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# High Dry Matter and High Moisture Silages for Milk Production

A. D. PRATT

H. R. CONRAD

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER

WOOSTER, OHIO

## CONTENTS

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## INTRODUCTION AND REVIEW OF LITERATURE

Dairy farmers are becoming increasingly conscious of the importance of the dry matter content of their silages. They are aware that the nutrients come from the dry matter content and that the percentage of dry matter largely controls the fermentation and determines the quality of the resulting silage.

The wilting of meadow crops before ensiling was early recognized as desirable. Woodward (22) in 1936 first described and recommended the procedure and Perkins (14) confirmed these findings. Later Perkins et al (15) designated 30 to 40 percent dry matter as the zone in which ensiling in tower silos was safe and 40 to 50 percent as the danger area. With the advent of sealed storage or gas-tight silos, ensiling at 40 to 60 percent dry matter became not only possible but desirable. Later the development of plastic sheets made possible successful sealing of conventional tower silos.

Gordon et al (6) reported success in storing under plastic, resulting in a desirable product. The high sugar content of the high dry matter silage served as an indication of the low amount of oxidation which occurred. Browning and Lusk (2) were also successful in storing in tower silos under a plastic sheet. Now this is a common farm practice.

High dry matter silage which is carefully stored either in gas-tight or conventional silos generally results in higher forage dry matter intake than low dry matter (or high moisture) silage. Blosser et al (1) reported that cows fed hay and silage ate 1 lb. more dry matter and produced 1 lb. more milk than those fed silage only. Larsen and Johannes (12) showed a straight line relationship between percent of dry matter in the forage and dry matter intake.

Gordon and co-workers (6) found a straight line relationship between pounds of dry matter intake and percent dry matter in silage, with 22 lb. intake at 30 percent dry matter and intake increasing to 28 lb. at 70 percent. They stated: "However, additional intake at dry matter contents above 50 percent is less dependable."

Gordon et al (7) showed a dry matter intake of 17.8 lb. from silage of 20 percent dry matter, 22.2 lb. from silage of 44 percent dry matter, and 24.6 lb. from hay. In another report, Gordon et al (8) showed a higher dry matter intake from 45.5 percent dry matter haylage than from 24.1 percent dry matter silage.

Roffler et al (18) also experienced greater dry matter intake per 100 lb. body weight from haylage than from silage, the comparative amounts being 2.2 and 1.7 lb., respectively. Voelker and Bartle (20) also report greater dry matter intake from haylage than from silage.

Investigators are not in agreement regarding the comparative digestibility of haylage and silage. Byers (3, 4) found no significant difference when the alfalfa was cut at the bud stage and stored as silage of 33.75 percent dry matter, haylage of 50.48 percent dry matter, or as hay. However, Gordon et al (9) found that digestibility coefficients were generally highest for hay, lowest for haylage, and intermediate for direct-cut silage. They found crude protein of haylage to be lower in digestibility than that of direct-cut silage ($P < .01$).

In contrast, Roffler et al (18) stored first-cutting alfalfa cut at the tenth bloom stage as wilted silage, haylage, and hay and found dry matter digestibilities of 64.3, 60.2, and 68.9 percent, respectively. The lack of agreement indicates that there still are some phases of the problem needing investigation.

Increased dry matter intake may be reflected in either increased milk production or body weight gains. Blosser et al (1) fed silage of 24.5 percent dry matter from a trench silo. One group was fed silage only while another group was fed 5 lb. of hay each and silage ad lib. Grain was fed at the rate of 1 lb. to each 4 lb. of 4 percent F.C.M. (fat-corrected milk). Those cows allowed hay produced 38.8 lb. of 4 percent F.C.M. and the other group averaged 37.7 lb. Those allowed hay ate 1 lb. more of roughage dry matter daily.

Byers (3) cut alfalfa at the bud stage and stored it without rain as silage, haylage, and hay. The silage and haylage were stored in conventional silos. The silage contained 33.75 percent dry matter while the haylage contained 50.48 percent. He found no significant differences in milk production of the three groups. The nature of the fermentation of this silage of 33 percent dry matter might be expected to be superior to that of the silage of 24.6 percent referred to above.

In contrast, Gordon et al (10) compared slightly wilted silage (36.0 percent dry matter) with half-dry silage (54.8 percent dry matter) made in gas-tight silos. He concluded that half-dry silage appeared to have slightly greater feeding value on the basis of milk production, 30-day decline in milk production, and maintenance of body weight.

Roffler (18) cut alfalfa-brome when alfalfa was at the tenth bloom stage and stored it as silage, haylage, and hay. The 4 percent F.C.M.

production was 28.4, 33.8 and 30.6 lb., respectively. The average pounds of daily gain were 0.2, 1.6, and 1.4, respectively.

Shepherd et al (19) ensiled alfalfa-grass mixed forage in gas-tight silos. The crop was wilted to 36 percent for one silo and to 54 percent for the other. The cows fed the drier silage ate 2 lb. more dry matter and produced 0.5 lb. less milk daily during an 80-day single reversal trial. Live weight and milk production were better maintained on the higher dry matter silage.

## PURPOSES OF EXPERIMENTS

These experiments were designed to show the response to differences in dry matter content of silage in:

- Dry matter intake
- Milk production
- Body weight changes

An additional aim was to find differences in response of the above measured variables to ground ear corn in comparison with ear corn silage.

## EXPERIMENT I

### Material Ensiled

First-cutting alfalfa-grass mixtures, in which brome was the predominating grass, were cut beginning May 24, 1963 and ensiled continuing through June 7. The ensiling period was extended by rainy weather. Each load was weighed and sampled before ensiling in a 14 by 50-foot gas-tight silo. The average dry matter content at ensiling was 43.5 percent. The composite sample contained 17.4 percent protein on the dry basis.

Similar alfalfa-grass mixtures were ensiled in a 14 by 40-foot tile silo between May 23 and 28. An attempt was made to wilt this material to 30 percent dry matter so the silo would not leak. A composite sample made from each load at ensiling contained 33.2 percent dry matter and 16.6 percent protein (dry basis).

### Experimental Plan

The haylage and silage were fed to similar groups of milking cows during a continuous feeding trial. Half of each group received ear corn silage as their grain and the other half ground ear corn. The experimental feeding began July 11 for those cows which had recently calved. Others were added to the groups as they calved. Experimental feeding was concluded May 21.

TABLE 1.—Summary of Data, 1963-64.

| Cow | Days on Exp. | Av. Weight | Weight Change | Lb. Dry Matter Eaten: Silage | Grain | Total | Total/ 1000 Lb./Day | 4% F.C.M.: Total | 1000 Lb./Day | Lb. 4% F.C.M. / Lb. D.M. Eaten |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (Lb.) | (Lb.) | | | | | (Lb.) | | |
| Silage and Ground Ear Corn | | | | | | | | | | |
| H 1496 | 259 | 1380 | +195 | 5,629 | 2,899 | 8,528 | 23.8 | 10,687 | 29 9 | |
| J 1573 | 206 | 764 | — 37 | 2,879 | 1,521 | 4,400 | 28.0 | 5,953 | 37.8 | |
| H 1367 | 243 | 1395 | + 62 | 5,415 | 2,823 | 8,238 | 24.3 | 9,586 | 28.3 | |
| G 1545 | 207 | 1290 | — 11 | 4,389 | 2,209 | 6,598 | 24.7 | 8,949 | 33.5 | |
| H 1569 | 239 | 1140 | +315 | 4,657 | 2,355 | 7,012 | 25.7 | 7,725 | 28.4 | |
| Av. | 231 | | +105 | | | | 25.3 ± 0.08* | | 31.6 ± 1.7 | 1.23 |
| Silage and Ear Corn Silage | | | | | | | | | | |
| H 1426 | 306 | 1608 | — 95 | 6,736 | 3,367 | 10,103 | 20 5 | 11,939 | 24.3 | |
| H 1368 | 231 | 1313 | + 27 | 4,852 | 2,458 | 7,310 | 24.1 | 9,243 | 30.5 | |
| H 1533 | 295 | 1431 | +106 | 6,569 | 3,352 | 9,921 | 23.5 | 11,483 | 37.2 | |
| J 1570 | 249 | 755 | 0 | 3,425 | 1,823 | 5,248 | 27.9 | 6,247 | 33.2 | |
| Av. | 270 | | + 10 | | | | 24.0 ± 1.5 | | 31.3 ± 2.8 | 1.19 |
| Haylage and Ground Ear Corn | | | | | | | | | | |
| H 1463 | 214 | 1351 | + 84 | 5,539 | 2,884 | 8,423 | 29.1 | 10,047 | 34.7 | |
| G 1545 | 99 | 1289 | — 11 | 2,202 | 1,020 | 3,222 | 25.3 | 5,127 | 40.2 | |
| H 1467 | 295 | 1398 | + 84 | 7,045 | 3,653 | 10,680 | 25.9 | 12,432 | 30.1 | |
| J 1575 | 234 | 888 | +201 | 3,730 | 2,000 | 5,730 | 27.6 | 6,236 | 30.0 | |
| Av. | 211 | | + 90 | | | | 27.0 ± 0.9 | | 33.8 ± 2.4 | 1.21 |
| Haylage and Ear Corn Silage | | | | | | | | | | |
| H 1463 | 21 | 1320 | 0 | 371 | 204 | 575 | 20.7 | 1,250 | 45.1 | |
| H 1451 | 245 | 1446 | + 82 | 5,829 | 3,021 | 8,850 | 25.0 | 9,657 | 27.1 | |
| J 1270 | 244 | 928 | +205 | 3,723 | 1,980 | 5,703 | 25.2 | 5,573 | 24.6 | |
| H 1196 | 136 | 1302 | —184 | 3,115 | 1,646 | 4,761 | 26.9 | 7,619 | 43.0 | |
| Av. | 162 | | + 26 | | | | 24.5 ± 1.3 | | 35.0 ± 5.0 | 1.21 |

*Standard error.

The silages and grain were analyzed for dry matter content twice each week to assist in feeding 2 lb. of forage dry matter to each pound of grain dry matter.

#### Experimental Animals

Only purebred Holstein, Guernsey, and Jersey cows in early stage of milk production were used. They were weighed for 3 successive days at the beginning and close of the experiment. As some animals were on the experiment longer than others, the data are presented as an average per day. Because of the great variation in body weights of individuals, the data are presented on a 1000 lb. body weight basis.

#### Management of Animals

The grain was fed first in the morning. Time was allowed for eating the grain and then haylage or silage was fed. The same sequence was followed in the afternoon. The mangers were cleaned and refusal was weighed and recorded the next morning before grain feeding.

The cows were bedded with shavings to avoid bias from eating of bedding.

The cows were turned out daily in a paved yard for exercise and checking for heat periods. Salt and bonemeal were available in the yard. Water cups were available to each cow in the stalls. The mangers were enclosed to avoid scattering of the feed.

#### Results

The data used in grouping the cows appear in Appendix Table I.

The feeding trial data appear in Table 1 of the text. Cow H-1463 was transferred from one group to another after 21 days to balance the number of cows per group.

To determine if there was a difference in dry matter intake of haylage and silage, the data of the two groups fed haylage and those fed silage were considered together. The two groups fed haylage ate 25.7 $\pm$ 0.9 lb. dry matter while the two groups fed silage ate 24.7 $\pm$ 0.8 lb. Obviously this difference was not significant.

When the groups fed ground ear corn and ear corn silage were considered similarly, a dry matter intake of 26.0 $\pm$ 0.6 lb. was found for the former and 24.2 $\pm$ 0.9 lb. for the latter. While this difference suggested significance, a decision was made to repeat this experiment.

## EXPERIMENT II

### Material Ensiled

Alfalfa-grass was ensiled after wilting in 1965. Sixty-five tons were ensiled May 24 at the early bud stage of alfalfa in a 10 by 40-foot concrete stave silo at an average dry matter content of 22.9 percent. The weather was not conducive to drying and an attempt to dry the crop to 30 percent dry matter was futile. Seepage ran from between the staves for 4 to 5 weeks.

The weight of crop ensiled was 131,471 lb., the top spoilage weighed 2215 lb., and 98,314 lb. were fed. Therefore losses from fermentation, evaporation, spoilage, and seepage amounted to 30,942 lb., most of which was seepage. The dry matter recovery was 76.7 percent. About 94.5 tons of similar crop were put in a 14 by 50-foot gas-tight silo after heavy wilting at an average of 42.7 percent dry matter on May 26. The top 6500 lb. (63.8 percent dry matter) was not suitable as feed for dairy cows, although it probably would have been accepted by steers on limited forage. Of the 80,628 lb. of dry matter ensiled, 76,616 lb. or 95.0 percent were recovered.

Both the silage and haylage averaged 17.0 percent protein when ensiled.

### Forage to Grain Ratio

The same experimental plan was followed as in Experiment I with two exceptions. Haylage and silage were fed at the ratio of 1.5 lb. of forage dry matter to 1 lb. of grain dry matter (or 40 percent of the total ration dry matter was from grain). Previous experimental work suggested that the 2:1 ratio of forage to grain dry matter might be too low in energy for cows in high milk production.

Sufficient soybean oilmeal was fed daily to all animals to make up 10 percent of the grain dry matter. This practice was adopted to insure adequate protein for high milk production.

### Experimental Animals

The data on the experimental cows used in Experiments II and III are presented in Appendix Table II.

### Animal Health

Those cows which did not adjust readily to their assigned ration were given a maximum of 5 lb. of alfalfa hay daily. Accurate records were kept of the amounts fed and refused. Hay feeding was reduced and discontinued as appetites improved.

Two cows, H-1496 and H-1737, which were fed high moisture silage developed acetonemia. Cow H-1496 finally became adjusted to the ration and was a satisfactory experimental animal.

Cow H-1737 had been a high producer in her previous lactation. She started on experiment on November 11 weighing 1097 lb. By November 18 she had reached a consumption of only 16.4 lb. silage dry matter before beginning to refuse silage. Refusal continued until December 6, when she showed definite clinical symptoms of acetonemia. ACTH was administered and ear corn silage was replaced by a mixed dry grain ration. By December 14 she weighed only 1008 lb. She was producing only 25 lb. of milk daily at the time of treatment but increased to 50 lb. in 18 days. On January 4, haylage was substituted for high moisture silage and intake of forage dry matter gradually increased. She produced 60 lb. of milk on January 6. Even though the grain was changed from mixed grain back to ear corn silage, she continued to produce more than 50 lb. of milk daily through February 21 and was still producing 46 lb. at the close of the experiment on April 11. She had then regained the body weight lost earlier and weighed 1106 lb. at the conclusion of the experiment.

The data for this cow were excluded when the data for Experiments II and III were analyzed. This account is presented only to emphasize the problems inherent in the use of high moisture silage for cows capable of high production.

Eleven of the cows showed mastitis at some time. The affected animals were distributed through all four experimental groups. There were similar numbers of cases in the groups fed haylage and high moisture silage and in the groups fed mixed grain in contrast to ear corn silage. There was no evidence that mastitis was due to the rations.

### Chemical Analyses

Samples of silage and grain were taken twice each week for dry matter determinations. The toluene distillation method was used to determine the dry matter content of the silage. The dry matter contents of silage as well as grain were determined by oven drying. The dried samples were composited for protein analyses. Protein percentages were: haylage, 16.64; high moisture silage, 12.64; ear corn silage, 9.34· ground ear corn, 9.22; and soybean oilmeal, 46.39 percent.

Determinations of volatile fatty acids and lactic acid were made to characterize the silages. These analyses appear in Table 2. The decreases in acetic acid and increases in lactic and butyric acid content of haylage with increases in dry matter content in samples 1, 2, and 3 are notable. The same trends in acetic and butyric acids with increases in dry matter content of the high moisture samples 1, 2, and 3 are also quite apparent. The low lactic acid content of the latter is typical of high moisture silages.

**TABLE 2.—Organic Acid Content of Legume-Grass Silages Fed in Experiments II and III.**

| Experiment | Experimental Silo | Sample No. | Dry Matter Content | Organic Acids | | |
|---|---|---|---|---|---|---|
| | | | | Acetic | Butyric | Lactic |
| | | | (%) | Percent Dry Basis | | |
| II | Gas-tight | 1 | 32.5 | 3.14 | 1.63 | 4.18 |
| II | Gas-tight | 2 | 37.0 | 3.00 | 1.00 | 7.32 |
| II | Gas-tight | 3 | 42.0 | 2.33 | 0.10 | 7.81 |
| III | Gas-tight | 4 | 32.0 | 4.47 | 0.44 | 9.03 |
| II | Concrete stave | 1 | 20.0 | 8.45 | 10.65 | 0.90 |
| II | Concrete stave | 2 | 23.5 | 6.60 | 9.45 | 0.00 |
| II | Concrete stave | 3 | 26.0 | 5.00 | 4.88 | 0.58 |
| III | Tile | 1 | 55.0 | 0.65 | 0.03 | 1.76 |

Sample 4 from the tile silo, with a dry matter content of 55 percent, was extremely low in acetic and butyric acid content and comparatively higher in lactic acid. However, it was low in lactic acid in comparison with haylage of similar dry matter content. The tile silo did not exclude air well and oxidation of lactic acid would be expected. If lactic acid is conducive to weight gains in dairy cows as in beef cattle (11), low lactic acid content may be one reason why cows fed high moisture silages lose body weight.

Samples 1, 2, and 3 of haylage and high moisture silage were fed in Experiment II. Sample 4 from the gas-tight silo and sample 1 from the tile silo were fed in Experiment III.

### Digestion Trials

Two non-lactating Jersey cows were fed haylage only on a 7-day digestion trial. One gave a digestion coefficient of dry matter of 59 percent and the other 66.8 percent. These data do not indicate low digestibility of haylage of 51 percent dry matter content when cut at the bud stage.

### Results

The data on dry matter intake and milk production in Experiment II, presented in Table 3, have been analyzed statistically. All milk production records were adjusted for stage of lactation and age. Even though body weight changes were adjusted for dry matter intake, a difference of 0.87 lb. body weight per day for haylage over silage was significant ($P < 0.05$) independent of the pounds of dry matter eaten. This is interpreted as being due to the higher lactic acid content of haylage than of silage.

Whether cows were fed haylage or high moisture silage did not significantly affect milk fat percentage.

Regression of total dry matter eaten on milk fat percentage was significant. When the yields of 4 percent F.C.M. were calculated per 1000 lb. body weight per day, the cows fed haylage produced 2.6 lb. more than those fed high moisture silage. This was a highly significant difference.

Whether the cows were fed ground ear corn or ear corn silage affected milk fat production and milk fat percentage significantly.

TABLE 3.—Feeding Trial Data for Experiment II.*

| Tr. | Cow | Weight Change | Av. Body Wt. | Actual Milk | 4% F.C.M. | Haylage Actual | Haylage D.M. |
|---|---|---|---|---|---|---|---|
| | | (Lb./Day) | | | | | |
| Haylage and Ear Corn Silage | | | | | | | |
| | J 1597 | 0.55 | 975 | 39.3 | 45.8 | 49.8 | 18.39 |
| | H 1604 | —1.01 | 1434 | 63.0 | 63.0 | 54.5 | 21.49 |
| | H 1646 | 0.26 | 1202 | 57.3 | 52.2 | 50.7 | 18.87 |
| | H 1654 | —1.62 | 1521 | 60.6 | 56.3 | 62.5 | 25.05 |
| | J 1666 | 0.20 | 874 | 26.1 | 32.6 | 33.4 | 12.70 |
| | H 1673 | 0.34 | 1163 | 54.0 | 50.6 | 52.3 | 20.08 |
| | H 1681 | 0.25 | 1289 | 52.9 | 48.3 | 56.6 | 21.39 |
| Haylage and Ground Ear Corn | | | | | | | |
| | H 1545 | 0.11 | 1402 | 62.9 | 61.1 | 64.8 | 25.01 |
| | H 1625 | 1.60 | 1421 | 82.5 | 70.6 | 66.1 | 25.18 |
| | J 1631 | 0.53 | 933 | 31.5 | 37.3 | 47.6 | 17.76 |
| | H 1662 | 1.68 | 1235 | 54.5 | 52.2 | 64.2 | 23.69 |
| | J 1663 | 0.14 | 966 | 28.1 | 33.5 | 38.0 | 14.26 |
| | H 1733 | 1.02 | 1176 | 52.1 | 48.4 | 61.2 | 22.50 |
| Silage and Ear Corn Silage | | | | | | | |
| | H 1463 | 1.90 | 1378 | 54.0 | 51.5 | 68.5 | 17.78 |
| | J 1587 | 0.08 | 855 | 27.7 | 27.9 | 57.7 | 13.35 |
| | H 1650 | 0.24 | 1241 | 46.7 | 43.0 | 75.5 | 17.23 |
| | H 1665 | —0.79 | 1336 | 56.0 | 58.3 | 80.7 | 19.00 |
| Silage and Ground Ear Corn | | | | | | | |
| | H 1496 | —1.05 | 1373 | 42.4 | 40.8 | 64.2 | 15.03 |
| | H 1533 | —0.09 | 1415 | 45.5 | 42.3 | 88.3 | 20.44 |
| | J 1576 | 0.60 | 891 | 34.4 | 39.2 | 65.9 | 15.69 |
| | H 1584 | 1.20 | 1407 | 48.4 | 42.2 | 73.1 | 17.38 |
| | H 1590 | 1.10 | 1312 | 54.3 | 52.9 | 71.5 | 18.34 |
| | H 1614 | 1.22 | 1298 | 43.1 | 39.2 | 81.2 | 18.50 |
| | J 1661 | —0.77 | 705 | 23.3 | 29.1 | 37.9 | 8.66 |

*Milk production was adjusted for differences in dry matter intake, age, and stage of lactation.

**TABLE 3. (Continued)—Feeding Trial Data for Experiment II.***

| Tr. | Cow | Grain D.M. | Total D.M. | 4% F.C.M./ 1000 Lb. Body Weight | D.M./ 1000 Lb. Body Weight | Days on Exp. |
|---|---|---|---|---|---|---|
| | | (Lb /Day) | | | | |
| Haylage and Ear Corn Silage | | | | | | |
| | J 1597 | 13.24 | 31.92 | 47.04 | 32.74 | 118 |
| | H 1604 | 14.88 | 36.57 | 43.95 | 25.50 | 79 |
| | H 1646 | 14.17 | 33.27 | 43.44 | 27.67 | 118 |
| | H 1654 | 16.94 | 42.15 | 37.06 | 27.71 | 85 |
| | J 1666 | 9.12 | 21.81 | 37.30 | 24.95 | 89 |
| | H 1673 | 14.11 | 34.33 | 43.50 | 29.51 | 95 |
| | H 1681 | 14.93 | 36.33 | 37.47 | 28.17 | 100 |
| Av. | | | | 38.9 | | |
| Haylage and Ground Ear Corn | | | | | | |
| | H 1545 | 14.07 | 39.40 | 43 62 | 28.10 | 119 |
| | H 1625 | 17.31 | 42.65 | 49.73 | 30.01 | 95 |
| | J 1631 | 12.82 | 30.71 | 40.06 | 32.90 | 128 |
| | H 1662 | 16.74 | 40.53 | 42.30 | 32.80 | 118 |
| | J 1663 | 10.78 | 25.30 | 34.78 | 26.19 | 128 |
| | H 1733 | 14.96 | 37.75 | 41.19 | 32.09 | 118 |
| Av. | | | | 42.0 | | |
| Silage and Ear Corn Silage | | | | | | |
| | H 1463 | 12.35 | 31.58 | 37.41 | 22.92 | 66 |
| | J 1587 | 9.72 | 23.28 | 32.64 | 27.21 | 125 |
| | H 1650 | 13.03 | 30.41 | 34.71 | 24.49 | 118 |
| | H 1665 | 13.24 | 32.45 | 43.67 | 24.28 | 92 |
| Av. | | | | 37.1 | | |
| Silage and Ground Ear Corn | | | | | | |
| | H 1496 | 11.20 | 26.60 | 29.77 | 19.36 | 118 |
| | H 1533 | 14.78 | 35.49 | 29.94 | 25.07 | 119 |
| | J 1576 | 11.04 | 26.86 | 44.08 | 30.15 | 100 |
| | H 1584 | 11.88 | 29.83 | 30.03 | 21.19 | 86 |
| | H 1590 | 12.63 | 31.48 | 40.36 | 23.99 | 72 |
| | H 1614 | 13.75 | 32.41 | 30.27 | 24.97 | 119 |
| | J 1661 | 6.90 | 15.74 | 41.31 | 22.32 | 118 |
| Av. | | | | 35.1 | | |

*Milk production was adjusted for differences in dry matter intake, age, and stage of lactation.

## EXPERIMENT III

### Experimental Plan

A third feeding trial was conducted using the same cows involved in Experiment II. The entire experimental plan was the same except that the cows which had been fed high moisture silage were now fed high dry matter silage which had been stored in a conventional tile silo. The crop was ensiled on June 4, 9 days after the gas-tight silo was filled. The crop was a mixture of alfalfa and grasses similar to the haylage to which it was compared but at a later stage of growth and wilted to a dry matter content of 43.4 percent. This silage was expected to be high in digestibility, judging from past experience with green-chopped alfalfa-grass at a comparable harvest date.

No attempt was made to check the percentage of dry matter recovered from the tile silo as there were open joints in the upper part of the silo and considerable spoilage resulted.

There was no difficulty with cows not accepting this silage, as was the case with the high moisture silage of Experiment II.

This feeding trial began on January 20 immediately following the close of Experiment II and continued through April 14. The feeding and management of the cows was the same as in Experiment II.

### Results

Cows fed the high dry matter silage (47.5 percent dry matter in the portion fed) from the tile silo gained 1.25 lb. per day compared with 0.617 lb. per day for those fed haylage (39.5 percent dry matter) from the gas-tight silo. This difference was significant at the 5 percent level of probability.

The data obtained in Experiment III are presented in Table 4. Regressions of dry matter intake on milk production, milk fat production, and 4 percent F.C.M. were highly significant in each case. However, when related to 1000 lb. body weight, these relationships were not significant.

Sample 4 from the gas-tight silo and Sample 1 from the tile silo (Table 2) show lactic acid percentages on a dry basis of 9.03 and 1.76, respectively. This indicates that the lactic acid which formed early in the fermentation process in the tile silo had been oxidized to products of lower molecular weight and perhaps to water. The silage of 55 percent dry matter content from the tile silo would be expected to undergo less fermentation before the resulting pH checked fermentation. The silage from the gas-tight silo, with a dry matter percent of 32, would be expected to undergo greater fermentation before being checked by the resulting pH. The silage from the gas-tight silo had 64.7 percent of its organic acids in the form of lactic, while that from the tile silo had 72.1 percent as lactic acid.

## DISCUSSION

The differences in response of the cows to haylage and silage in Experiment I suggested that the higher dry matter of haylage resulted in greater milk production per 1000 lb. body weight. However, the differences were not significant with only four cows per group.

When the experiment was repeated (Experiment II), the production data were adjusted for age and stage of lactation. The dry matter of haylage resulted in significantly greater gains ($P < 0.05$) of body weight per pound of dry matter eaten. Table 2 shows the greater lactic acid content of haylage. Klosterman et al (11) and Roffler et al (18) have shown greater daily body weight gains of steers and heifers fed silages high in lactic acid content. These data show that greater body weight gains of *milking cows* per pound of dry matter eaten result from high dry matter silage of high lactic acid content.

Comparisons of milk production of cows fed high dry matter and high moisture silage showed a greater production of 2.6 lb. of 4 percent F.C.M. per 1000 lb. body weight per day from haylage. This was a highly significant difference.

In Experiment III, the higher dry matter silage from the tile silo resulted in significantly greater gains in body weight per day per pound of dry matter eaten. Milk production, milk fat production, and 4 percent F.C.M. were greater ($P < 0.01$) when regressed on dry matter intake without adjustment for body weight differences. However, when these data were adjusted to 1000 lb. body weight, the differences were not significant.

The difference in dry matter content of the two silages compared here was less than the difference in Experiment II. The dry matter content of both silages in this experiment was in the area above which unfavorable fermentation products are usually expected. It is notable that the silage from the tile silo which had visible leaks was equal in feeding value to that from the sealed storage.

Data from the silo filled with high moisture silage in Experiment II illustrate the excessive losses which may be expected from direct-cut silage making. The green weight of alfalfa-grass ensiled was 131,471 lb. Oven-dried samples from each load were composited. The dry matter content was 30,150 lb. averaging 22.9 percent dry matter. Top spoilage of 2,215 lb. was removed. The silage was weighed daily as fed and 98,314 lb. moist weight containing 23,129 lb. dry matter were

TABLE 4.—Feeding Trial Data for Experiment III.*

| Tr. | Cow | Weight Change | Av. Body Wt. | Actual Milk | 4% F.C.M. | Haylage Actual | Haylage D.M. |
|---|---|---|---|---|---|---|---|
| | | (Lb./Day) | | | | | |
| Haylage and Ear Corn Silage | | | | | | | |
| | J 1597 | 0.87 | 1045 | 20.8 | 26.1 | 47.2 | 18.91 |
| | H 1604 | —0.15 | 1386 | 40.2 | 40.4 | 58.6 | 21.59 |
| | H 1646 | 0.32 | 1231 | 35.0 | 33.1 | 48.9 | 19.31 |
| | H 1654 | 0.65 | 1636 | 37.8 | 33.0 | 62.9 | 24.85 |
| | J 1666 | 0.32 | 897 | 15.3 | 18.1 | 32.1 | 12.92 |
| | H 1673 | 1.12 | 1228 | 31.8 | 28.8 | 53.0 | 21.28 |
| | H 1681 | 0.05 | 1304 | 33.6 | 29.4 | 49.4 | 19.68 |
| Haylage and Ground Ear Corn | | | | | | | |
| | H 1545 | 0.04 | 1409 | 41.6 | 41.2 | 58.9 | 23.65 |
| | H 1625 | 0.44 | 1439 | 46.8 | 42.9 | 63.3 | 25.47 |
| | J 1631 | 0.94 | 1003 | 17.5 | 20.0 | 44.3 | 17.71 |
| | H 1662 | 1.03 | 1379 | 32.3 | 33.3 | 58.2 | 23.31 |
| | J 1663 | 1.14 | 1018 | 13.1 | 15.6 | 39.0 | 15.52 |
| | H 1773 | 0.96 | 1278 | 28.3 | 28.2 | 52.4 | 21.14 |
| Silage and Ear Corn Silage | | | | | | | |
| | H 1463 | 0.62 | 1289 | 46.6 | 44.3 | 43.7 | 21.24 |
| | J 1587 | 0.75 | 890 | 16.2 | 16.1 | 32.9 | 15.80 |
| | H 1650 | 2.14 | 1347 | 25.8 | 24.0 | 47.0 | 22.22 |
| | H 1665 | 1.47 | 1362 | 36.9 | 37.4 | 52.4 | 24.79 |
| Silage and Ground Ear Corn | | | | | | | |
| | H 1496 | 1.95 | 1394 | 34.2 | 32.5 | 55.1 | 25.99 |
| | H 1533 | 2.63 | 1522 | 10.5 | 9.1 | 49.0 | 23.09 |
| | J 1576 | 0.61 | 885 | 24.5 | 29.3 | 39.2 | 18.78 |
| | H 1584 | 1.45 | 1415 | 34.0 | 29.6 | 45.0 | 21.37 |
| | H 1590 | 1.93 | 1345 | 50.1 | 43.6 | 56.6 | 27.22 |
| | H 1614 | 1.37 | 1429 | 25.8 | 22.4 | 42.4 | 19.97 |
| | J 1661 | 1.23 | 711 | 12.3 | 14.1 | 30.1 | 14.24 |

*Milk production was adjusted for differences in dry matter intake, age, and stage of lactation.

TABLE 4. (Continued)—Feeding Trial Data for Experiment III.*

| Tr. | Cow | Grain D.M. | Total D.M. | 4% F.C.M./ 1000 Lb. Body Weight | D.M./ 1000 Lb. Body Weight | Days on Exp. |
|---|---|---|---|---|---|---|
| | | (Lb./Day) | | | | |
| Haylage and Ear Corn Silage | | | | | | |
| | J 1597 | 12.95 | 31.87 | 25.04 | 30.49 | 85 |
| | H 1604 | 14.70 | 36.29 | 29.15 | 26.17 | 60 |
| | H 1646 | 13.32 | 32.64 | 26.89 | 26.50 | 84 |
| | H 1654 | 17.02 | 41.87 | 20.18 | 25.58 | 75 |
| | J 1666 | 8.83 | 21.75 | 20.23 | 24.25 | 85 |
| | H 1673 | 14.65 | 35.93 | 23.50 | 29.26 | 85 |
| | H 1681 | 13.53 | 33.22 | 22.53 | 25.46 | 85 |
| Av. | | | | 23.9 | | |
| Haylage and Ground Ear Corn | | | | | | |
| | H 1545 | 14.48 | 38.14 | 29.29 | 27.06 | 85 |
| | H 1625 | 17.46 | 42.93 | 29.84 | 29.84 | 85 |
| | J 1631 | 12.29 | 30.01 | 20.00 | 29.90 | 75 |
| | H 1662 | 15.80 | 39.12 | 24.17 | 28.37 | 85 |
| | J 1663 | 10.82 | 26.34 | 15.32 | 25.87 | 75 |
| | H 1773 | 13.08 | 34.23 | 22.11 | 26.78 | 85 |
| Av. | | | | 23.5 | | |
| Silage and Ear Corn Silage | | | | | | |
| | H 1463 | 14.76 | 36.00 | 34.36 | 27.93 | 77 |
| | J 1587 | 10.96 | 26.77 | 18.11 | 30.06 | 78 |
| | H 1650 | 15.32 | 37.55 | 17.87 | 27.87 | 85 |
| | H 1665 | 17.06 | 41.86 | 27.48 | 30.72 | 85 |
| Av. | | | | 24.5 | | |
| Silage and Ground Ear Corn | | | | | | |
| | H 1496 | 17.62 | 43.61 | 23.35 | 31.29 | 85 |
| | H 1533 | 16.06 | 39.15 | 5.98 | 25.72 | 85 |
| | J 1576 | 13.02 | 31.80 | 33.20 | 35.93 | 78 |
| | H 1584 | 14.92 | 36.39 | 20.97 | 25.64 | 86 |
| | H 1590 | 18.62 | 45.85 | 32.40 | 34.07 | 78 |
| | H 1614 | 14.16 | 34.14 | 15.68 | 23.88 | 85 |
| | J 1661 | 9.83 | 24.08 | 19.83 | 33.85 | 85 |
| Av. | | | | 21.6 | | |

*Milk production was adjusted for differences in dry matter intake, age, and stage of lactation.

recovered. The difference between green weight of the material ensiled and the wet material removed was 30,942 lb., with the loss largely due to seepage. If the water formed by oxidation were equal to the water lost by evaporation, the seepage would be 15 ± tons.

Any attempt to calculate the loss of protein is subject to large errors because of the assumptions made. The material ensiled contained 17.0 percent protein on a dry matter basis or 5,125 lb. crude protein. The 23,129 lb. dry matter analyzed 12.64 percent crude protein or 2,925 lb. There was an error in this calculation as the protein analysis was made on the composite from the oven-dry semi-weekly sampling. The dry matter contents of silage and haylage were determined by the toluene distillation method for making changes in daily feeding but the oven-dry method was used in obtaining a sample for proximate analysis. An undetermined loss of ammonia would result from oven drying. The crude protein loss would then be somewhat less than 2200 lb. With soybean oilmeal retailing at $105 per ton, this protein loss would cost $250 for replacement.

If the alfalfa had been wilted to 50 percent dry matter, there would have been 71,000 lb. less water to haul.

Whether the cows were fed ear corn silage or a mixed dry grain ration did not have a significant effect on milk fat production or on milk fat percentage.

## SUMMARY AND CONCLUSIONS

Three feeding experiments were conducted to compare haylage and silage.

In Experiment I, forage dry matter and grain dry matter were fed in a 2:1 ratio. The cows fed haylage produced more 4 percent F.C.M. but the differences were not great enough to be of statistical significance with only four cows per group.

In Experiment II, the ratio of forage to grain dry matter was narrowed to 1.5 to 1 or 60 percent forage and 40 percent grain dry matter. Excessive losses of dry matter and protein occurred when direct-cut material was ensiled. When milk production was adjusted for age and stage of lactation of the cow, milk yield was 2.6 lb. of 4 percent F.C.M. greater per pound of dry matter eaten from haylage than from silage. This was a highly significant difference.

High dry matter silage with a high lactic acid content resulted in significantly greater daily body weight gain per pound of dry matter eaten than dry matter from high moisture silage.

Satisfactory high dry matter silage may be made in conventional tower silos if care is taken to prevent entrance of air at the doors and if the surface is sealed properly. Greater recovery of the dry matter ensiled may be accomplished with a gas-tight silo.

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# APPENDIX

**APPENDIX TABLE I.—Data Used in Grouping Cows in Experiment I, 1963-64.**

| Cow | Age Yr.-Mo. | Calving Date | Av. M.E.* 4% F.C.M. | Predicted 4% F.C.M. for This Lactation |
|---|---|---|---|---|
| Silage and Ground Ear Corn | | | (Lb.) | (Lb.) |
| H 1496 | 4-1 | 9-15 | 14,913 | 15,629 |
| J 1573 | 3-1 | 10-14 | 9,884 | 8,670 |
| H 1367 | 7-5 | 9-21 | 11,397 | 11,397 |
| G 1545 | 3-4 | 7-20 | 13,792 | 15,585 |
| H 1569 | 2-10 | 5-8 | 14,199 | 17,181 |
| Av. | | | 12,837 | 13,692 |
| Silage and Ear Corn Silage | | | | |
| H 1426 | 5-8 | 7-21 | 13,550 | 13,686 |
| H 1368 | 7-5 | 10-4 | 11,587 | 11,587 |
| H 1533 | 3-6 | 6-27 | 13,832 | 15,492 |
| J 1570 | 2-10 | 5-17 | 10,343 | 8,840 |
| Av. | | | 12,328 | 12,401 |
| Haylage and Ground Ear Corn | | | | |
| H 1463 | 5-2 | 9-28 | 14,661 | 14,954 |
| G 1545 | 3-4 | 7-20 | 13,792 | 15,585 |
| H 1467 | 5-0 | 6-30 | 14,494 | 14,784 |
| J 1575 | 2-9 | 5-8 | 12,589 | 14,981 |
| Av. | | | 13,884 | 15,076 |
| Haylage and Ear Corn Silage | | | | |
| H 1463 | 5-2 | 9-28 | 14,661 | 14,954 |
| H 1451 | 5-4 | 9-18 | 15,315 | 15,163 |
| J 1270 | 8-4 | 4-30 | 8,610 | 8,782 |
| H 1196 | 10-1 | 9-14 | 14,913 | 15,659 |
| Av. | | | 13,375 | 13,640 |

*Mature equivalents of all previous lactations.

**APPENDIX TABLE II.—Data Used in Grouping Cows for Experiment II, 1965-66.**

| Group | Cow | Age at Calving Yr.-Mo. | Fresh Before Exp. Days | Body Weight | Av. M.E.* 4% F.C.M. | Predicted 4% F.C.M |
|---|---|---|---|---|---|---|
| | | | | (Lb.) | (Lb ) | (Lb ) |
| Haylage and Ear Corn Silage | | | | | | |
| | J 1597 | 3-8 | 19 | 1,022 | 12,618 | 12,250 |
| | H 1604 | 4-8 | 4 | 1,479 | 14,687 | 14,122 |
| | H 1646 | 3-10 | 6 | 1,030 | 15,139 | 13,775 |
| | H 1654 | 3-10 | 4 | 1,430 | 15,924 | 14,345 |
| | J 1666 | 3 7 | 4 | 888 | 11,024 | 9,932 |
| | H 1673 | 3-6 | 4 | 1,147 | 14,380 | 12,614 |
| | H 1681 | 3-1 | 4 | 1,277 | 14,977 | 12,481 |
| Av. | | | | | 14,107 | 12,788 |
| Haylage and Ground Ear Corn | | | | | | |
| | H 1545 | 5 8 | 7 | 1,397 | 15,298 | 15,298 |
| | H 1625 | 4-3 | 12 | 1,422 | 17,978 | 16,801 |
| | J 1631 | 4 1 | 25 | 940 | 13,611 | 12,850 |
| | H 1662 | 3-7 | 21 | 1,186 | 14,059 | 12,550 |
| | J 1663 | 3-7 | 8 | 1,002 | 11,631 | 10,475 |
| | H 1738 | 3-9 | 30 | 1,320 | 13,400 | 13,152 |
| Av. | | | | | 14,282 | 13,521 |
| Silage and Ear Corn Silage | | | | | | |
| | H 1463 | 7-7 | 4 | 1,443 | 13,907 | 13,907 |
| | J 1587 | 4-9 | 25 | 924 | 11,018 | 10,700 |
| | H 1650 | 3-8 | 21 | 1,315 | 15,022 | 13,525 |
| | H 1665 | 3-7 | 4 | 1,370 | 10,649 | 9,425 |
| Av. | | | | | 12,649 | 11,889 |
| Silage and Ground Ear Corn | | | | | | |
| | H 1496 | 6-7 | 10 | 1,500 | 13,496 | 13,500 |
| | H 1533 | 5-8 | 17 | 1,574 | 13,366 | 13,375 |
| | J 1576 | 5-1 | 4 | 921 | 14,760 | 14,760 |
| | H 1584 | 4-11 | 4 | 1,462 | 14,602 | 14,175 |
| | H 1590 | 4-11 | 4 | 1,354 | 15,763 | 15,303 |
| | H 1614 | 4-3 | 28 | 1,396 | 12,464 | 12,000 |
| | J 1661 | 3-7 | 6 | 749 | 10,274 | 9,425 |
| Av. | | | | | 13,532 | 13,220 |

*Mature equivalents of all previous lactations.

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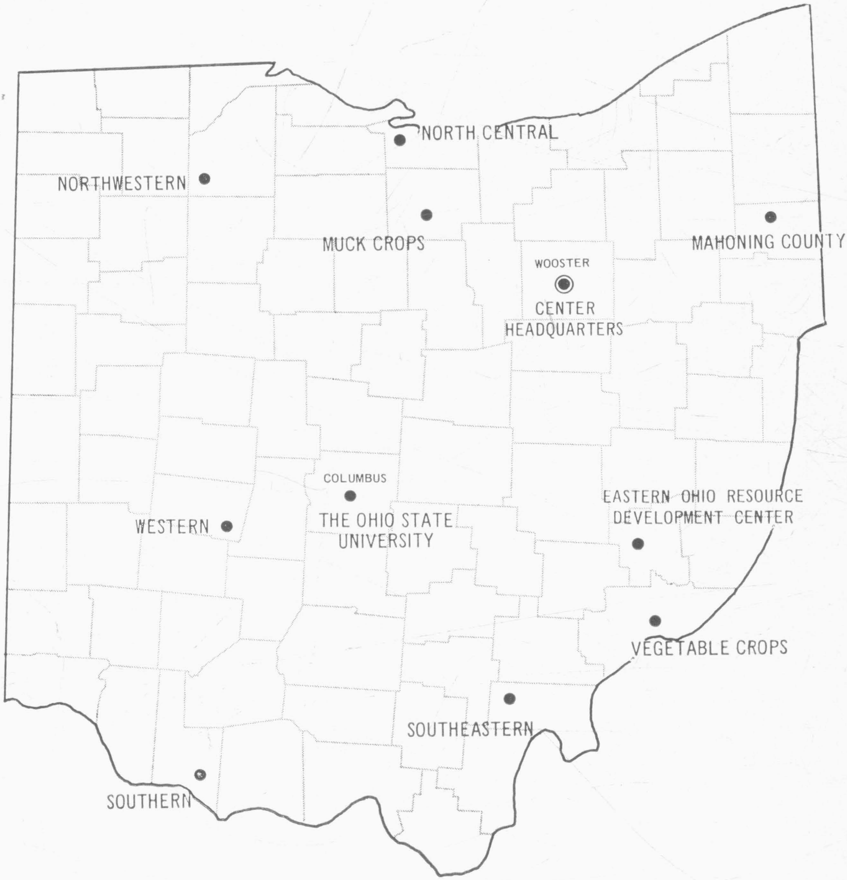


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