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THE EFFECT OF RATIO OF HAY TO SILAGE DRY MATTER ON MILK PRODUCTION

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THE EFFECT OF RATIO OF HAY TO SILAGE DRY MATTER ON MILK PRODUCTION

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Dairy farmers are interested in knowing to what degree legume-grass silage may be substituted for hay of similar quality in the ration of the milking herd. This question is especially important in the northeastern United States where cloudy weather and rain are frequent when the first cutting must be made. Three consecutive days without rain seldom occur during the period of May 15 to June 10 for curing hay. Permitting the crop to stand until later before cutting results in lowered digestibility and drop in milk production (8).

Experiences with silage reported at the early part of this century were universally favorable. This may have been partially due to replacing corn fodder or hay of low quality. While the workers were probably aware of the quality of forage with which they were working, it is difficult to interpret their results in light of present forage quality standards.

Canadian workers (1) reported an experiment in which four balanced groups of cows were fed grain at the ratio of one pound to four pounds of milk and silage to appetite. For forage, group A had only grass silage while B had in addition, one-third of a pound of hay per hundred pounds of body weight, C had two-thirds of a pound of hay per hundredweight and D had a full pound of hay per hundredweight. They reported that no significant differences were found in milk production, change in body weight, or in butterfat content of the milk. Therefore, they advocated the use of large amounts of grass silage.

The report of Sykes *et al.* (37) that alfalfa silage was unsatisfactory as the only roughage for growing dairy heifers in a limited milk and grain feeding system, suggests a careful look at existing data to determine whether caution must also be used in feeding legume silage as the only forage for milk production.

Blosser *et al.* (5) in 1951 found in an experiment with 15 milking cows that milk yields were better maintained on a ration containing five pounds of medium quality chopped alfalfa hay plus alfalfa-grass silage than on silage without hay. Those fed hay plus silage averaged 38.8 pounds of 4 percent F.C.M. daily as compared with 37.7 for those on silage only.

Bechdel (3) reported in 1923 on the feeding of silage and hay made of a mixture of one-third timothy and two-thirds red clover cut when the clover was in full bloom. A grain mixture containing 20.25 percent crude protein was fed in proportion to milk production. The cows fed both silage and hay had ingested 15.5 pounds of dry matter as compared with 17.3 pounds for those fed hay alone. The milk production (as computed to a 4 percent F.C.M. basis by the writers) was 9.2 percent greater when silage was substituted for a little more than half the hay. He concluded that clover silage and hay were better for milk production than hay alone.

Clark (7) of the Montana Station fed clover hay in comparison with clover silage to groups of five cows each. The cows were allowed fixed amounts of timothy hay and grain in proportion to milk production. The simple reversal experiment was of five weeks per period. Although they had slightly more grain the cows produced 7 percent more (when calculated to 4 percent F.C.M.) when they were fed clover silage. A second experiment was conducted when no timothy hay was allowed and the cows produced only 96 percent as much milk while they were fed silage. During a third experiment the cows produced 4 percent more while they were fed silage. For the three experiments combined, 6 percent more milk was produced during the periods while they were fed silage. It is significant that no mention was made of the dry matter content of either hay or silage.

The value of red clover silage and hay for milk production was studied by Huffman *et al.* (17) who cut on June 15 a mixture of 90 percent red clover in the three-fourth bloom stage, 5 percent timothy in the boot stage and 5 percent bromegrass in the bud stage. Part was wilted and ensiled without a preservative. Part was ensiled without wilting with 50 pounds of molasses per ton. The part used for hay had three light showers before being baled on June 22 but graded No. 1 on color and leaf. He found the dry matter of the silage 62 percent digestible and that of hay 64 percent digestible. There was a corresponding difference in the calculated T.D.N. of the two forages. Although the cows ate more dry matter from hay and gained more weight they produced slightly more milk when fed silage. The coefficient of digestibility of protein of silage was 54 percent while that of hay was 63 percent. The probability of a loss of leaves from the hay is suggested by the higher crude protein content of the silage calculated on a dry matter basis.

In three feeding trials reported by Pratt and Holdaway (29) clover-molasses silage produced 3.5 percent more 4 percent F. C. M.

than clover hay. The ratios of pounds of 4 percent F.C.M. per pound of dry matter eaten were 1.05 for clover-molasses silage and 1.0 for clover hay. It is assumed that the molasses made the silage more palatable and also increased the energy intake above maintenance for milk production.

Bechdel *et al.* (4) after feeding alfalfa silage in comparison with alfalfa hay concluded "Alfalfa silage is not satisfactory as the sole roughage for milking cows. It should be fed in connection with at least 5 pounds of hay daily which need not be of high grade."

The effect of addition of hay to a basic ration of corn silage and grain at a ratio of one pound for four of milk, was investigated by Waugh *et al.* (39). Four groups were fed (1) no hay; (2) one-fourth pound hay per hundredweight of body weight; (3) one-half pound per hundredweight of body weight; and (4) one pound per hundredweight of body weight. Those offered 1.0 pound ate 0.83 pound and showed the highest dry matter intake. The group fed 0.5 pound of hay produced the greatest amount of milk fat and 4 percent F.C.M. This ration is different from one containing grass silage, as the carbohydrate which is deficient in grass silage is supplied by corn silage.

The effect of wilting on the characteristics of silage was emphasized by Eckles *et al.* (11), Perkins *et al.* (26), and later by Woodward and Shepherd (41), and Woodward (40). Martin *et al.* (22) found that the effect of wilting upon acidity was greater than the effect of preservatives. The total acidity of wilted legume silage was shown to be lower than that of high moisture silage. Stone and coworkers (35) found an increase in the sugar content of forage after wilting. They stated "all silages underwent a typical lactic acid fermentation irrespective of treatment and after the first two days contained principally lactobacilli." Gordon *et al.* (13) found that more sugar and nitrogen-free extract remain in half dry silage than in high moisture silage. They also found a higher pH in half dry silage. Their cows when fed half dry silage gained body weight instead of losing and declined less in milk production. They ate more dry matter per hundredweight of milk produced. Shepherd and others (31, 32) compared wilted alfalfa silage to alfalfa hay in four trials and found the palatability of wilted silage as good and the nutritive value equal to or superior to that of hay. Shepherd *et al.* (30) cut an alfalfa-clover mixture and (1) ensiled at 32 to 40 percent dry matter without a preservative· (2) made field cured hay; and (3) made barn dried hay. A study was made of losses from cutting to feeding. The dry matter that was fed as silage was 83 percent of that cut as compared with 75 percent when made into

field cured hay. Barn-cured hay was intermediate in this respect. The daily production of the three groups in 4 percent F.C.M. was not significantly different, averaging four gallons per day. They found that equal amounts of dry matter from the three sources resulted in equal production of 4 percent F.C.M. Likewise, Turk *et al.* (38) cut three comparable areas for silage, field-cured hay and barn-dried hay. The forage for silage was field chopped when partially wilted and ensiled without a preservative. The three forages were fed in a double reversal experiment in which six pounds of mixed hay were fed in addition to the experimental forage. Only 79 percent of the dry matter of the crop as cut for silage remained for feeding, intermediate in this respect between barn-cured and field-cured hay. The cows produced slightly more milk while on silage although they ate less dry matter. In a later report Shepherd *et al.* (33) reported experiments on six cuttings of alfalfa over a five-year period which showed that alfalfa barn-dried with heat resulted in 37.9 pounds of 4 percent F.C.M. daily compared with 36.2 from wilted silage. The dry matter intake of the total ration was 33.1 pounds while the cows were fed barn-dried hay and 32.1 while fed wilted silage. The relative efficiencies were 1.14 pounds of milk from a pound of dry matter for cows fed hay and 1.12 pounds while fed wilted silage.

Newlander and coworkers (24) found that silages contained more ether extract than hays, and less nitrogen free extract. The greater ether extract is now recognized to be due to solubility of the organic acids formed by fermentation of the nitrogen free extract. They found the coefficients of digestibilty of nitrogen free extract of hays to be higher than those of silage while the reverse was true for ether extract.

In an earlier report Shepherd and Woodward (34) described an experiment in which silage, averaging 56 percent dry matter and ranging from 43 to 72 percent dry matter, was consumed in amounts containing more dry matter than was eaten in the form of hay. Those fed high dry matter silage declined less in milk flow than those fed hay. They stated that "Analyses showed that most of the dry matter lost was nitrogen free extract." Lundquist *et al.* (21) also found silage was superior to hay when both were made from grass and alfalfa cut when the alfalfa was in the bud stage and fed as the sole source of nutrients. The dry matter content of the silage was not given. Their cows when fed silage produced 23.1 $\mp$ 1.43 pounds of milk and 20.4 $\pm$ 1.58 when fed hay.

Little and Wolcott (19) found that when hay crop silage and barn-cured hay, cut the same day, were fed in an all roughage ration

to "depleted" cows, there were no significant differences in milk production.

To compare the feeding value of field-cured baled hay and hay-crop silage, Little *et al.* (18) fed silage cut June 24 and 25 in comparison with hay cut July 1 and cured without rain to cows depleted by 45 days of feeding an all hay ration. The same amount of 4 percent F.C.M. was produced per pound of dry matter while the cows were fed each forage although the cows ate more dry matter in the form of hay. The writers interpret this to mean that the loss of nitrogen-free extract by fermentation of the silage was equalled by the decrease in digestibility of the hay due to being cut one week later (8). Field losses were not involved in this comparison.

Horwood and Wells (16) fed second-cutting alfalfa cut September 23 and 24 in the tenth bloom stage, as hay and as silage preserved with 30 pounds of molasses per ton (diluted one to three with water). Three cows per group were fed for three 35-day periods in a double reversal experiment with the result that the cows produced 3.5 percent more milk on silage. They gained about 20 percent more body weight while on hay indicating that they had consumed sufficient energy to have produced more milk.

Graves and others (14) fed two groups of four cows each, with comparable previous lactation records, with hay and silage made from immature pasture herbage. Those fed only silage made an equivalent lactation of 9,942 pounds 4 percent F.C.M. which as compared to previous lactation records of 16,196 was 61.4 percent of their production on a complete ration with grain. Those fed hay only produced an equivalent of 10,757 pounds 4 percent F.C.M. which as compared to their previous record of 16,547 pounds on a complete ration was 63.6 percent of their previous production. According to standards for production and maintenance the cows on hay ate 19 percent in excess of requirements while those on silage ate only 5 percent in excess of requirements. This experiment differs from those referred to previously in that the forage would be very high in protein.

McCullough (23) reported an experiment in which differences in dry matter digestibility, crude protein, crude fiber and calculated total digestible nutrients accounted for 93 percent of the variation in average silage dry matter intake. Camburn *et al.* (6) studying alfalfa and timothy, found that the nutrients, other than ether extract, in the hays were somewhat more digestible than those in the silages. The Vermont workers reported elsewhere (25) an experiment in which silages had been made with a variety of preservatives. They found

the silages and hays made at the same stage of growth to be equally digestible except for ether extract which was lower in the sun-cured hay. The digestibility of the ether extract of sun-cured hay was reported to be markedly depressed.

PURPOSE OF EXPERIMENT

The purpose of this experiment was to determine: (1) whether grass-legume silage could completely replace hay of the same type in the ration of milking cows; (2) if not, the extent to which substitution could be made; and (3) the effects of such substitution on milk production.

EXPERIMENTAL METHODS

Mixed alfalfa-grass was direct-cut with a field chopper and ensiled without a preservative. The moisture content of this material was high and excessive leakage occurred. Part of the field was mowed for hay at the same stage of growth. This was baled and finished on a mow drier with heat.

Both forages were fed on a dry matter basis in the following ratios:

	Percentage of Forage Dry Matter				
Treatment	I	II	III	IV	V
Silage	100	80	50	20	0
Hay	0	20	50	80	100

Feeding. Grain and forage were fed in the ratio of one pound of grain dry matter to three pounds of forage dry matter: stated differently, 25 percent of the ration dry matter was from grain and 75 percent from forage thereby avoiding grain changes during the experimental period. Elliot and Loosli (12) in studying the effect of dietary ratio of hay to concentrate on milk production, ration digestibility and urinary energy losses found that when the estimated net energy (E.N.E.) above maintenance was held constant changes from 20 to 40 to 60 percent of the E.N.E. from hay made no difference in production for cows milking at the 45 pound level. In the experiment reported here the ratio of 25 percent grain dry matter to 75 percent forage dry matter results in 36 percent of the E.N.E. coming from grain. Dry matter analyses of silage, hay and grain were made at the mid point of each 10-day period and the amounts fed each cow for the next period were based on these dry matter analyses. Whenever feeding changes were made the 1:3 ratio was maintained. Refusal was weighed back and any necessary adjustments in forage and grain feeding were made daily.

Grain Mixture. The mixture fed to all cows consisted of 450 pounds ground shelled corn, 300 pounds ground oats, 100 pounds wheat bran, 50 pounds soybean oilmeal and 10 pounds iodized salt. This mixture was calculated to contain an average of 12.8 percent crude protein. Steamed bonemeal and salt were offered free choice in the exercise yard.

Experimental Animals. Twelve Jersey and three Holstein cows in early lactation were divided into five similar groups of three each and randomly assigned to treatments I, II and III in the winter of 1954-55. Twelve Jersey and six Holstein cows were similarly assigned to treatments III, IV and V in 1955-56.

In 1956-57 one Jersey, one Guernsey and three Holstein cows were similarly assigned to each of groups I, III and V in an experiment to determine whether wilted silage would act as direct-cut-silage had in substituting for hay.

The basis for grouping the cows was (1) mature equivalent (M.E.) 4 percent F.C.M. based on previous performance; (2) daily production at the start of the experiment; (3) age; (4) breed; and (5) body weight.

Experimental Design. A continuous feeding trial was utilized. It consisted of two 10-day preliminary periods and of ten 10-day experimental periods in 1954-55, of two preliminary and nine 10-day periods in 1955-56 and two preliminary and nine 10-day periods in 1956-57.

During the preliminary periods each cow received uniform rations of 50 percent forage dry matter from legume-grass silage and 50 percent from hay. Milk production during the preliminary period was used to adjust by analysis of covariance the production during the experimental periods for differences among animals not attributed to the silage-hay rations before testing for statistical significance as suggested by Lucas (20). The change to the ratio called for by each treatment was made abruptly at the beginning of the first experimental period. The only exception to this was in treatment I in 1954-55, when small amounts of hay were allowed for the first two days to facilitate adjustment.

Weighing of Cows. The cows were weighed for three successive days at the beginning of preliminary period 1 and experimental period 1, and again at the close of the final period. They were weighed at intervals throughout the experiment to assure weight change data.

Milk Sampling. Milk was composited for two milkings during each 10-day period and tested for butterfat to permit calculation of equivalent 4 percent F.C.M. per period.

RESULTS AND DISCUSSION

For reasons of uniformity the data of the first nine experimental periods only of the experiment on treatments I, II and III for 1954-55 were used. The average dry matter analyses on grain mixture, hay and silage are shown in Table 1 for the three years.

The legume-grass mixture was cut for silage and for hay on June 1, 1954. The field sample collected for analyses contained 27 percent dry matter and 175 micrograms of carotene on the dry basis. The silage was made without intentional wilting not because this method makes silage of ideal quality but because many farmers were making silage in that way in 1954 to avoid wilting which was regarded as a more time consuming practice.

A typical silage sample taken at mid-experiment contained 19.5 percent dry matter and had a pH of 5.10. Expressed silage juice showed a total acidity equivalent to 8.8 ml. of 0.1 N NaOH per 10 ml. of juice and total steam volatile fatty acid content of 0.344 milliequivalents of acid per ml. When the silage juice was diluted to five volumes and one ml. used for chromatographic separation of the volatile fatty acids, it was found to contain 0.84 acetic acid, 0.26 percent propionic acid and 1.00 percent butyric acid. In contrast a typical sample of silage of 48 percent dry matter used in a later experiment contained 7.46 percent acid which was composed of 1.57 percent acetic, 0.52 percent propionic, 0.04 percent butyric and 5.33 percent lactic acids (as compared with 0.0 to 1.3 percent lactic in untreated low dry matter silage (27). The high concentration of the latter presumably was the result of the high dry matter content of the silage. Even though the odor of butyric acid is objectionable to the human, the cow may not object correspondingly, as butyric acid is produced in the rumen and regurgitated in the cud so that the cow is accustomed to its taste and odor.

The hay was field baled and finished on a mow drier. Usually the hay was more acceptable to the cows than the silage. In 1956 the hay was over-ventilated with heated air making the stems brittle and harsh. In this year the silage was more readily acceptable.

Proximate analyses of the hays, silages and grain mixture used also appear in Table 1.

The feed intake and the milk production for the three years presented in Table 2 are averaged on a per cow per day basis for each treatment. When the daily production for the groups on each treatment was adjusted by regression analysis to that of the preliminary period the variations between adjusted means were not significant.

TABLE 1.—Average Chemical Analyses of Feeds Used[1].

Year	Dry Matter	Crude Protein	Non-protein Nitrogen[2]	Ether Extract	Ash	Crude Fiber	N.F.E.
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1954-55							
Hay	88.40	11.49	0.28	1.39	8.22	29.38	49.52
Silage	21.70	11.60	0.63	--	--	--	--
Grain	85.70	13.60	--	--	--	--	--
1955-56							
Hay	88.28	14.00	0.33	1.21	8.22	49.60	26.97
Silage	22.50	13.67	0.76	2.19	8.40	30.45	45.29
Grain	85.15	13.70	--	1.03	4.34	19.59	38.66
1956-57							
Hay	87.50	14.45	0.35	1.24	7.54	31.79	44.98
Silage	42.22	13.33	0.88	1.67	8.29	31.64	45.07
Grain	82.77	13.25	--	2.80	5.22	5.41	73.32

[1] Dry basis.

[2] Trichloracetic acid soluble nitrogen.

The dry matter of the total ration was lower in the case of low dry matter silage than when hay only was fed. This was not true of high dry matter silage where dry matter intake from silage was slightly greater than from hay. The ratio of pounds of 4 percent F.C.M. per pound of dry matter eaten in 1954-55 and 1955-56 shows the production of milk when the cows were fed silage to be more efficient than when fed hay. This finding is in agreement with the recent results of Stone *et al.* (36). When low dry matter silage was fed, the dry matter intake became progressively greater as the proportion of hay eaten increased during 1954-55 and 1955-56. This trend was not seen in the data of 1956-57 when the silage had a high dry matter content. During the first two years when the silage had a low dry matter content, the cows showed a preference for hay which was of good quality; however, in 1956-57 when the silage had a high dry matter content and the hay had been overdried making the stems brittle, the cows showed a decided preference for silage.

Table 3 presents the average body weights of the groups of cows at the beginning of experimental period I and end of the experiment for each year. The uniformity of weights of the groups for 1954-55 and 1955-56 reflects success in balancing the groups. In 1956-57 divergence in both body weights and milk production made balancing difficult. Grouping to give similar initial production seemed more important. Because of differences in individual and in average group weights between years and within 1956-57, body weight changes and

TABLE 2.—Average Feed Intake and Milk Production Per Cow Per Day.

Treatment[1]	Group	Actual Milk	Butterfat	4% F.C.M.	4% F.C.M. / 1000# body wt.	Silage	Hay	Grain	Dry Matter Intake	4% F.C.M. / Dry Matter	Body wt. change[2] Actual	Body wt. change[2] /1000# body wt.
		(lb.)	(%)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
					Low Dry Matter Silage							
1954-55												
100: 0	I	24.8	4.7	27.5	32.2	67.6	0.2	5.9	19.6	1.41	- 18	- 21
80: 20	II	23.5	4.6	25.6	28.0	59.7	3.6	6.4	21.4	1.20	+ 28	+ 31
50: 50	III	24.5	4.9	27.6	32.5	39.7	9.3	6.6	22.3	1.24	+ 15	+ 18
1955-56												
50: 50	III	27.1	4.4	28.7	30.9	41.3	10.1	7.6	24.7	1.16	+ 19	+ 21
20: 80	IV	25.6	4.3	28.8	29.2	19.4	18.9	8.7	28.4	1.01	+ 34	+ 35
0:100	V	31.4	4.0	31.6	33.7	--	25.3	9.1	30.1	1.05	+ 17	+ 18
					High Dry Matter Silage							
1956-57												
100: 0	I	25.9	3.9	25.2	22.9	46.0	--	8.8	28.9	0.87	+ 15	+ 14
50: 50	III	28.1	4.0	28.2	28.8	24.4	12.0	9.1	29.9	0.94	+ 9	+ 9
0:100	V	22.2	4.1	22.7	20.2	--	23.3	8.7	28.4	0.84	+ 40	+ 36

[1] Ratio of pounds of silage to hay dry matter in the ration.

[2] During 90 days of experiment.

TABLE 3.—Average Body Weights of Groups at the Beginning and Close of the Experiments.

Year	Treatment	Beginning	Close	Change[1]	Standard Deviation
		(lb.)	(lb.)	(lb.)	(lb.)
		Low Dry Matter Silage			
1954-55	I	862	844	- 18	± 36
	II	898	926	+ 28	± 40
	III	841	856	+ 15	± 33
1955-56	III	919	938	+ 19	± 36
	IV	969	1003	+ 34	± 51
	V	929	946	+ 17	± 50
		High Dry Matter Silage			
1956-57	I	1090	1105	+ 15	± 81
	III	975	984	+ 9	± 27
	V	1105	1145	+ 40	± 76

[1] During 90 days.

milk production have been calculated on the 1000 pound body weight basis. For 1954-55 and 1955-56 when high moisture silage was fed no definite trend in body weight changes or production is apparent that can be related to the ratio of silage to hay. The loss in body weight (Table 3) for the group fed all silage in 1954-55 seems to indicate lack of energy in the ration since silage was fed *ad lib.*, quality of the silage seems to have limited intake to a level below that sufficient for maintenance of body weight. Loss of body weight has been observed in other experiments in which low moisture silage provided the only roughage (28). In the latter case this type of ration resulted in loss of production at the end of lactation. The 100:0 silage:hay group in 1954-55 ate 22.7 pounds of silage dry matter per 1000 pounds of body weight in contrast with 26.5 pounds for 1956-57 when high dry matter silage was fed. Contributing to the ability of the 100:0 group in 1956-57 to maintain their weight was the low milk production per pound of dry matter eaten.

Digestion trials were conducted in connection with these feeding trials with the cows remaining in their regular stalls. Trials were also run on additional cows fed the same forage:grain ratios. In all trials the grain provided 25 percent of the ration dry matter and forage 75

percent. The efficiency of utilization of the nitrogen of the ration used for milk production was reported by Conrad *et al.* (9). In 1954-55 and 1955-56 when the silage was low in dry matter, equal efficiency nitrogen utilization for milk production was shown by the group fed silage only and that fed hay only; however, the group fed silage only showed a greater over-all efficiency in utilization of nitrogen and a lower level of milk production partly due to the lower protein content of the ration in the 1954-55 digestion trial. No notable differences in nitrogen efficiency or urine losses were observed in cows fed different proportions of hay and silage that could not be explained on the basis of the amount of digestible dry matter consumed or the crude protein content of the ration (9).

In Table 4 the coefficients of digestibility of dry matter and of protein are presented for animals fed the different ratios of silage:hay dry matter. There is no definite trend due to change in silage:hay dry matter ratio.

Cows 1184 and 1132 were on digestion trial at a time when the silage contained 57 percent dry matter and was tobacco brown due to high sugar content and heat of fermentation. One fresh green sample of ensiled material analyzing 55.0 percent dry matter contained 4.0 percent reducing sugar on a dry matter basis thus providing the sugar for production of the tobacco brown condition.

If a legume-grass mixture of 20 percent dry matter content at cutting was wilted to 60 percent dry matter content, a ton of original weight would shrink to 667 pounds of which 400 pounds would be dry matter (ignoring interstitial oxidation and field losses) and 267 pounds of moisture. If no oxidation occurred the sugar of the 1600 pounds would be concentrated in 267 pounds, or six-fold the original concentration. Granting normal oxidation, the increased sugar content in conjunction with the difficulty in excluding air from the drier material accounts for the development of tobacco brown silage. The effect of this tobacco brown condition on digestibility of protein was notable. Although the silage was palatable, fermentation of the readily fermentable carbohydrate had left a high proportion of lignin.

Cows producing at the rate of those used in these experiments produced as much when low dry matter silage was the sole source of forage in the ration as when hay cut simultaneously from alternate strips of the same field was included. Moreover, the dry matter contained in the low dry matter silage was used much more efficiently than that of the hay. These results are in agreement with the extensive results obtained at Cornell University over an 8-year period on silage

TABLE 4.—Proportions of Silage and Hay Dry Matter Fed and Digestibility of Protein and Dry Matter.

Year	Ration		Cow	Digestibility	
	Silage	Hay		Protein	Dry Matter
	(%)	(%)		(%)	(%)
			Low Dry Matter Silage		
1954-55	100	0	1014	64.0	63.5
	100	0	1108	65.0	65.5
	100	0	1159	64.1	65.4
Average				64.4	64.8
1954-55	80	20	1112	61.6	62.9
	80	20	895	65.4	65.8
	80	20	1129	65.3	64.9
Average				64.1	64.5
1954-55	50	50	843	65.4	67.3
	50	50	1170	60.8	66.7
	50	50	1105	62.9	65.3
1955-56	50	50	1112	64.8	60.8
	50	50	1112	68.9	65.0
	50	50	843	70.9	67.8
	50	50	843	68.0	67.8
Average				66.0	65.8
1955-56	20	80	1137	67.3	68.9
	20	80	1137	68.7	70.0
	20	80	1073	71.3	65.6
	20	80	1073	70.0	71.1
Average				69.3	68.9
1955-56	0	100	1108	62.4	71.4
	0	100	1108	70.1	72.4
	0	100	1159	62.0	66.1
	0	100	1159	60.6	66.6
Average				63.8	69.1
			High Dry Matter Silage		
1956-57	100	0	1184	56.2	62.5
	50	50	1132	66.3	63.0
	0	100	1159	69.6	65.6

slightly higher in dry matter (36). In neither set of experiments is the contention supported that part of the forage must be supplied in the form of hay. In drawing these conclusions one is not justified in asserting that the sole usage of direct-cut legume-grass silage as the only forage is always advantageous. One important consideration is the large proportion of nutrients lost by seepage and fermentation. Although the dry matter losses from fermentation were not directly evaluated in the low dry matter silage of this experiment, a more recent study showed that only 56 percent of the ensiled dry matter of a 17 percent dry matter silage was satisfactory to feed cows (27). Another

consideration bearing on these results is the level of dry matter studied. The lowest dry matter content reported in Table 1 is 21.7 percent. What results would be obtained if the dry matter content was 17 percent is unpredictable from the results of this experiment. In this and in the Cornell experiments (36) liberal grain feeding in ratio to the milk produced was practiced. In contrast, Hillman *et al.* (15) found a marked advantage in favor of hay when no grain was fed. Finally in all trials cows adjusted poorly to the change in ration from the transition period to the ration containing equal parts of silage and hay dry matter during the preliminary period. Milk production decreased abruptly in a few days by 19.6, 7.8 and 21.5 percent respectively for the three trials. In the second trial (1955-56) cow 1132 declined in butterfat percentage more rapidly than in pounds of milk. This same cow previously had been 80 days in recovering from a change from corn silage to half legume-grass silage and half hay at the start of the preliminary period in 1954-55. The loss in milk yields from the transition to legume-grass silage may drop the level of milk production to a point that makes the cow unprofitable for the remainder of the lactation. Thus, whether or not dairy cows can produce satisfactorily on legume-grass silage as the only forage may depend on the time allowed for adjustment to the ration and the way the cows are conditioned to the silage ration (10).

At the levels of production of these trials the cows maintained production as well on high dry matter silage as on hay; however, difficulties in getting adequate intake on low dry matter silage by cows in higher production suggest that the less acceptable silages may not entirely replace hay for cows at high levels of production.

It is interesting to note that the low dry matter silages contained a relatively large amount of butyric and acetic acids. This occurrence raises the question as to their possible role in the observed increase in efficiency of feed utilization. Some investigators have concluded that higher efficiency of feed utilization observed when legume-grass silage is fed arises from the production of a higher proportion of propionic acid in the rumen (36). However, Armstrong *et al.* (2) showed that various mixtures of acetic, propionic and butyric acids, ranging in acetic acid content from 10 to 90 percent, produced relatively low heat increments in sheep—15 kilocalories per 100 kilocalories—and did not vary much among mixtures. On the other hand, dried grass had heat increments varying between 21 and 38 kilocalories per 100 kilocalories. Thus an alternative postulate is that mixtures of the volatile fatty acids of the silages had a lower calorigenic effect and slightly

higher heat of combustion than an equal quantity of digestible nutrients from hay. Summated the volatile acids equaled 21 percent of the silage liquid which approximates 20.6 percent on the dry basis of the digestible organic matter consumed. Approximate estimates of the energy utilization for maintenance, production and heat increment suggested that this was an adequate explanation for the difference in efficiency.

SUMMARY AND CONCLUSIONS

Milk production trials were conducted during three winters for 90-day periods to determine the effects of feeding a constant proportion of grain dry matter to forage dry matter and with a varying ratio of silage dry matter to hay dry matter.

In 1954-55 three groups were fed with the following silage:hay dry matter ratios: 100:0, 80:20, and 50:50. In 1955-56 three groups were fed ratios of 50:50, 20:80 and 0:100. During both of these years silage of about 22 percent dry matter was fed. In 1956-57, silage of 48 percent dry matter content was fed in the ratios of 100:0, 50:50 and 0:100. The silage:hay ratio had no significant effect on milk production.

Cows fed low dry matter silage as their only forage produced more milk per pound of dry matter eaten than cows fed hay as their only forage but at the expense of body weight. During 1956-57 when fed high dry matter silage they gained body weight but produced less milk.

No well defined trend existed among the other groups.

At least a minimum of hay (perhaps 5 pounds) should be fed to supplement low dry matter silage for cows in high production if they are to maintain their body weights.

Cutting while forage is still immature and ensiling at a favorable dry matter content are factors that are most important in producing silage with high digestible dry matter content. The content of digestible dry matter of silage, the reduction of peak labor loads, the type and amount of storage available and the machinery requirements for silage or hay making seem to be more important considerations than silage:hay ratio in planning the dairy feeding program.

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