/d)	25.9	25.3
Milk fat	(%)	3.81	3.90
Milk protein	(%)	2.92	2.95
FCM, 4 %	(kg/d)	25.1	24.9
Live weight change	(kg/d)	0.08	0.09

1) weeks 5-18 of lactation   2) corrected for volatiles

Wilting has generally no influence on milk composition (ROHR and THOMAS, 1984). In a number of experiments, however, wilted silage supported a higher level of milk fat (CHRISTIANSEN et al., 1971; BERTILSSON, 1987; ROHR et al., 1989), the effect apparently being most pronounced with diets high in starchy concentrates (ROHR et al., 1989). When the intake of wilted silage was substantially higher as compared to low-moisture silage, Swedish workers found also an increase in milk protein (SPRÖNDLY, 1983; BERTILSSON, 1987).

Silage additives may stimulate intake and milk yield to a certain degree. In an analysis of data from dairy-cow experiments, WALDO (1978) found a response in milk yield to formic acid of 4 - 6 %. As formaldehyde is suspected of causing injuries of health, its use as silage additive is unlikely to continue. As far as inoculants are concerned, hitherto results are conflicting (KENT et al., 1988, 1989; COLENBRANDER et al., 1988; GORDON, 1989; MAYNE, 1990) and more research work is required. Today, there is also an increasing interest in cell-wall degrading enzymes as silage additives. At low concentrate intake, a cellulase/hemicellulase preparation was found to increase the daily amount of milk produced as well as milk protein yield (CHAMBERLAIN and ROBERTSON, 1989). Further studies are necessary to confirm this effect.

In the furture more attention must be paid to milk quality factors like fat composition and suitability for cheese making. The portion of unsaturated fatty acids in milk fat is related to the oil content of the forage (SAITO and NAKANISHI, 1969; CHRISTIANSEN et al., 1971) and can therefore be expected to be higher with early cut silage. Maize silage has been shown to decrease the portion of oleic acid and the iodine number of milk fat (DROZDOV, 1985; GRAVERT, 1988) and may thus impair the spreadability of winter butter. With regard to cheese making, the provision of silages with low counts of clostridia is a must. More than 30 years ago, THOMÉ et al. (1957) produced evidence that increasing numbers of clostrium spores in silage entail a corresponding increase of spores in faeces and milk. Uniform wilting (SCHUKKING, 1978) and the use of nitrite-containing additives (WEISSBACH and KÖHLER, 1989) are helpful in producing silages with low counts of lactate-fermenting clostridia.

Alterations in forage quality are of similar or even greater importance for growing-fattening cattle than for dairy cows. As to the response of growing cattle, comparisons between forages should rather be based on empty body or carcass gains than on live weight gains. This is because gut fill may differ considerably between hay-fed and silage-fed animals (MC CARRICK, 1966). Digestibility of hay or silage has a great effect on the productivity of beef cattle. In summarizing 40 feeding trials, FLYNN and WILSON (1978) showed a clear relationship between DM digestibility and animal performance in terms of live weight gain and carcass gain (table 7).

Table 7: Relationship between silage DM digestibility and production of beef cattle[1] (FLYNN and WILSON, 1978)

	DM digestibility (%)			
	60.4	65.0	68.6	74.5
Number of trials	6	10	16	8
Mean live weight gain (kg/d)	0.30	0.46	0.66	0.90
Mean carcass gain (kg/d)	0.23	0.33	0.41	0.51

1) with silage as the sole feed

In the Irish trials, about 70 % of the variation in carcass gains of steers fed grass silage as the sole feed could be explained by differences in digestibility (FLYNN, 1988). In two experiments, STEEN (1984) examined the effects of increasing the digestibility of grass silage offered to beef cattle by harvesting

three crops of grass after shorter growth intervals rather than two crops after longer growth intervals. Intake, live-weigt gain and carcass gain were significantly higher for the early cut silages. An improvement in animal performance due to earlier cutting of herbage for silage was also reported by other authors (THOMAS et al., 1980; STEEN and MC ILMOYLE, 1982b, 1982c; THOMAS et al., 1988). According to STEEN and MC ILMOYLE (1982b), the use of high digestibility silage is at least as important for mature, store cattle as for young, growing animals. Substitution rates are higher with early cut than with late cut silages and higher in young than in mature animals (STEEN and MC ILMOYLE, 1982b). THOMAS et al. (1988) studied the composition of empty body gain of steers fed restricted amounts (18 g DM/kg LW) of early-cut silage alone or late-cut silage alone or with barley (table 8).

Table 8: Daily gains in live weight, empty-body weight and empty body components of steers fed grass-silage-based diets (THOMAS et al., 1988)

		Early cut silage alone	Late cut silage alone	Late cut silage+barley (72:28)	Late cut silage+barley (44:56)
ME-intake	(MJ)	73.5	58.9	65.3	69.6
Live weight at slaughter	(kg)	393	354	382	408
Gains:					
Live weight	(g)	661	369	582	798
Carcass weight	(g)	696	292	552	800
Protein	(g)	87	31	76	116
Fat	(g)	260	121	189	302
Energy	(g)	12.24	5.48	9.23	14.58
Efficiency of ME-utilization for growth	(kg)[1]	0.33	0.26	0.33	0.46

1) Maintenance requirements were calculated from Agricultural Research Council (1980)

Protein and fat accretion was significantly higher with early cut as compared to late-cut silage. The amounts retained with early-cut silage, however, were less than those from a similar increment of ME achieved by substituting late-cut silage with barley. The higher efficiency of ME-utilization of the mixed diet has been related to the lower portion of ME from digestible cell walls (THOMAS et al., 1988; BEEVER et al., 1988).

Several authors have studied the performance of beef cattle given silages of either ryegrass or red clover. In animals of different size categories, intakes and daily gains were higher with clover silage than grass silage of similar digestibility (THOMAS et al., 1981; STEEN and MC ILMOYLE, 1982a; TAYLER and WILKINS, 1976). With little or no supplementary feed, red clover silage having a digestibility lower than grass silage nevertheless had a higher intake and produced higher live-weight gains (TAYLER and WILKINS, 1976; DAY et al., 1978).

In the EUROWILT experiments, DM intake in beef cattle was increased through wilting by 9 - 13 % (ROHR and THOMAS, 1984). Yet, the wilted silages without additive produced 5 % lower live-weight gains than HCOOH-treated high-moisture silages. Performance did not differ when both the wilted and unwilted silages had an addition of formic acid. When analyzing a series of 7 Irish experiments, FLYNN (1988) found higher intakes and somewhat higher live-weight gains with wilted silage but carcass gains tended to be lower. Where high dry matter contents could be achieved within a short period of time, daily gains and proteins accretion were similar or even higher with wilted as compared to unwilted silages (CHARMLEY and THOMAS, 1989; HINKS et al., 1976). When taking into account a) the contribution of alcohols in direct-cut silages, b) the reduction in digestibility on wilting, c) the differences in gut fill and d) the concentration of fat in the empty body, THOMAS and THOMAS (1988) interpreted results of CHARMLEY and THOMAS (1984) to the effect that differences in gross efficiency between wilted and unwilted silages were more apparent than real.

Some of the above-mentioned publications already illustrate the significance of additives when direct-cut silage is fed to growing cattle. With regard to the effect of formic acid based additives, THOMAS and THOMAS (1988) examined the data from 41 experiments. On average, the use of additive resulted in a 32 % increase in gain. In analyzing 14 experiments conducted at Grange, FLYNN and WILSON (1977) came up with a similar figure. That the response in beef cattle performance to formic acid is more than that observed with dairy cows may be a reflection of lower concentrate portions (THOMAS and THOMAS, 1988). With increasing amounts of supplementary feed the difference between

control and HCOOH-treated silages is less pronounced. Information with regard to other acids is meagre. In a comparison between formic and sulphuric acids, FLYNN and O'KIELY (1984) found little difference in carcass gain. KENNEDY (1990) came to the conclusion that sulphuric acid is a less effective silage additive than formic acid. Results on the effects of inoculants are not conclusive (HAIGH et al., 1984; STEEN et al., 1990; CLEALE et al., 1990); further elucidation is necessary.

In many regions of the European continent, maize silage is the preferential forage for growing fattening cattle. This is because excellent animal performance can be attained with just small amounts of concentrates. In comparative studies, however, it has been shown that high-quality grass silage may definitely compete with maize silage in this respect.

Table 9: Clover/grass silage vs. maize silage in diets for growing-fattening bulls[1] (LEHMANN, 1985)

Silage:		Maize	Clover/Grass	
Group		1	2	3
Number of bulls		15	15	20
Silage composition:				
DM content	(g/kg)	316	334	325
NE content	(MJ/kg DM)	6.9	6.0	6.0
Intake:				
Concentrates	(kg DM/d)	1.2	0.9	0.9
Silage	(kg DM/d)	4.6	5.6	5.3
NE	(MJ/d)	40	40	39
Live-weight gain	(kg/d)	1.11	1.13	1.07
MJ NE/kg LWG		36.6	35.2	36.7

1) 145-512 kg live weight

LEHMANN (1985) in Switzerland compared both forages in fattening bulls over a live-weight range from 150-510 kg (table 9). With no more than 1-1.5 kg of concentrates, live-weight gains of 1.1 kg/d were achieved in both cases. The lower energy content of the clover/grass silage was compensated by a higher DM intake.

In an experiment at our station, medium-quality grass silage gave a lower response in finishing bulls than maize silage (table 10).

Table 10: Finishing bulls (305-575 kg LW) with either maize silage, beet top silage or grass silage (DAENICKE and Rohr, 1988)

Silage:		Maize	Beet-top	Grass
Silage composition:				
DM content	(g/kg)	342	167	562
DOM	(g/kg DM)	694	558	571
ME	(MJ/kg DM)	11.2	9.2	9.1
Intake:				
Concentrates	(kg DM/d)	2.65	2.68	2.68
Silage	(kg DM/d)	6.25	7.12	6.36
ME	(MJ/d)	104	102	95
Performance data:				
Live-weight gain	(kg/d)	1.38	1.37	1.24
Carcass gain	(kg/d)	0.71	0.75	0.64
Belly cavity fat	(kg)	47.8	43.4	37.0

On the other hand, beet top silage resulted in similar gains as maize silage due to significantly higher intakes. As indicated by the lower amount of belly cavity fat, the carcasses were less fat with the beet top silage.

References

BANKS,J.M., CLAPPERTON,J.L., MUIR,D.D. and GIRDLER,A.K. (1986). J.Sci.Food Agric. 37, 461-468

BEEVER,D.E., CAMMELL,S.B., THOMAS,C., SPOONER,M.C., HAINES,M.J. and GALE,D.L. (1988). Br.J.Nutr. 60, 307-319

BERTILSSON,J. (1987). Swedish J.agric.Res. 17, 123-131

BERTILSSON,J. and BURSTEDT,E. (1983). Swedish J.agric.Res. 13, 189-200

BOSWELL,C.C. (1971). J.Br.Grassl.Soc. 24, 194 (Abstr.)

CASTLE,M.E. and WATSON,J.N. (1970). J.Br.Grassl.Soc. 25, 65-70

CHAMBERLAIN,D.G. and ROBERTSON,S. (1989). Occas.Symp.Brit.Grassl.Soc. 23, 187-189, Hannah Res. Inst.

CHARMLEY,E. and THOMAS,C. (1984). Landbauforsch. Völkenrode, Sdhft 69, 21-23

CHARMLEY,E. and THOMAS,C. (1989). Anim.Prod. 48, 91-98

CHRISTIANSEN,B., SKOVBORG,E.B. and ANDERSEN,P.E. (1971). 2. Beretning fra Faellesudvalget for Statens Planteavls-og Husdyrbrugsforsøg, Kopenhagen

CLEALE,R.M., FIRKINS,J.L., VAN DER BEEK,F., CLARK,J.H., JASTER,E.H., MC COY,G.C. and KLUSMEYER,T.H. (1990). J.Dairy Sci. 73, 711-718

COLENBRANDER,V.F., GRANT,R.J. and SCHAAF,G. (1988). Applied Agric.Res. 3, 55-59

CORBETT,J.L., LANGLANDS,J.P. and REID,G.W. (1963). Anim.Prod. 5, 119-129

DAENICKE,R. and ROHR,K. (1988). Landbauforsch.Völkenrode 38, 329-337

DAY,N., HARKESS,R.D. and HARRISON,D.M. (1978). Anim.Prod. 26, 97-100

DEMARQUILLY,C. (1983). Ann.Zootech. 22, 1-35

DROZDOV,N.M. (1985). Molochnaya Promyshlennost' 6, 33-34

DULPHY,J.P. and ROUEL,J. (1988). Ann.Zootech. 37, 31-42

DULPHY,J.P., MICHALET-DOREAU,B. and DEMARQUILLY,C. (1984). Ann.Zootech. 33, 291-320

DURGIAI,B. (1989). Landwirtschaft Schweiz 2, 161-167

FLYNN,A.V. (1988). In: Recent Developments in Ruminant Nutrition 2, pp 265-273 (Eds. W.Haresign and D.J.A.Cole) Butterworths, London

FLYNN,A.V. and WILSON,R.K. (1977). Proc.Intern.Meeting on Animal Production from Temperate Grassland (Dublin) Abstract 303

FLYNN,A.V. and WILSON,R.K. (1978). 7th Gener.Meeting Europ.Grassl.Fed. (Gent) pp 6.3-6.15

MEIJS,J.A.C. (1986). 4. Verslag van de beweidingsproef in 1984, IVVO, Rapport Nr. 187

MINSON,D.J., HARRIS,C.E., RAYMOND,W.F. and MILFORD,R.J. (1964). J.Br.Grassl.Soc. 19, 298-305

OSBOURN,D.F., THOMSON,D.J. and TERRY,R.A. (1966). 10th Intern.Grassl. Congr. (Helsinki) pp 363-367

PEOPLES,A.C. and GORDON,F.J. (1989). Anim.Prod. 48, 64-70

PHIPPS,R.H., WELLER,R.F. and BINES,J.A. (1987). Grass and Forage Science 42, 49-58

PRECHT,D., FREDE,E., HAGEMEISTER,H. and TIMMEN,H. (1985). Fette, Seifen, Anstrichmittel 87, 117-126

RAE,R.C., THOMAS,C., REEVE,A., GOLIGHTLY,A.J., HODSON,R.G. and BAKER, R.D. (1987a). Grass and Forage Science 42, 249-257

RAE,R.C., REEVE,A. and THOMAS,C. (1987b). J.Sci.Food Agric. 39, 230-231

ROHR,K. (1972). Kieler Milchw.Forschungsber. 24, 23-96

ROHR,K. and THOMAS,C. (1984). Landbauforsch. Völkenrode Sdrhft 69, 64-70

ROHR,K., LEBZIEN,P., DAENICKE,R. and SCHAFFT,H. (1989). Landwirtsch.Forschung 42, 27-46

SAITO,T. and NAGANISHI,T. (1969). Jap.J.Dairy Sci. 18, A 142-149

SPRÖNDLY,E. (1983). SHS meddelande 121

STEEN,R.W.J. (1984). Anim.Prod. 38, 171-179

STEEN,R.W.J. and MC ILMOYLE,W.A. (1982a). Anim.Prod. 34, 95-101

STEEN,R.W.J. and MC ILMOYLE,W.A. (1982b). Anim.Prod. 34, 301-308

STEEN,R.W.J. and MC ILMOYLE,W.A. (1982c). Anim.Prod. 35, 245-252

STEEN,R.W.J., UNSWORTH,E.F., GRACEY,H.I., KENNEDY,S.J., ANDERSON,R. and KILPATRICK,D.J. (1990). Grass and Forage Science 44, 381-390

STEHR,W. and KIRCHGESSNER,M. (1976). Anim.Feed Sci.Techn. 1, 53-60

TAYLER,J.C. and WILKINS,R.J. (1976). In: Principles of Cattle Production, pp 343-364 (Eds. H.Swan and W.H.Broster), Butterworths, London

TAYLOR,W. and LEAVER,J.D. (1984). Anim.Prod. 39, 325-333

THOMAS,C., GIBBS,B.G., ASTON,K. and TAYLER,J.C. (1980). In: Forage Conservation in the 80', pp 383-387 (Ed.C.Thomas) Janssen Services, London

THOMAS,C., GIBBS,B.G. and TAYLER,J.C. (1981a). Anim.Prod. 32, 149-153

FLYNN,A.V. and O'KIELY,P. (1984). Proc.7th Silage Conf., pp 15-16 (Eds. F.J.Gordon and E.F.Unsworth) Queens University, Belfast

GORDON,F.J. (1976). Anim.Prod. 22, 175-187

GORDON,F.J. (1989). Grass and Forage Science 44, 353-357

GRADISON,A.S., MANNING,D.J., THOMSON,D.J. and ANDERSON,M. (1985). J.Dairy Res. 52, 33-39

GRAVERT,H.O. (1988). In: Bedeutung der Milchinhaltsstoffe, MFI-Seminar (Köln) S. 26-35

HAIGH,P.M., APPLETON,M. and CLENCH,S.F. (1984). Mimeograph NC/C/719, Agric.Developm.Adv.Service

HINKS,C.E., EDWARDS,D.E. and HENDERSON,A.R. (1976). Anim.Prod. 22, 217-224

HODEN,A., COULON,J.B. and DULPHY,J.P. (1985). Bull.Tech.C.R.Z.V. Theix, INRA, 62, 69-79

HONIG,H., ROHR,K. and DAENICKE,R. (1984). Landbauforsch. Völkenrode Sdrhft 19, 39-41

KENNEDY,S.J. (1990). Grass and Forage Science 45, 17-28

KENT,B.A., ARAMBEL,M.J. and WALTERS,J.L. (1988). J.Dairy Sci. 71, 2457-2561

KENT,B.A., ARAMBEL,M.J. and WINSRYG,M.D. (1989). J.Dairy Sci. 72, 2325-2330

KRISTENSEN,V.F., SKOVBORG,E.B. and ANDERSEN,P.E. (1979). 30th Ann.Meet.EAAP, N 1.7 (Harrogate)

LEAVER,J.D. (1982). Grass and Forage Science 37, 285-290

LEAVER,J.D. (1985). J.Dairy Res. 52, 313-344

LEAVER,J.D. (1988). In: Recent Developments in Ruminant Nutrition 2, pp 213-222 (Eds.W.Haresign and D.J.A.Cole) Butterworths, London

LE DU,Y.L.P., BAKER,R.D. and NEWBERRY,R.D. (1981). Grass and Forage Science 36, 307-318

LE DU,Y.L.P. and HUTCHINSON,M. (1982). In: Milk from Grass, pp 43-57 (Eds.C.Thomas and J.W.O.Young) Hurley: ICI/GR)

LEHMANN,E. (1985). DLG-Mitteilungen 100, 105, 115, 116

MC CARRICK,R.B. (1966). Proc.10th Intern.Grassl.Congr. (Helsinki) pp 575-580

MAYNE,C.S. (1990). Anim.Prod. 51, 1-13

MEIJS,J.A.C. (1983). Proc.14th Intern.Grassl.Congr. (Kentucky) pp 667-670

MEIJS,J.A.C. (1984). In: Grassland Beef Production, pp 151-160 (Ed.W.Holmes) Martinus Nijhoff Publ., Boston/The Hague/Dordrecht/Lancaster

THOMAS,C., DALEY,S.R., ASTON,K. and HUGHES,P.M. (1981b). Anim.Prod. 33, 7-13

THOMAS,C. and THOMAS,P.C. (1988). In: Recent Developments in Ruminant Nutrition 2, pp 274-307 (Eds.W.Haresign and D.J.A.Cole) Butterworths, London

THOMAS,C., GIBBS,B.G., BEEVER,D.E. and THURNHAM,B.R. (1988). Br.J.Nutr. 60, 297-306

THOMÉ,K.E., SWARTLUND ,P., LODIN,L.O., MATTSON,S., WESSBER,P., BUHRGARD,A.B. and LINDGREN,B. (1957). Medd.No.38 från Statens Mejeriförsök

THOMSON,D.J., BEEVER,D.E., HAINES,M.J., CAMMELL,S.B., EVANS,R.T., DHANDA,M.S. and AUSTIN,A.R. (1985). J.Dairy Res. 52, 17-31

VÉRITÉ,R. and JOURNET,M. (1970). Ann.Zootech. 19, 255-268

VON BOTHMER,G. (1987). In: 4. Seminar der Deutsch-Niederländ.Arbeitsgruppe f.Rinderhaltung, S. 65-75 (Hsg.V.Stolpmann), Braunschweig

WALDO,D.R. (1977). J.Dairy Sci. 60, 306-326

WEISSBACH,F. und KÖHLER,S. (1989). Tierzucht 43, 383-385

WRIGHT,I.A., RUSSEL,A.J.F. and HUNTER,E.A. (1989). Anim.Prod. 48, 43-50

HYGIENIC PROBLEMS IN CONSERVED FORAGE

Sven Lindgren
Department of Microbiology
Swedish University of Agricultural Sciences
Box 7025, S-750 07 Uppsala, Sweden

SUMMARY

Conservation of forage is traditionally based upon one or a mixture of some well established principles like reduction in water (drying), acidification, anaerobic storage and storage at low temperatures. Developments and modification of feed storage systems during the last decades have mainly focused on efficiency and economy of handling. These developments have resulted in systems with deficiencies in biological function. For many of the new systems, unacceptable microbial growth can be frequently observed. For the farmer the main consequences of this growth in the forage are losses in nutritional value, reduction in DM, heat production, loss in conservation efficiency and health hazards like mycotoxicosis, infections and respiratory allergies for animals as well as humans. In addition the dairy will be subjected to spore contaminated milk.

INTRODUCTION

After harvest, biological structures of vegetable nature are subjected to a rapid microbial deterioration. This fundamental recycling of nutrients is in conflict with the ambition of man to preserve food and feeds for later consumption. When proper storage conditions are not obtained, deterioration restricts the suitability of harvested products for animal feeding. The growth of micro-organisms reduces the nutritional value and can lead to health hazards, e.g. toxicosis, infections and respiratory allergies for animals as well as for humans (Lacey, 1975; Woolford, 1990).

Factors affecting contamination and unacceptable growth in stored forage can be identified from the field to the feeding table (see Fig 1). Conditions causing an unacceptable microbial growth during storage are rather well documented, but the influence of field associated problems are more obscure.