EFFECTS OF VARIOUS TREATMENTS ON THE PRESERVATION, COMPOSITION, UNIFORMITY AND NUTRITIONAL QUALITIES OF ALFALFA SILAGE

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EFFECTS OF VARIOUS TREATMENTS ON THE PRESERVATION, COMPOSITION, UNIFORMITY AND NUTRITIONAL QUALITIES OF ALFALFA SILAGE

By

Roy O. Thomas

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ABSTRACT

EFFECTS OF VARIOUS TREATMENTS ON THE PRESERVATION, COMPOSITION, UNIFORMITY AND NUTRITIONAL QUALITIES OF ALFALFA SILAGE

by Roy O. Thomas

During a two year period a series of feeding trials were conducted to determine the relative value of alfalfa hay and alfalfa silage pretreated by heavy wilting and/or certain compounds. The second year a study of the reproducibility of silage made from direct-cut alfalfa forage was conducted along with a further comparison of alfalfa hay and direct-cut pretreated silages. Selected hay and companion hay were used in 1961-62 (Experiment 1) and 1962-63 (Experiment 2), respectively.

In Experiment 1, Trial 1 direct-cut silages pretreated with either formalin, chloroform, ethanol or acetone plus formalin were compared to heavily wilted silage and hay by growth and dry matter intake of dairy heifers. Body weight gains were 1.73, 1.67, 1.83, 1.91, 2.01, 2.15 and 1.73 pounds per heifer per day for untreated and ethanol, formalin, chloroform, and acetone plus formalin treated direct-cut silages, wilted silage and hay groups, respectively. In the same order, dry matter intakes were 13.9, 13.5, 14.7, 14.2, 15.9, 17.6 and 15.1 pounds per heifer per day. Observed differences in body weight gains among treatment groups were not significant. Dry matter intake was significantly higher ($P < 0.05$) from wilted silage than from untreated and ethanol or chloroform treated direct-cut silages. Differences among direct-cut silage and hay groups were not significant.

Dairy heifers (Experiment 1, Trial 2) were fed hay, wilted and ethanol

treated wilted silage, and acetone (2 treatment levels, 5 and 10 pounds per ton), and sodium metabisulfite treated direct-cut alfalfa silage. Daily gains in body weight were 1.06, 1.47, 1.41, 1.16, 1.14, 1.18 and 1.18 pounds per heifer for hay, wilted, ethanol treated wilted, and acetone (5 pounds per ton), acetone (10 pounds per ton), ethanol, and sodium metabisulfite treated direct-cut silages, respectively. In the same order, dry matter intakes were 14.6, 14.4, 14.3, 13.5, 12.4, 12.1 and 12.0 pounds per heifer per day. Observed differences among treatment groups were not significant in the case of either gains in body weight or dry matter intakes.

Dairy heifers (Experiment 2, Trial 1) gained in body weight at the rate of 1.96, 1.37, 1.56, 1.46, 1.58 and 1.55 pounds per heifer per day when fed alfalfa hay, untreated 1 (6 animals), untreated 2 (11 animals), and ethanol, acetone, and tylosin treated silages, respectively. In the same order, dry matter intakes were 19.2, 14.8, 14.4, 14.1, 15.6 and 16.3 pounds per heifer per day. Observed differences in body weight gains among groups were not significant. In general, hay dry matter was consumed in larger amounts than direct-cut silage dry matter. Dry matter intakes were not significantly different among silage groups.

Heifers (Experiment 2, Trial 2) gained 1.95, 1.74, 1.74, and 2.03 pounds per heifer per day on hay and acetone, formalin, and acetone plus formalin treated direct-cut silages, respectively. In the same order, daily dry matter intakes were 18.5, 15.3, 15.2 and 15.1 pounds per heifer. Differences in body weight gains were not significant, however dry matter intake was greater for the hay group than for the silage groups.

Results from the growth trials showed that dairy heifers gained at satisfactory rates on alfalfa hay, heavily wilted alfalfa silage and direct-cut alfalfa silage as the only source of feed. Compounds tested were of little if any value for treating alfalfa forage before ensiling.

Lactating cows produced 27.0, 28.6, and 29.4 pounds of milk per cow per day, and consumed 30.9, 26.1 and 25.0 pounds dry matter per cow per day when fed heavily wilted silage, acetone or ethanol treated direct-cut alfalfa silage. In the same order, daily gains in body weight were 1.1, 1.1 and 0.7 pounds per cow, respectively.

In Experiment 2, cows fed hay and acetone treated direct-cut silage produced 47.1 and 47.4 pounds milk per cow per day, consumed 29.1 and 19.8 pounds forage dry matter per cow per day and gained 1.55 and 0.53 pounds in body weight per cow per day. Cows fed hay consumed more dry matter and gained more body weight than cows fed acetone treated direct-cut silage.

Lactating cows and growing heifers gave the same answer as to the nutritive value of hay and acetone treated silage in Experiment 2.

Observed body weight gains and dry matter intakes of dairy heifers, organic acid concentrations, and pH values indicated that silages made from direct-cut alfalfa forages were highly reproducible. Pretreatment (ethanol, tylosin, acetone, formalin, or acetone plus formalin) of forage harvested and stored at the same time in similar concrete stave silos, influenced the resulting silages little if at all.

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INTRODUCTION

Excellent quality forage is recognized as the cheapest source of nutrients for dairy cattle. Preserving high quality forage in the form of hay is difficult particularily when weather conditions are not conducive to drying. Ensiling, another method of preserving forage, is popular for preserving corn and sorghum in the United States but has not become the primary method of preserving legume and grass crops. Weather conditions influence silage making less than hay making and thus ensiling should be a more desirable method of preserving legume and grass crops.

The data reported herein are results of animal feeding and chemical composition investigations conducted in an effort to determine methods of improving alfalfa silage. The effect of treating forage before ensiling and the variations between direct-cut forage treated and stored in the same way were studied.

REVIEW OF LITERATURE

Many factors influence the value of stored forages. In this review, more current information was added to the reviews of Brown (1961), Hillman (1959), Watson (1939) and Watson and Nash (1960). Related material was reviewed to more clearly indicate the factors responsible for the apparent differences in the comparative value of stored forages. The general areas covered are: (1) hay vs. silage as feeds for lactating cows and growing dairy heifers, (2) effect of pretreatment of ensiled forage on the performance of animals, (3) effect of certain factors on the chemical quality of silage, (4) losses of forage due to harvesting, curing and storing, and (5) relation of temperature to preservation of silage.

Hay vs. Silage as Feeds for Lactating Cows and Growing Dairy Heifers

Brown *et al.* (1963) observed increases in the intake of dry matter by cows as alfalfa silage (direct-cut) was replaced with alfalfa hay. The proportions of hay fed (DM basis) were 0, 25, 50, 75, and 100 per cent of the forage ration. Milk production tended to increase as the proportion of hay was increased in the one trial, however, the differences were small and non-significant when results from two trials were combined. In another experiment, (Brown, 1961) alfalfa silage (direct-cut plus 8 lbs. metabisulfite per ton) or companion hay was fed with and without grain. Dry matter intake per 100 pounds beginning body weight of the hay group was higher than that of the silage group. However, when calculated on the basis of intake per 100 pounds average body weight for the trial, the difference between groups was not significant. Milk production was higher

for the cows fed silage. Hillman (1959) observed similar comparative milk production of cows fed early bloom alfalfa silage, hay plus silage, or hay. In another experiment, cows fed alfalfa silage and a companion hay produced equal amounts of milk. Daily dry matter intake per 100 pound body weight was lower (2.46 pounds) for the silage group than for the hay group (3.14 pounds). Daily body weight gains were 0.46 and 1.0 pounds per cow for silage and hay fed cows, respectively.

On the other hand, Gordon et al. (1963) reported no difference in dry matter intake or milk production of cows fed low moisture alfalfa silage or companion hay. Hill et al. (1954) observed slightly higher dry matter intake of cows fed bud stage alfalfa-grass silage than that of cows fed companion hay. Fat corrected milk production values were 23.1 and 20.4 pounds per cow per day and increases in body weight were 63 and 26 pounds (147 day period) per cow for the silage and hay groups, respectively. The hay group consumed 146 pounds of dry matter per 100 pounds of fat corrected milk produced compared to 132 pounds for the silage group. Huffman et al. (1951) found that 8.4 pounds dry matter from immature alfalfa silage (38.4% DM) replaced 12.6 pounds of very good U. S. No. 1 alfalfa hay and increased fat corrected milk production by 2.1 pounds per day. Replacing all of the hay with this silage increased production 5 pounds per cow per day.

Logan and Miles (1963), using another approach, observed no significant difference in milk production, body weight change, or milk composition among groups of cows. Cows were fed 3.5 or 7.0 pounds of alfalfa-grass silage or 3.0 pounds silage plus 1 pound hay per 100 pounds body weight. Total digestible nutrient intakes were equalized with concentrates.

Murdock *et al*. (1962) studied the effects of feeding two levels of hay and two levels of concentrates with direct cut grass silage. Small differences in milk production were found due to the level of hay feeding, whereas, differences of three and four pounds per day due to level of concentrate feeding were significant ($P < 0.01$).

From the work reviewed the conclusions of Brown (1961) and Hillman (1959) are justified. Cows generally consume more dry matter from hay than from silage. The higher dry matter intake has not consistently resulted in higher milk production. Effect of plant maturity on performance of cows fed silage and hay needs further clarification in light of limited work reviewed. The apparent difference due to crop maturity may be due to more selection of forage in case of animals fed hay compared to less selection by animals fed silage.

Relatively few reports are available on the comparative performance of dairy heifers fed silage and hay. Everett (1963) pointed out that most of the research comparing silage with hay or hay-silage combinations were confounded by supplementing the forage with grain.

Sykes *et al*. (1955) observed unsatisfactory growth from birth to calving of dairy animals fed wilted alfalfa silage. Animals fed good quality hay grew at a satisfactory rate. Small differences in growth and total digestible nutrient intake between groups were observed during the first 150 day period, while milk and grain were fed. Slower growth and lower nutrient intake during the 5 to 12 month period were found for animals fed silage as compared to animals fed hay. A limited amount of hay added to the silage ration failed to produce satisfactory growth during the 5 to 12 month period. Little or no difference was observed in growth between groups in the 12 to 24 months age range.

Similar results were reported later when dairy heifers were fed silage or hay (Thomas *et al*., 1959). Addition of limited amounts of hay or concentrates to the silage ration increased the growth rate but not to the level supported by good quality hay. In another study at the same station (Thomas, Moore and Sykes, 1961), the decreased growth due to silage feeding for periods up to seven months was practically overcome if the animals were fed more adequately in subsequent periods.

Every lot of hay is not an adequate ration for growing animals and unsatisfactory growth in one instance may be satisfactory growth in another instance. For example, Everett (1963) observed 0.09, 1.28 and 1.69 pounds average daily gains of dairy heifers fed direct cut and wilted alfalfa silages and companion hay, respectively. The 1.69 pounds gain of the group fed hay was low compared to the more than 2.0 pounds gain per heifer per day for animals fed silage reported by Sykes *et al*. (1955).

The reports reviewed and the review of Everett (1963) indicated that heifers fed silage grew at a slower rate than similar heifers fed good quality hay. Dry matter intake of animals fed silage was usually less than that of animals fed hay. On the other hand, care should be taken in making recommendations to farmers concerning the comparative use of silage and hay for feeding heifers, because of the well known variability in hay quality.

Effect of Pretreatment of Ensiled Forage on the Performance of Animals

The importance that has been attached to pretreatment of ensiled forage may be illustrated by a statement of Watson and Nash (1960), "The use of stimulants, acids or sterilants, however, are only essential for the preservation of protein rich fodders".

Two broad classifications may be used for the treatment of forage before ensiling. These are (1) adjusting the moisture level (wilting) of the ensiled forage and (2) addition of various materials ("preservatives") at the time of ensiling.

Wilting

Watson (1939) and Barnett (1954) stressed that wilting, although an effective method of directing fermentation to make better quality silage, was not a satisfactory solution to the problem because of unpredictable weather.

Gordon *et al*. (1960) stored first crop alfalfa (20 and 44 per cent dry matter) in gas tight silos and compared the performance of cows fed these silages and barn dried companion hay. Significantly higher dry matter intake ($P < 0.01$) and fat corrected milk production ($P < 0.05$) were observed for the group fed 44 per cent dry matter silage than for the group fed 20 per cent dry matter silage. Efficiencies expressed as dry matter consumed per 100 pounds of milk produced were 72.6, 85.4 and 90.5 pounds for 20 and 44 per cent dry matter silages and hay, respectively. These observed differences in efficiency could not be explained by coefficients of digestibility of dry matter which were 55, 56 and 60 per cent, respectively. In a later report (Gordon *et al*., 1961), results from three years failed to show a consistent difference in dry matter intake or milk production of cows fed high or low moisture silage.

Similarly, Cloninger and Kesler (1962) reported no difference in milk production, weight change or nutrient intake of cows fed high (76.65% H_2O) or low (49.6% H_2O) moisture red clover silages stored in gas tight silos. Similar results were observed (Gordon et al., 1959) when cows were fed wilted (30.0% DM) or direct-cut orchardgrass silages.

In view of the more recent findings reviewed here and the reviews of Everett (1963) and Watson and Nash (1960), wilting of forage before ensiling may increase dry matter intake. This increase in feed intake may not appear as an increase in milk production. The same conclusion was made in the preceeding review of hay versus silage feeding.

Few attempts have been made to evaluate the effects of wilting forage before ensiling on the performance of heifers. The work reviewed by Watson (1939) and more recently by Watson and Nash (1960) and Everett (1963) was inconclusive as to the performance of growing heifers fed wilted or unwilted silages.

Thomas et al. (1961a) reported a positive correlation ($r = 0.79$) between dry matter content of silage and daily dry matter intake of heifers. The silage ranged from 18 to 54 per cent dry matter. Dry matter intake of heifers was measured in feeding periods of 10 to 15 day duration.

In another test (Thomas, et al., 1961b), average daily gains of 0.87 and 0.76 pounds in 1957 and 0.93 and -0.29 pounds per heifer in 1958 were observed for heifers fed low moisture and direct-cut silages, respectively. Similar heifers fed companion hay gained approximately 0.9 pounds per heifer per day in both trials. Apparently the direct-cut silage produced more variable gains than either low moisture silage or hay. The authors suggested that moisture content of the ensiled alfalfa may have caused the observed differences, however, they also indicated that the tests were of a preliminary nature.

Everett (1963) observed daily gains of 0.09 and 1.28 pounds per heifer and daily dry matter intakes of 1.60 and 2.01 pounds per 100 lbs. body weight for groups of dairy heifers fed direct-cut and wilted alfalfa silages, respectively. These silages were made in stacks.

No conclusions as to the effect of prewilting ensiled forage on heifer performance appear to be warranted at this time. This review and the reviews of Everett (1963), Watson (1939) and Watson and Nash (1960) indicated that satisfactory growth was produced from well preserved high, medium, and low moisture silages as well as from good quality hay. Dry matter intake of animals fed high moisture silage may be somewhat lower than that of animals fed lower moisture silage.

The literature reviewed to this point gave the impression that dry matter intake generally was a poor indicator of milk production and growth in the case of lactating cows and growing heifers, respectively. There are no doubts that feed intake is important in a practical operation but higher feed intake (comparing one feed to another at equal costs) with equal returns in salable animal products is never a more profitable situation.

Additives

The use of so called "preservatives" to obtain a better quality in legume and grass silages has been tested extensively. McCullough *et al.* (1960) ensiled early cut, first crop alfalfa to which was added either ground snap corn, citrus pulp, molasses, or sodium metabisulfite. Meta-

bisulfite treated silage was judged unsatisfactory for feeding lactating cows. Milk production decreased 15.9 and 1.0 per cent for groups of lactating cows fed corn and molasses treated silages, respectively. In a previous trial molasses treated silage failed to maintain milk production as well as snap corn treated silage.

In a later experiment (McCullough, 1963), wheat silage preserved with distillers' dried grains increased milk production of cows in 4 of 5 tests as compared to ground snap corn preserved silage.

Other workers have not found preservatives to be as helpful. Wittwer et al. (1955) in a two year study ensiled unwilted red clover mixed with alsike, ladino, alfalfa, timothy, and quack grass in 50-ton wooden silos. Molasses, brewers' dried grains, no preservative and sodium bisulfite treatments were used each year. No significant differences were found in milk production, body weight change, or dry matter intake among treatment groups. The authors noted a trend in favor of brewers' dried grain treated silage in body weight gain and in efficiency of milk production which was thought to be due to the grain added to the ensiled forage. These authors found no economic advantage due to the addition of any one of the materials to unwilted forage.

Miller et al. (1962) found no increase in milk production, weight gain or presistency of milk production due to the addition of soybean flakes to high moisture (15.3-17.7% DM) ryegrass-oat-crimson clover silage. The silages were supplemented with 2 pounds of coastal bermuda grass hay and 15.2 pounds of concentrates per cow per day. Miller and Dalton (1961) added citrolas at the rates of 0, 149, 274 and 425 pounds per ton to flower stage oat forage which was ensiled and later fed with concentrates to

lactating cows. The 149 and 247 pound levels of citrolas significantly increased dry matter intake ($P < 0.01$) of cows fed these silages as compared to the 0 and 425 pound levels. All groups declined in body weight and fat corrected milk production followed a pattern similar to dry matter intake, however, differences among groups were not significant.

Pratt and Conrad (1961) reported similar milk production from cows fed bacitricin and metabisulfite treated and untreated alfalfa-grass silage harvested June 9-17. Two types of experimental designs (3 x 3 Latin square with extra period, and a 36 day continuous trial) were used. The cows fed the untreated silage produced as well or better and at the same or higher efficiency as cows fed treated silages.

Rusoff et al. (1959) observed higher silage intake by cows fed untreated white Dutch clover silage than by similar cows fed silages treated with bacitricin, molasses, or sodium metabisulfite. Differences in fat corrected milk production among treatment groups were not significant.

Olson and Voelker (1961) observed non-significant differences in the response of lactating cows fed enzyme plus lactic acid culture treated or untreated alfalfa silages as measured by fat corrected milk production and intake of dry matter. Production was 34 pounds of fat corrected milk for both groups and intake of fresh silage was 37.2 and 36.0 pounds for enzyme treated and control silages, respectively.

The comparative feeding value of the same enzyme treated silage (Olson and Voelker, 1961) was tested with heifers which gained 16 per cent faster on the enzyme treated silage than on the untreated silage. This difference was not statistically significant.

The value of other materials for treatment of ensiled forage has been

tested by heifer growth. McCullough _et al_. (1960) observed daily gains by dairy heifers of 1.63 and 1.34 pounds per heifer when fed snap corn and molasses treated silages, respectively. Ramsey _et al_. (1960) tried to wilt oat forage for silage, however, wilting was not successful due to weather conditions. The dry matter intakes of heifers were 1.3, 1.4, 1.4 and 1.4 pounds per 100 pound body weight for control, "wilted", bacitricin, and "Silo joy" treated oat silages, respectively.

Brown (1961) found significantly different average daily gains of Holstein heifers fed direct cut alfalfa silage preserved with either 8 pounds sodium metabisulfite, 20 or 50 pounds denatured ethanol per ton. The daily gains were 1.02, 1.45 and 1.68 pounds per day, respectively, during a 30 day feeding period. Dry matter intakes were 14.0, 13.2 and 13.7 pounds per day, respectively. In the same order, pH values were 5.1, 4.6, and 4.8 and dry matter percentages of the silages were 23.0, 20.3, and 21.6, respectively.

The voluminous literature dealing with additives for preserving silages reviewed by Watson (1939), Barnett (1954) and more recently by Watson and Nash (1960) may be summerized in one statement. Additive type treatment has failed to improve silage quality consistently as measured by milk production of cows or growth of heifers. Watson and Nash (1960) agreed except in the case of high protein crops. The present review indicated that the conclusion could be extended to leguminous crops in the United States, however, one report showed that the rate of gain of dairy heifers was increased by pretreatment of alfalfa with denatured ethanol. More research needs to be conducted to substantiate this result.

Effect of Certain Factors on the Chemical Quality of Silage

According to Archibald et al. (1954) good quality silage has the following characteristics (dry matter basis except pH): 1. A pH of 4.5 or less (the nearer 4.0 the better): 2. Low volatile base content (0.5 per cent or less, expressed as ammonia): 3. Lactic acid content of 3 to 5 per cent or more: 4. Butyric acid content of 2 per cent or less. Other attributes that have been used to describe quality are odor, taste and texture.

Factors of interest in this review that affect the chemical quality are moisture level and preservatives. Two other points are reviewed briefly as an illustration of the complexity of problems of silage making. These two are carbohydrate and protein level and air exclusion.

Carbohydrate and Protein Level

Watson (1939) indicated that the acidity, a product of fermentation, is the effective preserving agent of silage. pH is a measure of acidity used almost universally by investigators studying silage.

Jacobson and Wiseman (1962) proposed a method relating fresh forage sugar and protein content to silage pH. According to this method index numbers were calculated by multiplying total sugar content by 100 and dividing by crude protein content. Fresh forages with index numbers of 35 or higher produced silages with pH values of 4.0, while forages with an index of less than 35 usually produced pH values higher than 4.0. Data to support this proposal were obtained from tests with orchard grass forage stored in laboratory silos.

Kroulik _et al_. (1955) observed about twice as much sugar in orchard grass forage as in alfalfa forage. Protein levels were about the same for the two forages. Most of the sugar disappeared during the fermentation and storage of the forages. These authors suggested that high moisture forage with high levels of sugar favored lactic acid bacteria. Archibald (1961) suggested that part of the variability noticed in silage making may be due to crop composition. This investigator observed a significant inverse relationship between sugar content of forages and average air temperature. Sugar content decreased as the crop matured. Watson (1939), Watson and Nash (1960) and Barnett (1954) suggested that forages with high protein content produce less desirable silage than forages with lower levels of protein.

Air Exclusion

The effects of air (oxygen) on ensiled forage has been noted many times (Watson, 1939, and Barnett, 1954). A comprehensive study was reported recently (Langston _et al_., 1958). These investigators reported the effects of varying amounts of air exclusion in first, second, and third cuttings of orchardgrass and alfalfa forage. Apparently orchardgrass and alfalfa differ in regards to the effects due to air abuse. Cuttings of the same crop differ in regards to the same abuse. Alfalfa forage produced better quality silage than did orchardgrass forage. A notable contribution from this work was that no single criterion (pH, ammoniacal nitrogen, butyric, or lactic acid levels, or spore counts) was reliable in classification of the silages. Lancaster and McNaughton (1960) observed an increase in lactic acid content of ryegrass-white clover silage with increase in

consolidation (packing).

Moisture Level

Moisture level has often been related to quality of silage (Watson, 1939), (Barnett, 1954), (Watson and Nash, 1960), (Archibald, 1946, 1954), (Woodward and Shepherd, 1942) and (Hayden *et al*., 1945). Unfortunately, the studies have not always separated variables other than moisture level. Woodward and Shepherd (1942) statistically studied some 175 lots of experimental silages concluding that low moisture and low pH silages (different groupings of same silages) were significantly better (dry matter intake of cows) than high moisture and high pH silages, respectively. Hayden *et al*. (1945) and Archibald (1946, 1954) found that the quality of silage was influenced by moisture level of the silage. Archibald (1954) stated that above 75 per cent moisture poor silage was almost a certainty. All of the investigators cited agreed that about 60-70 per cent moisture was the ideal level for producing good quality silage.

Apparently a lower moisture level than generally found in succulent forage is desirable for production of top quality silage. Barnett (1954) and Watson (1939) doubted that wilting was a practical solution to improving silage due to adverse drying weather. Other facets of the overall problem such as sugar level, protein level, and maturity need more study to determine the real value of wilting. Lancaster and McNaughton (1961) observed decreases in lactic acid content of silage as the ensiled crop matured.

Effect of Additives

To continue a discussion of the effects of certain treatments on the chemical quality of silages, an indication of the compounds that have been identified from silage was thought to be of value. Many compounds have been found in silage by investigators who have studied the product. Recently Morgan and Pereira (1962a, b) analyzed fractions removed by steam (1962a) and a flow of nitrogen gas (1962b) from poor quality grass and good quality corn silages. The steam distillate of the silages contained normal C_2 to C_6 organic acids, isobutyric and alpha and beta methylbutyric acids, 2-methylpropanal, acetone, benzaldehyde, and furfural. Cis-3-hexanol and 3-(methylthio) proponal were found in the grass silage but not in corn silage fractions. The nitrogen gas fraction contained methylsulfite, ethanal, propanal, acetone, butanone, methanol, ethanol, propanol, 2-butanol, methyl acetate, and ethyl and propyl esters of formic, acetic, propionic and butyric acids. As pointed out by the authors, some of the compounds identified may have been formed during one or more of the procedures used in extraction and purification.

Since pH and lactic acid concentrations are almost universally accepted as related to silage quality one or both was used in many instances to relate levels of compounds to quality. Watson (1939), Watson and Nash (1960) and Barnett (1954) stressed that pH decreases as lactic acid concentration increases. In contrast, Lessard _et al_. (1961) described laboratory results that indicated higher lactic acid content does not always cause pH to drop. High moisture alfalfa silage contained 4.90, 6.73, and 0.0 per cent lactic acid (dry matter basis) at 36 hours, 8 and 240 days of storage, respectively. The corresponding pH values were 5.58, 5.64 and 5.56, respectively. These results may also indicate that the laboratory esterification procedure used to prepare lactic acid for analysis was not dependable or that concentrations of the acid did not reach levels sufficiently high to depress pH.

The effect of additives at the time of ensiling has been widely studied. Hegsted et al. (1939) reported 0.21 and 0.77 per cent ethanol in the dry matter of alfalfa silages preserved by the AIV method or with molasses, respectively. The following year values of 0.32 and 0.69 per cent, respectively, were found. In comparison, Wisconsin work reviewed by Watson (1939) showed alcohol concentration in corn silage of 0.02 and 0.87 per cent of the dry matter at 0 and 146 days of storage, respectively. Non-volatile acids expressed as lactic acid were 2.02 and 7.99 per cent of the dry matter at 0 and 132 days, respectively. The pH values dropped from 5.9 for fresh corn to 3.8 for silage stored 132 days.

Results presented by Hayden et al. (1945) indicated that the AIV acid method of preserving alfalfa silage was the only forage treatment that consistently lowered pH value of silage to less than 4.0. Molasses, ground shelled corn and phosphoric acid were other additives tested.

Shepherd (1949) reported pH values of silages made during several years at Beltsville. Fresh green crops (alfalfa or soybeans) ensiled with and without several preservatives showed variable pH values. Three untreated alfalfa silages had pH values ranging from 3.98 to 5.4. Additions of molasses, corn and cob meal, alfalfa and timothy hays or salt had little if any effect on pH of alfalfa silages as compared to the respective control silages. The above treatments lowered the pH of soybean silages.

Kroulik et al. (1955) found that pH of direct cut alfalfa silage (77.6% moisture) increased from 4.2 to 4.7 between 10 and 127 days storage time. An increase was not apparent in the case of sulfur dioxide (SO_2) treated or wilted alfalfa silage.

Alderman _et al_. (1955) reported an average pH of 4.49 for 48 samples of silage from farm size tower silos filled with unwilted forage (bisulfite treated) which averaged 28.4 per cent dry matter. Cowan _et al_. (1956) reported the pH values for untreated direct-cut alfalfa silage harvested at prebloom, 1/10 bloom, and full bloom stages of maturity at 5.7, 5.3 and 5.5, respectively. Bisulfite treatment of alfalfa forage harvested at the same stages produced silages with pH values of 4.3, 4.7 and 4.8, respectively, while wilted forage produced silages with pH values of 5.3, 5.2 and 5.1, respectively. These forages were stored in 4' x 8' steel cylinders. The pH values of one-half bloom alfalfa silage preserved with 0, 5, 8, 12 and 18 pounds of metabisulfite per ton were 4.7, 5.2, 4.9 and 4.8, respectively.

Some antibiotics have been tested for their effectiveness as silage preservatives. According to Dexter (1957), terramycin, neomycin, penicillin, bacitracin, aureomycin, streptomycin and a mixture of these antibiotics failed to improve consistently the quality of full bloom alfalfa silage. Variability of alfalfa silage was typical of difficulties encountered by farmers. In contrast, Rusoff, Breidenstein and Frye (1959) found that bacitracin, molasses and bisulfite decreased the pH of white Dutch clover stored in plastic silos, to less than 4.5 as compared to pH of 5.17 for control forage. All the silages had good color and odor characteristics.

Pratt and Conrad (1961) used laboratory silos to test two of the same compounds. Alfalfa-bromegrass was treated with bacitracin or sodium metabisulfite and ensiled in glass lined cylinders. The top of the forage in the cylinders was weighted to equal the pressure in a silo 30' to 40' high. Bacitracin had no effect or increased the oxidation in the small silos as indicated by chemical analysis of the resulting silage. Total acidity was higher in the bacitracin treated silage than in the bisulfite or control silages. Bacitracin treatment allowed variable total acidity in farm size silos whereas the other two treatments were much more uniform in this respect.

Leatherwood et al. (1963) treated first crop alfalfa and barley (early dough stage) forages with certain cellulytic enzymes and a culture of lactobacillus casei. Results of chemical analyses showed that cellulose content of the silages decreased while acidity, reducing substances and dry matter loss increased due to the enzyme treatment as compared to control silage.

Owen (1962) in a similar test studied the effect of adding cellulase, hemicellulase, pectinase, and zinc bacitracin to Altas sorghum ensiled in fruit jars. No differences in chemical composition (proximate analysis) were observed between enzyme treated and untreated silages. Significant differences were found among enzyme treatments in ether extract and ash content ($P < 0.05$) and nitrogen free extract ($P < 0.01$). Bacitracin significantly ($P < 0.05$) increased crude protein and decreased nitrogen free extracts as compared to silages without bacitracin.

Ibbotson (1963) reported higher pH values for forages treated with limestone before ensiling in farm silos, however, the silage quality was not decreased as measured by color, smell and texture. Follow up work in laboratory containers showed higher concentrations of acetic and butyric acids in the limestone treated than in the untreated forage. Magnesium

oxide treated silage had higher pH than limestone treated silage.

Watson (1939) Barnett (1954) and Watson and Nash (1960) concluded that a preservative was needed for high moisture forage containing high levels of protein.

From these reviews and the present one, the conclusion that preservatives tested have not improved silage quality consistently appears to be reasonable. The farmer has much more to gain by attention to the details of good equipment and ensiling techniques than by adding preservatives.

Other Factors

Several other factors have been studied in relation to the chemical quality of silage. Gibson et al. (1958) used test tubes as silos to study the effect of constant storage temperature on silage quality. Differences in pH values could not be attributed directly to temperature (22°, 30° or 40°C), development of different types of organisms, or to different materials stored. Lowest pH values, however, were observed in the 40°C treatment and highest in the 22°C treatment. All pH values were above 5.0 at the end of 8 days storage. Watson and Nash (1960) stressed that studies such as this one give little insight into the effects of temperature in larger silos.

Other chemical measures of silage quality have been proposed. The value of these measures has been tested by animal performance. Gordon et al. (1962) reported the butyric acid content expressed as per cent of dry matter was 7.3 and 5.0 of silages made from fertilized and unfertilized forages, respectively. The fertilized forage received 400 pounds of ammonium nitrate per acre about two weeks before harvest. Performance of cows indicated that the unfertilized forage was of better quality. No difference in cow performance the following year was observed although chemical differences were about the same as in the previous year.

Butyric acid and other organic acids as quality indicators were further tested (Rusoff and Randel, 1962) by adding organic acid mixtures characteristic of low and high quality silages to low quality hay. Heifers consumed more of the "low quality" acid treated hay. Allen et al. (1955) observed no difference in palatability between silage and similar silage plus butyric acid.

Non-protein nitrogen content, particularly ammoniacal nitrogen, has been suggested as an indicator of silage quality. Gordon et al. (1961 b) reported twice as much ammoniacal nitrogen (NH_3-N) in direct-cut silage as in low moisture silage. The total acid concentration was higher in the direct-cut silage, and cows consumed less dry matter from this silage. Gordon et al. (1962) reported higher NH_3-N in orchard grass silage made from nitrogen fertilized forage compared to unfertilized forage. Milking cows fed the two silages produced less fat corrected milk, consumed less dry matter and lost weight on the fertilized forage in one test. Animal performance the following year did not substantiate the first year results.

No chemical test or series of tests can be relied upon to determine silage quality consistently. Moisture level, sugar content, and protein level of the ensiled forage are important in making silage but the significance of each or the relationship one to the other is poorly understood. The statement of Watson and Nash (1960) to the effect that little has been learned about silage since 1938 may be extended to "little is known about silage making". Fortunately, when forage is stored under conditions (not well understood) which exclude air reasonably well, a feedable product is usually obtained.

Losses of Forage Due to Harvesting, Curing and Storing

The losses of nutrients between the standing crop and the feeding of that crop should have a considerable influence on the method or methods selected to harvest and preserve the crop. Today, as for centuries, the two general methods used to harvest the crop are grazing and cutting. Reported losses due to grazing (Huffman, 1939) and due to curing of hay (LeClerc, 1939), (Huffman, 1939), (Watson, 1939), (Barnett, 1954) and (Watson and Nash, 1960) ranged from 10 to 35 per cent of the original crop.

Silage

Losses in the ensilage method of forage preservation may also vary considerably due to the method used to direct the fermentation process. Trimberger *et al*. (1955) found 1.0 per cent loss of dry matter between the standing crop and storage of direct-cut silage. The losses due to wilting may be small or rather large due to the amount of water removed or conditions under which wilting is attempted. Nash (1959) reported increases of one to three per cent in total dry matter due to slight wilting. In contrast Shepherd *et al*. (1954) reported losses between cutting and storing of about 6 to 12 per cent due to field drying to moisture levels of 60 to 65 and 37 to 52 per cent, respectively.

Losses after the crop has been harvested and stored may also influence the selection of a method of handling the forage. Watson (1939) summarized the losses in the silo as 16.8, 35.8, 23.6 and 57.9 per cent of dry matter, starch equivalent, digestible crude protein, and digestible "true" protein, respectively, for silages made from clover-grass mixtures and legumes by the ordinary process (unwilted, untreated). In a later review, Watson and Nash (1960) gave the average losses of dry matter reported before and after 1938 as 15.9 and 19.5 per cent, respectively, of the original crop for unwilted, untreated forages.

Effect of Moisture Level on Losses

Watson (1939) and Watson and Nash (1960) summarized the reported dry matter losses from wilted forage. The average loss was 13.4 per cent of the original crop. Shepherd (1949) reported from 8.6 to 15.6 per cent total dry matter losses of which 2.6 to 8.8 per cent were top spoilage. Moisture levels of the alfalfa forage as stored ranged from 57.0 to 67.7 per cent.

Murdock (1960) reported that dry matter, crude protein, and nitrogen free extract losses during storage were lowest at about 34 per cent dry matter content of the ensiled forage. The alfalfa-orchardgrass forage was stored in experimental silos after wilting periods of from 0 to 8 hours. Dry matter losses were 28.5, 27.8, 17.1, 7.3, 8.3 and 16.3 per cent for forages stored at 19.8, 22.8, 27.1, 33.9, 34.4 and 39.6 per cent dry matter, respectively. Losses of crude protein and nitrogen free extract followed the same pattern as dry matter losses. The pH values for all silages were above 5.0.

In contrast, Bender et al. (1936) described low moisture silage stored in an upright silo as unfit to feed animals. The material near the bottom

was charred while that nearer the top was spoiled by mold. This 100 per cent loss was rather extreme but possible when low moisture material (44% moisture) is ensiled. Recovery of dry matter decreased as the per cent of dry matter in stored material increased and with time in storage according to Pratt and Conrad (1961). Recovery of dry matter of untreated legume-grass forage stored in small glass lined steel cylinders was 95 per cent.

Effects of Additives on Losses

Losses are generally determined when preservatives are evaluated. A legume-grass forage was direct-cut and ensiled with no preservative, dried brewers' grain, molasses, or sodium metabisulfite (Allred *et al*., 1955). Total dry matter losses were determined by total weight and bag techniques. Losses were 30.1, 31.9, 32.4 and 28.1 per cent for the total weight technique and 29.5, 30.5, 30.0 and 28.3 per cent for the bag technique for no preservative, sodium metabisulfite, molasses, and brewers' dried grains treatments, respectively. These results do not agree with the opinion of Barnett (1954) that the bag technique was not reliable for determining losses.

In contrast, Bratzler *et al*. (1955, 1956) and Cowan *et al*. (1953, 1956) reported a very definite reduction in losses of silage dry matter when sodium metabisulfite was added as a preservative. This saving was not great for orchardgrass, but losses from legume forages were reduced about one-half compared to untreated controls. These data were collected from small silos and barrels used as silos.

Knodt *et al*. (1952) observed 12.2 and 25.9 per cent loss of dry matter from a timothy-red clover forage treated with sulfur dioxide and corn and cob meal, respectively.

Camburn et al. (1938) reported less than 17 per cent loss of dry matter of which about 7 per cent was top spoilage. This group used 4' x 12' wooden silos to store 12, 12 and 4 lots of alfalfa, timothy and soybeans, respectively. The alfalfa silage from the top of silos was described as of poor quality. Molasses added as a preservative in this study decreased losses slightly.

McCullough et al. (1960) reported recovery of dry matter of alfalfa (early bud stage) plus snap corn, citrus pulp, molasses, or metabisulfite stored in 20 ton upright silos during 1958 and 1959. Recovery of dry matter in 1958 was 62.5, 75.5, 88.5, and 86.7 per cent of sodium metabisulfite, molasses, snap corn, and citrus pulp treated silage, respectively. The 1959 recoveries were considerably higher for replicated snap corn and molasses treatments. Recoveries of snap corn treated silage dry matter were 87.4 and 90.4 per cent compared to 88.5 and 75.5 per cent recoveries of molasses treated silages in 1958. Recovery of hydrolyzable carbohydrates was much higher in the snap corn treated silage than in the other silages. Differences between treatment effects on losses should be compared with wide differences between different lots of similarily treated silages. McCullough, Sisk and Sell (1958) observed differences between two years of about 30.0 percentage units in recovery of nutrients of oat silage preserved with sodium metabisulfite. A 20 units difference was observed between years for similar oat silages preserved with snap corn. The significance of differences between additives becomes doubtful in these comparisons due to the large yearly differences.

Wilting may reduce losses of dry matter about 3 per cent during storage of forage crops as silage compared to unwilted forage. However, the loss from wilted forage may be extremely high under conditions less than ideal. Small savings in forage dry matter may be found due to the use of feed materials (ground grains) as preservatives. Several observations of losses should be made since variability has been large. In general, preservatives have not saved dry matter during storage of high moisture forage.

Other Factors

Losses during storage of silage may be influenced by several factors other than level of moisture and preservatives. Voelker (1959) suggested that some of the observed differences in losses might be due to airtightness of silo, surface exposed while feeding, depth of stored silage, and type and moisture content of crops. This investigator adjusted the feeding level of test animals and added refused silage as part of the total loss, which may reduce error in determining spoilage.

Miller, Clifton and Cameron (1962), and Miller, Dalton and Miller (1961), reported higher total loss of dry matter for slow filling than for rapid filling of silos.

Gordon et al. (1961a) reported results of two experiments comparing sealed and unsealed bunkers. Losses for unsealed and sealed treatments were 37.1 and 19.1 per cent in Experiment 1, and 46.9 and 21.3 per cent in Experiment 2, respectively. The difference between Experiment 1 and 2 unsealed silages disappeared when calculated as loss per square foot of surface area. Air leakage in any type of silo would increase the surface area and, thus, increase both seepage and gaseous losses according to these

results.

Langston et al. (1958) found that air pumped through silage, poor packing, and poor sealing increased losses of dry matter and greatly decreased the quality of silage. Apparently air inclusion in silage increased losses. This may explain some of the high losses cited previously.

Runoff Losses

Losses during the fermentation and storage period have been classified as runoff, fermentation and top losses. Watson and Nash (1960) indicated that top losses were avoidable. The writer agrees if the statement includes "under ideal conditions". Runoff, according to Woodward and Shepherd (1942), was not troublesome at forage moisture levels of less than 68 per cent.

Archibald and Gunness (1945) reported the average of 7 year runoff losses to be 0.54 per cent of the ensiled dry matter from a 100-ton silo. The material ensiled was wilted in most years. The range in dry matter per cent of the runoff was 4.6 to 10.0 with an average of 7.6 per cent.

The range in dry matter loss was 2.4 to 9.5 per cent from direct-cut legume-grass silages (Allred et al., 1955). Wittwer et al. (1955) reported the average two year runoff loss from the same silages. Losses were 7.4, 4.4, 7.4, and 6.0 per cent of the ensiled dry matter for molasses, brewers' dried grains, no preservative and sodium metabisulfite treated silages, respectively. This loss was about one-fourth of the total loss of dry matter (Allred et al., 1955 cited previously). Brewers' dried grains decreased seepage as measured by the bag technique.

These runoff losses agree with those reviewed by Watson (1939), Barnett (1954) and Watson and Nash (1960). Any loss of course is "too much" but runoff has been very much over-rated as a source of loss. No doubt, the mess around the silo site caused by seepage, is a problem that needs solving.

Relation of Temperature to Preservation of Silage

Several investigators have reported that high temperature decreases the quality of silage. In general, high temperature has been associated with failure to exclude air sufficiently well to prevent aerobic fermentation. Some have found that dry matter loss may not be increased by high temperature; however, the protein loss has usually been greater in high than in low temperature fermentation (Watson and Nash, 1960).

The peak temperature attained in silage may be used to classify the fermentation process according to the classification of Watson and Nash (1960). These authors divided the processes into very low, low, and high temperature. The corresponding temperature ranges were below 80°, between 86° and 120° and above 120° F., respectively. The factors that control temperature in silage were reviewed by the same authors.

Langston *et al*. (1958) ensiled alfalfa and orchardgrass forages in steel tanks under different conditions of air exclusion and at different moisture levels. Peak temperatures increased as the dry matter of the ensiled forage increased. Difference could not be attributed to moisture level in the case of wilted and direct-cut bisulfite treated orchardgrass silages stored in tower silos (Gordon *et al*., 1959).

The packed, weighted and sealed alfalfa silages attained peak temperatures within 2 to 5 days, whereas the unpacked and unsealed silages did not reach maximum temperature until 28 or more days (Langston *et al*., 1958, cited above). High temperatures were associated with poor quality silage although alfalfa was more tolerant of high temperatures than orchardgrass.

High temperatures were also associated with high fermentation losses. Losses of dry matter were three times as high in the poor quality alfalfa silage as in the good quality silage. The four alfalfa silages classed as poor in quality reached temperatures of 54 and 72° C. Gordon et al. (1961a) reported higher temperature in unsealed bunkers than in sealed bunkers.

Gordon et al. (1959) reported an increase in temperature in the first 4 and 10 days of storage for wilted and direct-cut silages, respectively. Increases were less than 10° F. followed by a slow decline to outside temperature.

Apparently crop ensiled and outside temperature as well as available oxygen in the ensiled mass affect the observed temperature of silage. From the reviews of Watson (1939), Barnett (1954) and Watson and Nash (1960) high temperature may indicate poor preservation.

EXPERIMENTAL PROCEDURE

During a two year period (1961-63) a series of studies were conducted to determine the value of treating alfalfa forage before ensiling. Measurements used to evaluate the effects of treating by wilting and by adding compounds were growth of dairy heifers, milk production of cows, dry matter intake of heifers and cows, and chemical composition of the resulting silages. Loss of dry matter and temperature of the silage were obtained to increase the information from farm size structures.

The studies were divided into two growth and one milk production trial each year, so as to obtain the maximum amount of information from use of the available equipment and animals.

Effect of Wilting and Adding Compounds Before Ensiling on the Relative Value of Alfalfa Silage. Experiment 1 (1961-62)

First crop alfalfa (90-95%) was harvested in the late bud-early bloom stage of maturity. The forage was stored as direct-cut and heavily wilted material with or without additives (Table 1).

The direct-cut forage was cut, chopped and loaded into wagons with cutter bar forage harvesters. Wilted forages were cut with a cutter bar mower, raked with a side delivery rake, picked up, chopped and loaded into front unloading wagons with a field forage harvester. Two harvesters and two blowers were used to allow both wilted and direct-cut materials to be handled simultaneously. The harvesters were set for less than one-half inch theoretical length of cut. Each loaded wagon was weighed on platform scales and empty wagons were weighed several times during the filling

operation.

Table 1. Harvesting Dates and Treatments of Alfalfa for Silage and Hay Experiment 1, 1961.

	Trial 1		Trial 2	
Silo No.	Cutting date	Treatment[1]	Cutting date	Treatment[1]
3	7/11-12	Acetone-10 Formalin-3	7/8	Acetone-5
4	7/10	Wilted	7/5-6	Sodium-metabisulfite-8
5	7/13-14	None	7/7	Acetone-10
6	7/10-12	Formalin-3	7/6	Ethanol-20
7	7/12-14	Chloroform-5	7/5	Wilted
8	7/10-12	Ethanol-10	7/5	Wilted + Ethanol-20
9		Wilted		
10		Acetone-10		
11		Ethanol-10		
Hay - Selected from available supply				

1. Treatment and pounds added per ton.

Total fresh weight of each load of forage was calculated by subtracting the empty wagon weight from the loaded weight. The amount of additive (Table 1) for treated forages was calculated to the nearest 0.1 pound and weighed with a dairy scale. This amount was spread on top of the forage in the loaded wagon just prior to unloading. Acetone and formalin were mixed together after each had been weighed individually. Formalin was diluted with two volumes of water. Chloroform and water were mixed in equal parts.

The blower pipe was adjusted to deliver the material into the center of the silo. The forage was leveled as often as possible although the treatment compounds ethanol, chloroform, formalin and acetone were extremely unpleasant to personnel working in the silo. In fact, the filling operation had to be discontinued for several minutes prior to the start of hand work.

Trial 2 forage was stored under Trial 1 forage in 10' x 40' silos. In both trials the forage in each silo was leveled, trampled and covered with plastic. The top plastic (top of Trial 1 forage) was weighted with approximately 1500 pounds of direct-cut forage which was not included in the input-output calculations. The 12' x 20' silos were handled in the same way as the 10' x 40' silos except that only one forage treatment was stored per silo.

The inside walls of newly constructed 10' x 40' concrete stave silos were painted with an epoxy plastic paint which was reputedly acid resistant and impervious to moisture. Walls of the 12' x 20' silos were not painted. The six 10' x 40' silos were numbered 3 through 8 and the 12' x 20' silos numbered 9, 10, and 11.

Hay, a control forage in both trials, was a second cutting alfalfa-grass mixture estimated to contain more than 80 per cent alfalfa. The green color and high leaf content indicated a well cured early cut hay.

Dairy heifers and cows used to evaluate the silages and hay were obtained from the Michigan State University dairy herd. Seven Brown Swiss, 14 Jersey and 35 Holstein heifers were used in Trial 1, whereas, 21 Jersey and 35 Holstein heifers were used in Trial 2. The body weight of the heifers at the start of the trials ranged from 350 to 662 pounds and 250 to 907 pounds for Trial 1 and 2, respectively. In the same order, average beginning body weights were approximately 500 and 550 pounds, respectively.

Each animal was assigned to one of seven groups so that groups were balanced with respect to breed and body weight. Each group fed the Trial 1 forages was composed of one Brown Swiss, two Jersey and five Holstein heifers. Average body weight among groups differed by less than five pounds. Each Trial 2 group was composed of three Jersey and five Holstein heifers with less than three pounds difference in average body weight among groups.

Each group of animals in each feeding trial was randomly assigned to one of the silages or hay. A random numbers table was used for this purpose in the following way. A balanced group of animals was assigned one of a set of numbers 1, 2, 3, 4, 5, 6 or 7. Similarily, the six silages and hay were assigned numbers 1 through 7 for forages from Silo 3, 4, 5, 6, 7, 8, and hay, respectively. The sequence in which the assigned animal group numbers appeared as the last digit in the random numbers table determined the forage to be fed. For example, if 6 were the first number appearing below the starting point in the numbers table the group of animals numbered 6 was fed silage from Silo 3. This process was repeated until all groups had been assigned. Groups of animals were assigned to forage treatment in a similar manner for Trial 2. Forages from the six 10' x 40' silos were fed to heifers.

Fifteen cows were divided into three groups of five cows per group balanced with regard to milk production, body weight, age and stage of lactation. Each group was assigned to wilted, acetone or ethanol treated silage stored in 12' x 20' silos. Each group was sub-divided into two groups, three cows in one and two cows in the other. Each of the six groups was assigned to a different forage feeding sequence. (Table 2). Hay replaced the wilted silage in the third period.

Table 2. Sequence of Feeding Experimental Forages to Lactating Cows (Experiment 1)

Group (1)	Period 1	Period 2	Period 3
A	9	10	11
B	10	11	Hay (2)
C	11	9	10
a	9	11	10
b	10	9	11
c	11	10	Hay (2)

1. Groups designated by upper case letters 3 cows per group, lower case letters 2 cows per group.

2. Hay replaced wilted silage in Period 3. Numbers in the body of the table represent silo number.

Individual animals were weighed three consecutive days at the beginning of each trial and at the end of each period. The three daily weights for each animal were averaged. This average was considered the experimental weight. A platform, beam type scales with a dial indicator was used for weighing animals. Weighing was started at 1:00 p.m. for heifers and 10:30 a.m. for cows.

Cows were milked by machine two times per day and the amount of milk produced determined with a "Milk-O-Meter" (1). The fat content of

1. Manufactured by Technical Industries, Inc., Fort Lauderdale, Florida.

each cow's milk was determined weekly by Babcock test on a one day composite sample collected by the "Milk-O-Meter".

The amounts of feed offered and refused were determined on an individual animal basis. The animals were fed twice per day between 7:00 and 9:00 a.m. and 3:00 and 5:00 p.m. Concrete mangers were cleaned and the refused feed weighed prior to the morning feeding. Each animal was fed approximately ten per cent more forage than was consumed.

Cows were fed concentrates at the rate of one pound per two pounds of milk produced above 40 pounds per day in Experiment 1. Concentrates were not fed to cows producing less than 40 pounds milk per day.

Heifers were supplied a trace mineral salt-dicalcium phosphate mixture at the rate of approximately two ounces per heifer per day. Cows received salt and dicalcium phosphate at the same rate plus one per cent each in the concentrates fed.

Each animal had free access to water from a drinking cup.

Samples of forage for dry matter and chemical composition determinations were obtained at three different time intervals during the experiment. These samples may be divided into three groups: freshly chopped green forage, forage during early storage period, and forage (silage and hay) at the time of feeding.

A fresh forage sample of each treatment lot was collected from the discharge belt of the power unloading wagon as the material was unloaded. Several samples were taken from each wagon and placed in a plastic bag as collected. The container was kept closed except during the time more sample was being added.

The samples collected during the early storage period were taken with a "forage sampler" (developed at Pennsylvania State College) through a hole in the wooden door of the silo. The sample collected was a mixture of material from just inside the door to a maximum depth into the mass of approximately two feet. Only one sample was collected per hole. The hole was closed immediately after sample collection with a rubber stopper.

The samples at feeding were collected by the grab method from the feed cart at the morning feeding twice per week. The daily sample was placed in a plastic bag and stored (40° F.) until the end of the weekly collection period. The two daily samples were mixed for the weekly sample of forage fed. Samples of feed refused were collected and handled in a similar manner.

A sample of the hay to be fed during each week of the feeding trials was obtained by boring each bale with a "forage sampler". Refused hay samples were obtained weekly by the grab method. Refused hay samples were chopped by hand before subsampling.

Forage samples (green forage, silage and hay) were thoroughly mixed on a plastic sheet and sub-sampled for chemical determinations. Samples for dry matter determination were weighed into previously dried and weighed pans and immediately put in a forced draft oven maintained at 80° C. The sample was reweighed after a 48 hour drying period and the portion of the original sample remaining was considered dry matter.

The samples used for determining pH were weighed into beakers and distilled water added in the ratio of three milliliters water to one gram forage. An equilibration period of one-half to two hours at room temperature was allowed. Measurements of pH were made with a Beckman (Model G) pH meter equipped with glass and calomel electrodes. The water-forage sample was used rather than juice. No differences between readings of prepared sample and of juice therefrom were observed on several samples.

Fresh forage samples were extracted with dilute acid for determination of organic acids and soluble carbohydrates. Fifty grams of the forage were weighed in a glass jar and fifty milliliters of 0.6 N sulfuric acid added. The forage was then pressed down with a glass rod, a cap put on the jar, and the prepared sample stored in a refrigerator for 48 or more hours. Juice was squeezed out of this sample and centrifuged at 1200 gravities for twenty minutes. The supernatant was stored in small stoppered bottles in a refrigerator until analyzed.

Samples of runoff juice were caught from the end of the silo drain and carried to the laboratory. The samples were divided into two portions, one for pH and dry matter determinations, the other for chemical analyses. Dry matter and pH determinations were performed as rapidly as possible. pH was determined as described for the prepared silage samples. Dry matter was determined by pipetting 100 milliliters into a preweighed pan and removing most of the water by heating over a hot plate. The partially dried sample was dried to constant weight under the same conditions used for forage samples. Due to spattering during partial drying on the hot plate, the dry matter determinations were believed to be unreliable.

The portion for chemical analyses was acidified immediately by adding 2 milliliters of 50 per cent sulfuric acid to 50 milliliters of juice. The acidified juice was handled as described for the acid extract juice from the forage samples.

Analyses for solvents, organic acids, and soluble carbohydrates were performed on the sulfuric acid extracts of forage and the acidified run-off juice. Determinations of ethanol, acetone and formaldehyde were made with a Cenco gas chromatograph equipped with a 1/4" x 6' column packed with Carbowax 600 and a thermo conductivity cell. Column temperature was maintained at 110° C. and the carrier gas (Helium) flow at 60 milliliters per minute.

Determinations of acetic, propionic, butyric and formic acids were made by the method of Wiseman and Irvin (1957), however, their calculation was not used. Standard dilution calculations were applied with the assumption that one gram of silage was equal to a volume of one milliliter.

Lactic acid in the sulfuric acid extracts was determined by the procedure of Barker and Summerson (1941). A known lactic acid standard at four concentrations was taken through the procedure at the same time each group of samples was analyzed. Concentrations of lactic acid in the samples were determined from a straight line established by the known concentrations run at the same time.

Soluble carbohydrates were determined by the phenol sulfuric acid method of Dubois, et al. (1956). The optical density was read in a Beckman (Model B) spectrophotometer at 490 millimicrons. The samples were compared to known concentrations containing 10 to 80 micrograms of glucose per tube. Concentrations usually used were 20, 40, 60 and 80 micrograms per tube. The various concentrations of the known were run with each group of samples.

Effect of Adding Compounds Before Ensiling on the Relative Value and Uniformity of Alfalfa Silage Treated and Stored Alike.

Experiment 2 (1962-63)

First crop alfalfa (90-95%) was harvested in the early bud stage as direct-cut forage for ensiling or as companion hay. Replicated treatments of the direct-cut forage were stored with and without certain additives (Table 3).

Table 3. Harvesting Dates and Treatments of Alfalfa for Silages and Hay Experiment 2, 1962.

Trial 1			Trial 2	
Silo No.	Cutting date	Treatment[1]	Cutting date	Treatment[1]
3	6/1	None	5/24	Acetone-7
4	6/1	Ethanol-20	5/24	Acetone-7
5	5/31	Acetone-10	5/24	Formalin-3
6	5/31	Acetone-10	5/24	Formalin-3
7	5/28	Tylosin-2 gms.	5/23	Formalin-3 and Acetone-7
8	5/25	None	5/23	Formalin-3 and Acetone-7
11	5/28	Tylosin-2 gms.		
12	5/25	None		
Hay	5/28 and 5/31		5/23	

1. Treatment and pounds added per ton except tylosin which was grams added per ton.

Two forage harvesters and two blowers were used simultaneously. Harvesters followed each other in the field and alternate loads as delivered to the silo site were stored in the silos as duplicated treatments.

Additives were calculated, weighed and applied in a manner similar to Experiment 1, except for the tylosin. The tylosin was weighed on a triple beam laboratory balance and mixed with water in 5 gallon milk cans. Water was measured and sufficient tylosin mixture added to give a concentration of 4 grams tylosin base per gallon. Two quarts of the water-tylosin mixture were applied per ton of fresh forage. A garden knapsack sprayer with the nozzle removed was used to spread the water-tylosin mixture on top of the forage. Storage precedures were almost identical to those for Experiment 1. A noteworthy difference between Experiment 1 and 2 was that storage of each forage treatment and its duplicate was started and finished in one day. (Table 3).

The same six 10' x 40' and two of the 12' x 20' silos were used to store the silages harvested in 1962. Identification numbers of silos 10 and 11 were changed to 11 and 12, respectively, during the Experiment 2 feeding trial.

A control forage (hay) was harvested from the same field at the same time as the direct-cut silage. Both lots of hay (Trial 1 and Trial 2) were cured and baled without rain damage. The last four wagon loads (Trial 1) were wet by rain between baling and storage. These four loads required twenty-four hours of mechanical drying.

The hay was chopped to about one inch lengths with a Letz forage chopper (Model Number 340) before feeding. A supply to feed for one to two weeks was chopped at one time and stored under the same open type shed as the baled hay.

Nine groups of dairy heifers, one Jersey and five Holstein heifers per group, balanced with respect to body weight, were assigned to eight silages or companion hay (Trial 1) as in Experiment 1. Seven similar groups were used in Trial 2. Average body weights of the heifers at the start of Trial 1 and Trial 2 were approximately 630 and 690 pounds, respectively.

Twelve lactating cows were divided into two groups of six cows per

group balanced with regard to milk production, age, body weight and stage of lactation. One group was fed acetone treated direct-cut silage from Silos 5 and 6 and the other group was fed companion hay. Lactating cows and growing heifers (Experiment 2, Trial 1) were fed the same silage and hay simultaneously to obtain data for a comparison of silage and hay in relation to milk production and growth as measurements of nutritive value.

The concentrate feeding rate per cow was 0.4 pounds per one pound milk produced in excess of 20 pounds per day.

During the early part of the runoff period, the amount of runoff for each silo was estimated by measuring the time required to fill a container of known capacity (10 gallon milk can). A mechanism similar to that described by Archibald and Gunness (1945) was used for the remainder of the period.

Thermocouples (copper-constantan) were placed near the center of the silo at approximately five feet vertical intervals as the forage was loaded into the silo. The first thermocouple was placed about five feet from the bottom of the forage treatment. The plan was to install these devices in all forage treatments, but four installation attempts in the Trial 2 (bottom part of the 10' x 40' silos) forages failed.

Leads from each thermocouple were extended to the outside of the silo. The leads were attached to a potentiometer and the electrical potential noted. Temperature was determined from a table relating electrical potential and temperature.

Temperature was determined twice per day for approximately two weeks after filling and once per day for an additional two weeks period.

Samples were collected and handled in a manner similar to that used

in Experiment 1. Three minor differences in collecting samples were (1) metal cans were used as containers for the fresh chopped forage and weekly feed samples, (2) a soil auger was used to take samples through holes in the silo doors and (3) samples of chopped hay fed and refused were collected in the same way as silage fed and refused. The major difference was that weekly silage samples were frozen before sub-sampling for analyses other than dry matter. Dry matter was determined in the same way as in Experiment 1.

A few changes in processing samples were made the second year. Acid extracts of forage were made with 0.4 N sulfuric acid instead of the 0.6 N used in Experiment 1.

Period composite samples of forages fed were made by weighing 300 grams of the weekly sample into a plastic bag and freezing. Subsequent weekly forage samples were added to the frozen sample. The entire period sample was thawed, mixed and sub-sampled for acid extract and pH preparations. Dry matter was determined at the same time these extracts were made; however, weekly dry matter determinations were used to calculate dry matter removed from the silo and dry matter intake of animals.

Samples of forage taken through holes in the silo doors were frozen and processed later.

Samples of runoff juice were stored a short time in a refrigerator, then a sub-sample was taken for pH reading and the remainder acidified. Dry matter and ash content were later determined on the acidified juice.

Dry matter of the acidified juice was determined gravimetrically. A sample was weighted into an aluminum pie pan and partially dried on a steam table. The sample was then placed in the previously described oven

and dried to constant weight.

The dried residue was broken out of the pie pans and placed into "pre-fired" and "pre-weighed" ashing crucibles. The sample in the crucible was dried to constant weight in the 80° C. oven and then burned at 600° C. for two 4 hour periods. The ash was stirred between the two periods to obtain complete combustion.

Chemical determinations of lactic acid and soluble carbohydrates were the same as those used in Experiment 1.

Analyses for ethanol, acetone, formaldehyde and acetic, propionic and butyric acids were done with gas chromatographs equipped with hydrogen flame detectors.

Two columns were used in an Aerograph Model 600 gas chromatograph to determine concentrations of the acids. Both columns were 5' x 1/8" commercially packed with the following materials: Column 1, was packed with 20 per cent Carbowax 20M on 60/80 firebrick, treated with phosphoric acid. This column was used to make the determination on all Experiment 2 extracts except the samples of silage fed; Column 2 used to determine acids in the extracts of samples of silage fed in Experiment 2, was packed with 15 per cent Veramid 900, 5 per cent isophthalic acid on 60/80 Chromosorb w. Ethanol and acetone in the same samples were also measured on this column.

The solvents were measured on a modified Cenco gas chromatograph equipped with a Beckman hydrogen flame detector. A Teflon (approximately 1/8" x 8') column packed with acid washed Chromosorb 20 on 80/100 firebrick was used for these determinations. The column was packed in this laboratory.

Sargent and Honeywell recorders were used with the Aerograph and Cenco-Beckman combination, respectively. Column temperatures used for the measurements of solvents were 100° and 80° C. for the Aerograph and Cenco-Beckman combination, respectively. Other operating conditions were similar to those given for organic acids measurements.

Conditions of operation of the column and detection mechanism for acids were: column temperature, 135° C.; injection port temperature, above 200° C.; carrier gas (N_2) flow rate, 25-35 ml. per minute; hydrogen flow rate, 25 ml. per minute. Sensitivity of the detection mechanism was set to the highest sensitivity at which most of the unknowns (100 or less dilution) stayed on the recorder scale. Sensitivity settings were kept constant after workable ones were found.

The sequence in which several solvents eluted from the column was formaldehyde, acetone, methanol, tertiary butanol, isopropanol and/or ethanol, secondary butanol, propanol, isobutanol and butanol. Isopropanol and ethanol were not successfully separated at any combination of column temperature and carrier gas flow rate. The sequence in which organic acids and some other compounds eluted was acrylic acid, acetoin (3-hydroxy butanone), ethyl lactate, ethyl-aceto acetate, acetic, propionic and butyric acid.

Volume per injection was kept constant for a group of unknowns and the corresponding standard curve determinations. Three volumes (4, 2, and 0.5 microliters) were used during the experiments. Distilled water dilution of each extract was made as required to keep the recording instrument on scale.

A known concentration of each compound measured was injected either

separately or in combination with known amounts of one or more other compounds at suitable time intervals to check on the operation of the measuring instruments used.

The alcohols, acetone, and formaldehyde knowns were made by volume to volume dilution with distilled water. The specific gravity (Handbook of Chemistry and Physics 43rd. Edition) and per cent concentration (on container) were used to calculate weight concentration in the diluted known.

Known concentrations of acetic, propionic, and butyric acid were made from barium acetate, sodium propionate and sodium butyrate, respectively. The solution was acidified (pH = 2.0 to 3.0) with sulfuric acid and the precipitate allowed to settle. The supernatant was used as the known concentration.

"Standard curves" were established by adjusting (dilutions) the amount injected into the instruments. Several points were established ranging from slightly below to slightly above those of the unknowns.

Frozen samples of silages fed were thawed, mixed, and divided into two portions. One portion was weighed and composited with a similar sample from other periods. Thus, a composite sample was prepared for each treatment forage for each trial. These composite samples and the remaining part of the original sample were refrozen. Composite samples were later used for proximate analysis. Conventional proximate analyses (A.O.A.C., 1961) were performed in the Michigan State University Biochemistry laboratory under the direction of Dr. E. J. Benne.

RESULTS AND DISCUSSION

Effect of Forage Treatment on Gain in Body Weight, Dry Matter Intake and Feed Efficiency of Dairy Heifers.

Experiment 1 (1961-62)

The comparative value of wilted alfalfa silage, hay and direct-cut alfalfa silage with and without certain additives was measured by gain in body weight and dry matter intake of dairy heifers. Two feeding trials were conducted, Trial 1 was an 87 day trial subdivided into 30, 30 and 27 day periods. Trial 2 was a 90 day trial subdivided into 32, 30 and 28 day periods. The supply of wilted silage (Silo 4) in Trial 1, was exhausted at the end of 19 days in the third sub-period which gave a total feeding period of 79 days for this forage.

Trial 1

The daily gains in body weight ranged from an average of 2.15 to 1.67 pounds per heifer (Table 4). Hay and untreated direct-cut silage groups both gained an average of 1.73 pounds per heifer. The average gains of the ethanol treated silage and hay groups may have been affected by the loss of a Holstein and a Jersey heifer, respectively, from these groups. Jersey animals, in general, gained less than Holstein animals.

Analysis of variance of the data (individual animal daily gain by periods) indicated a significant difference ($P < 0.01$) among periods and breeds (Table 5). These differences were expected and considered to be

Table 4. Gain in Body Weight, Dry Matter Intake and Feed Efficiency of Dairy Heifers Fed Silage and Hay, Experiment 1, Trial 1

Silo No.	Daily gain lb.	Daily DM* intake lb.	Gain per 100 lbs. DM* consumed	Treatment
3	2.01	15.9	12.6	formalin-acetone
4	2.15	17.6	12.2	wilted
5	1.73	13.9	12.4	none
6	1.83	14.7	12.5	formalin
7	1.91	14.2	13.5	chloroform
8	1.67	13.5	12.4	ethanol
Hay	1.73	15.1	11.4	

* DM = dry matter, lb. = pound

Table 5. Analysis of Variance of Gain in Body Weight of Heifers Experiment 1, Trial 1

Source	Degree of freedom	Mean square	F ratio
Total	161		
Ration	6	0.63	1.73
Period	2	30.31	82.99**
Breed	2	4.95	13.50**
Error	151	0.37	

** Indicates significance ($P < 0.01$)

of little value in comparing the rations. Treatment differences were not significant ($P > 0.05$), which agrees with the report by McCullough (1957) that more animals are required to show significance with this magnitude of difference between means.

The combination formalin and acetone silage treatment group gained at a rate of 2.01 pounds per day which approached the 2.15 pounds per heifer per day by the wilted treatment group. The gain of the formalin

treatment group was considerably lower which may be an indication that acetone was the effective compound in the formalin-acetone combination. Such could not be concluded because of the statistical non-significance of the difference. The most impressive of these results was that groups fed high moisture silages gained at 1.67 pounds and higher per heifer per day. The average daily gains for animals receiving high moisture silage, wilted silage and hay were 1.83, 2.15 and 1.73 pounds per heifer, respectively. Average gains were considered to be good for animals of this size fed a forage ration.

The term "dry matter" (see Experimental Procedure) as used in this paper is defined as the portion of original material remaining after drying for a period of 48 hours in an oven maintained at 80° C.

Average dry matter intakes of heifers fed the experimental forages in Trial 1 ranged from 17.6 to 13.5 pounds per heifer per day (Table 4). Significant differences (Table 6) among rations and among breeds ($P < 0.01$) and among periods ($P < 0.05$) were observed. Again, differences were expected among periods and breeds.

Table 6. Analysis of Variance of Dry Matter Intake of Heifers Experiment 1, Trial 1

Source	Degree of freedom	Mean square	F ratio
Total	161		
Ration	6	50.36	4.21**
Period	2	55.65	4.65*
Breed	2	84.22	7.04**
Error	151	11.97	

*, ** Indicates significance ($P < 0.05$) and ($P < 0.01$), respectively

Significant differences among treatments were located by "Tests of all comparisons among means" (Snedecor, 1956). The smallest difference (D) to be significant was calculated using the formula: $D = QS_{\bar{X}}$ where $S_{\bar{X}}$ = standard error of estimate and Q a factor from a table of Q values (Snedecor, 1956). In this case, $Q = 4.25$ and $S_{\bar{X}} = \sqrt{11.97/21}$, then $D = 3.2$. Two treatment means (dry matter intake) that differ by 3.2 or more would be significantly different ($P < 0.05$). The differences (Table 7) indicated that animals fed wilted silage (Silo 4) consumed greater ($P < 0.05$) amounts of dry matter than animals fed untreated (Silo 5), ethanol (Silo 8), or chloroform (Silo 7) treated silages. Differences among other treatment means were not significant ($P > 0.05$).

Table 7. Differences Between Ration Means of Dry Matter Intake Experiment 1, Trial 1

Ration[1]	Mean	$\bar{X}$-13.5	$\bar{X}$-13.9	$\bar{X}$-14.2	$\bar{X}$-14.7	$\bar{X}$-15.1	$\bar{X}$-15.9
4	17.6	4.1[2]	3.7[2]	3.4[2]	2.9	2.5	0.7
3	15.9	2.4	2.0	1.7	1.2	0.8	
Hay	15.1	1.6	1.2	0.9	0.4		
6	14.7	1.2	0.8	0.5			
7	14.2	0.7	0.3				
5	13.9	0.4					
8	13.5						

1. Numbers in this column correspond to silo numbers
2. Larger than (3.2) the difference required for significance ($P < 0.05$)

The ethanol treated silage group on the average consumed smaller amounts of dry matter than the untreated silage group which was in agreement with the findings of Brown (1961).

Dry matter intakes of animals fed direct-cut silage, wilted silage and hay averaged 14.4, 17.6 and 15.1 pounds per heifer per day, respectively. This was in agreement with many of the reports reviewed in which dry matter intake was lower for animals fed high moisture silage compared to similar animals fed wilted silage or hay.

Efficiency, expressed as pounds of gain per 100 pounds of dry matter consumed and calculated on a group basis, ranged from a low of 11.4 for the hay group to 13.5 for the chloroform treated silage group (Table 4). The groups fed direct-cut silage averaged 12.7 pound gain per 100 pounds dry matter consumed, whereas, the groups fed wilted silage and hay average 12.2 and 11.4 pounds gain per 100 pounds dry matter consumed, respectively.

Pretreatment of alfalfa forage by heavy wilting or addition of formalin, ethanol, chloroform, or formalin plus acetone did not significantly improve growth of dairy heifers fed the resulting silage as compared to untreated silage.

Trial 2

One of the Jersey heifers was removed from the metabisulfite treatment group early in the experiment. This heifer was sick due to unknown causes at the time of removal from the test. Daily gain of heifers fed wilted and direct-cut silages and hay ranged from 1.47 to 1.06 pounds per heifer (Table 8). The two groups fed wilted silages gained 1.47 and 1.41 pounds per heifer for the wilted and ethanol-wilted silage groups, respectively. Direct cut silages on the average produced daily gains on dairy heifers about 10 per cent higher than hay in Trial 2 compared with

Table 8. Gain in Body Weight, Dry Matter Intake and Feed Efficiency of Dairy Heifers Fed Silage and Hay, Experiment 1, Trial 2

Silo No.	Daily gain lb.	Daily DM* intake lb.	Gain per 100 lbs. DM* consumed	Treatment
3	1.16	13.5	8.6	acetone
4	1.18	12.0	9.8	sodium metabisulfite
5	1.14	12.4	9.1	acetone
6	1.18	12.1	9.8	ethanol
7	1.47	14.4	10.2	wilted
8	1.41	14.3	9.9	wilted + ethanol
Hay	1.06	14.6	7.3	

* DM = dry matter, lb. = pound

a 5 per cent improvement in Trial 1.

Treatment differences (Table 9) were not significant ($P > 0.05$); whereas, significant differences were observed among periods and between breeds ($P < 0.01$).

Table 9. Analysis of Variance of Gain in Body Weight of Dairy Heifers Experiment 1, Trial 2

Source	Degree of freedom	Mean square	F ratio
Total	166		
Rations (R)	6	0.53	1.92
Periods (P)	2	1.39	5.11**
Breeds (B)	1	9.68	35.36**
R X P	12	0.83	3.05**
R X B	6	0.44	1.62
Error	139	0.27	

** Indicates significance ($P < 0.01$)

A significant Ration x Period interaction ($P < 0.01$) was also noted.

This difference was found (method previously described) to be due to the low average daily gain (0.49 lbs.) of the animals fed metabisulfite treated silage during the first 32 day period. This group had the highest observed rate of gain during the second period. No explanation could be offered for the variable performance of the metabisulfite treatment group. On the other hand, the 0.49, 1.67 and 1.41 pounds gain for period 1, 2 and 3, respectively, may indicate that results from a short feeding period should be regarded with caution.

Acetone (5 or 10 pounds per ton), sodium metabisulfite or ethanol as preservatives failed to improve the quality of direct-cut silage in this test. Wilting of forage prior to ensiling improved the daily gain of heifers, but the addition of ethanol to wilted forage before ensiling was of no value.

The performance of animals receiving hay during the two trials may be used to indicate the value of a control ration. The hay was selected for uniformity (human judgement) and indicated that factor(s) other than the forages decreased average daily gains in Trial 2. A decrease of 0.63 pounds was observed between average Trial 1 and average Trial 2 animal gains. Approximately the same decrease was observed between corresponding averages of direct-cut silage groups and hay groups.

The average daily dry matter intakes of heifers fed the Trial 2 forage (Table 8) indicated that hay and wilted silage dry matter were consumed in larger quantities than direct-cut silage dry matter. The same trend was observed in Trial 1. The statistical analysis (Table 10), however, indicated that the differences among treatments were not significant ($P > 0.05$). Difference between breeds was significant ($P < 0.01$), but differences among periods were not significant ($P < 0.05$). Daily

dry matter intakes were 12.5, 14.4 and 14.6 pounds for animals fed direct-cut silage, wilted silage and hay, respectively. In the same order, de-

Table 10. Analysis of Variance of Dry Matter Intake of Dairy Heifers Experiment 1, Trial 2

Source	Degree of freedom	Mean square	F ratio
Total	166		
Ration	6	29.78	2.10
Period	2	37.23	2.63
Breed	1	325.61	22.96**
Error	157	14.18	

** Indicates significance ($P < 0.01$)

creases of 1.9, 3.2 and 0.9 pounds for Trial 2 compared to similar Trial 1 groups were observed. Average starting body weights for Trial 1 and Trial 2 animals were approximately 500 and 550 pounds, respectively, which does not explain the decrease in intake.

Efficiency (gain/100 lbs. dry matter) was 9.4, 10.1 and 7.3 for direct-cut silage, wilted silage and hay, respectively (Table 8). The range was 7.3 to 10.2 for hay, and wilted silage, respectively. In contrast, the averages in Trial 1 indicated that wilted silage was less efficient than the direct-cut silages.

Data from two growth trials in 1961-62, show that dairy heifers grow at a satisfactory rate when fed well preserved high moisture alfalfa silage as well as when fed wilted alfalfa silage or hay. Average gains in body weight of 1.83 and 1.16 pounds per day for Trial 1 and Trial 2, respectively, and in the same order dry matter intakes of 14.4 and 12.4 pounds per heifer per day are considered satisfactory for heifers of this size. The overall average for the nine groups (70 animals) fed high moisture silage was 1.53 pounds per heifer per day. Three groups (24 animals) fed wilted silage averaged 1.68 pounds per heifer per day and two groups (15 animals) fed hay averaged 1.40 pounds per day. These averages indicate clearly that well made silage and hay are valuable feeds for growing heifers. This is in contrast to the conclusions of Sykes et al. (1955), and Thomas et al. (1959a, 1961b).

Unfortunately, the tests gave no information to explain the observed differences in the performance of heifers between the two trials. Observations that may suggest further work include: (1) parasite (lice) level appeared to be higher during the second trial, (2) the animals were confined continuously from the start of Trial 1 to the end of Trial 2, (3) freezing of the silage may have influenced body weight gains and once a day feeding was necessary during part of Trial 2, (4) Trial 2 silages were stored under the Trial 1 silages. This may suggest that depth of forage in the silo influenced forage quality which decreased gains and dry matter intake of heifers.

Experiment 2 (1962-63)

The uniformity of silage making has not been sufficiently tested by animal performance. In fact, the author failed to find one report of research designed to measure this factor by growth or milk production. Watson and Nash (1960) complained that duplication had not been sufficient in recent silage studies. Due to these factors considerable effort was expended in the area of replicating silages. Two feeding trials composed of three 28 day periods each were planned. Due to shortage of forage the

third periods were of 14 and 7 days duration for Trial 1 and Trial 2, respectively.

Trial 1

Groups of dairy heifers fed the hay and replicated silages in Trial 1 gained at rates of 1.96 to 1.37 pounds per heifer per day (Table 11). The hay fed in this trial was of excellent quality (early

Table 11. Gain in Body Weight, Dry Matter Intake and Feed Efficiency of Dairy Heifers Fed Silage and Hay, Experiment 2, Trial 1

Silo No.	Daily gain lb.	Daily DM* intake lb.*	Gain per 100 lbs. DM consumed	Treatment
3	1.37	14.8	9.2	none[a]
4	1.46	14.1	10.3	ethanol
5	1.76	16.2	10.8	acetone
6	1.40	14.9	9.4	acetone
7	1.53	15.9	9.6	tylosin
11	1.77	16.7	10.6	tylosin
8	1.57	14.6	10.7	none[b]
12	1.53	14.1	10.8	none[b]
Hay	1.96	19.2	10.2	

* DM = dry matter, lb. = pound. [a] = untreated 1, [b] = untreated 2.

cut and well cured) which may explain the higher gain as compared to Experiment 1 hay groups. Average daily gains were 1.96, 1.37, 1.55, 1.46, 1.58 and 1.65 pounds per heifer for hay, untreated 1, untreated 2, and ethanol, acetone and tylosin treated silage groups, respectively.

Observed differences were not significant ($P > 0.05$) among treatments (Table 12). There was a 0.59 pound difference between the low (untreated silage group) and the high (hay group) in average daily gains which agreed

Table 12. Analysis of Variance of Gain in Body Weight of Dairy Heifers Experiment 2, Trial 1

Source	Degree of freedom	Mean square	F ratio
Total	105		
Treatment	5	0.65	1.66
Period	1	0.23	0.60
Breed	1	2.08	5.37**
P X T	5	0.43	1.10
Error	88	0.39	

** Indicates significance ($P < 0.01$)

with the differences observed in Experiment 1. The three replicated silage treatments gave an indication on the effect of numbers of animals per group on apparent differences among means. The observed differences in average daily gains between two groups of six animals were 0.04, 0.36 and 0.24 pounds for untreated 2 and acetone and tylosin treated replicate silages. The average of these differences (0.21) was two times as large as the 0.10 difference between averages of untreated 2 and tylosin treatment groups of 12 animals per group.

Daily intake of dry matter from the direct-cut silages was 15.2 pounds per heifer compared to 14.4 and 12.5 pounds for similar heifers in Experiment 1. The range was 14.1 to 19.2 for groups fed ethanol treated silage and hay, respectively, (Table 11). The comparative dry matter intakes may have been affected by loss of the Jersey heifer from the hay group. The averages for the treatments were 19.2, 14.8, 14.4, 14.1, 15.6 and 16.3 pounds for heifers fed hay and untreated 1, untreated 2, ethanol, acetone, and tylosin treated silages, respectively.

The statistical analysis of variance included the daily intake of

dry matter by individual animals for periods 1 and 2 only. Since there were only 14 days in period 3 these data were not used in the analysis. The mean daily dry matter intakes for the two periods (1 and 2) were 19.0, 14.4, 14.2, 15.3 and 15.9 pounds for heifers fed hay and untreated 1, untreated 2, ethanol, acetone and tylosin silages, respectively.

Significant differences among treatments ($P < 0.01$), between periods ($P < 0.01$) and breeds ($P < 0.05$) were indicated (Table 13). A "Harmonic number" was calculated (Snedecor, 1956) and this number (15.3) used in

Table 13. Analysis of Variance of Dry Matter Intake of Heifers Experiment 2, Trial 1

Source	Degrees of freedom	Mean square	F ratio
Total	105		
Treatment	5	39.11	3.75**
Period	1	184.64	17.69**
Breed	1	42.92	4.11*
Error	88	10.44	

*, ** Indicates significance ($P < 0.05$) and ($P < 0.01$), respectively

the formula $D = QS_{\bar{x}}$ to calculate the difference (D) required for significance ($P < 0.05$). D = 3.42 pounds per heifer per day. The differences between the above means showed that hay dry matter was consumed in significantly larger ($P < 0.05$) quantities than dry matter from ethanol, untreated 1, untreated 2 or acetone treated silages. The difference between hay and tylosin treated silage groups was 3.05, compared to the 3.42 required for significance ($P < 0.05$). Differences among silage treatment groups were not significant. These results compared favorably with those of Brown (1961) and Hillman (1959) in that hay dry matter was

consumed in larger quantities than silage dry matter.

Efficiency (gain/100 pounds dry matter consumed) was somewhat lower than observed in Trial 1 and higher than observed in Trial 2 of Experiment 1 (Table 11). The calculated efficiency values were 10.2, 9.2, 10.8, 10.3, 10.1 and 10.1 pounds gain per 100 pounds dry matter consumed for heifers fed hay and untreated 1, untreated 2, ethanol, acetone and tylosin treated silages, respectively. Direct-cut silages and hay averaged 10.1 and 10.2 pounds gain per 100 pounds dry matter consumed, respectively.

Trial 2

The compounds, acetone, formalin and a mixture of these compounds were used as silage preservatives in Experiment 1. The acetone-formalin treated silage group of animals gained at faster rates than other direct-cut silage groups in Experiment 1. These treatments were repeated in Trial 2 to further elucidate which, if either, treatment was effective as a preservative for alfalfa silage.

The average daily gains of 1.74, 1.74 and 2.03 pounds for acetone, formalin and acetone-formalin treatment groups in Experiment 2, Trial 2 indicated that neither acetone nor formalin alone was as effective as the two compounds combined for pretreatment of alfalfa silage (Table 14). The companion hay in this trial produced an average daily gain of 1.95 pounds compared to 1.96 for the hay in Trial 1. Unfortunately, the Jersey heifer was lost from one of the formalin-acetone treatment groups (Silo 7). The six Jerseys that completed the test averaged 1.21 pounds gain per heifer per day. The observed differences in daily gains were not significant ($P > 0.05$). Average daily gains in the first two 28 day

Table 14. Gain in Body Weight, Dry Matter Intake and Feed Efficiency of Dairy Heifers Fed Silage and Hay, Experiment 2, Trial 2

Silo No.	Daily gain lb.	Daily DM* intake lb.*	Gain per 100 lbs. DM consumed	Treatment
3	1.72	15.4	11.2	acetone
4	1.76	15.2	11.5	acetone
5	1.83	15.6	11.7	formalin
6	1.67	14.7	11.4	formalin
7	1.94	15.3	12.8	formalin + acetone
8	2.12	14.8	14.4	formalin + acetone
Hay	1.95	18.5	10.6	

* DM = dry matter, lb. = pound

periods were used for statistical analysis (Table 15). The third period was of 7 days duration and not included in the statistical analysis. Significant differences were observed between periods ($P < 0.05$) and breeds ($P < 0.01$).

Table 15. Analysis of Variance of Gain in Body Weight of Dairy Heifers Experiment 2, Trial 2

Source	Degree of freedom	Mean square	F ratio
Total	81		
Treatment	3	0.64	1.91
Period	1	1.39	4.12*
Breed	1	6.85	20.29**
P X T	5	0.28	0.83
Error	68	0.34	

*, ** Indicates significance ($P < 0.05$) and ($P < 0.01$), respectively

In contrast to the daily gain in body weight, differences among treatment groups in forage dry matter intake (Table 16) were significant

Table 16. Analysis of Variance of Dry Matter Intake of Dairy Heifers Experiment 2, Trial 2

Source	Degree of freedom	Mean square	F ratio
Total	81		
Treatment	3	33.33	6.03**
Period	1	22.76	4.12*
Breed	1	29.16	5.27*
Error	68	5.53	

*, ** Indicates significance ($P < 0.05$) and ($P < 0.01$), respectively

($P < 0.01$). Mean values for dry matter intake (two periods used in the statistical analysis) were 15.4, 15.1, 14.9 and 18.2 pounds per heifer per day for acetone, formalin and acetone-formalin treated silages and hay, respectively. Differences among silage groups in dry matter intake were not statistically significant. However, significantly more dry matter was consumed by the hay group than by the silage groups of heifers.

The average dry matter intake by heifers fed high moisture silages was 15.2 pounds per heifer per day. The same average value was observed in Trial 1. Similar values for Experiment 1 were 14.4 and 12.5 pounds per heifer per day. Experiment 2 heifers were approximately 130 pounds larger than Experiment 1 heifers which explained the difference in dry matter intake.

Efficiency of utilization of the dry matter (Table 14) was somewhat higher in Trial 2 than in Trial 1. The average gain per 100 pounds dry

matter consumed was 12.2 for animals fed high moisture silage compared to 10.2 pounds for similar animals in Trial 1.

The performance of animals in Experiment 2 trials measured by daily gain in body weight and dry matter intake was considerably different from those in Experiment 1. The average daily gains were higher in Trial 2 compared to Trial 1 whereas the reverse was observed in Experiment 1. The animals were confined for approximately the same length of time. Silage was frozen during Trial 2 of both experiments; however, animals were fed twice per day in Experiment 2. From these observations length of confinement and frozen silage were not reasonable causes for the observed differences between Experiment 1 trials. The data gave no information on the effect of one time versus two times a day feeding of animals.

Level in the silo was suggested as a possible reason for the observed difference between Trial 1 and 2 in Experiment 1. Data obtained in Experiment 2 did not substantiate that forage in the lower part of the silo was inferior to that at the higher level.

Dry matter intake, in general, followed a pattern similar to daily gain in body weight. A correlation coefficient was calculated to determine the relationship between average daily gain and average daily dry matter intake of groups of heifers. The correlation coefficient ($r = 0.66$) found when data for all groups were used in the calculation, whereas when only data from silage groups were used the coefficient ($r = 0.5$) was smaller. The squares of these coefficients 0.44 and 0.25 for all groups and silage groups, respectively, indicated that differences in dry matter intake accounted for less of the differences in daily gain for silage fed animals than for silage fed and hay fed groups combined.

An important realization from these data was that the present "tools" of measurement failed to detect small differences in value of forages. The data from the four feeding trials indicate that differences in average daily gain of groups of dairy heifers of 0.48, 0.33, 0.59 and 0.29 pounds, were not significant ($P > 0.05$). In the same order, the differences were 28.7, 28.9, 43.0 and 16.7 per cent calculated by average gain of $\frac{\text{high minus low group}}{\text{low group}}$ in each trial. These figures indicate that some of the contradictory reports found in the literature may have been due to chance rather than real differences due to the feeds compared.

These results showed no significance improvement of direct-cut alfalfa silage due to treatment of the green chopped forage with ethanol, acetone, formalin, formalin plus acetone, sodium metabisulfite, or tylosin.

Uniformity of Alfalfa Silage

A statement often heard is to the effect that "grass" silage is not dependable. This postulate was tested by measuring the performance of animals fed replicated silage. Data discussed previously show that measurement techniques available failed to indicate as significant rather large differences among treatment means. The differences observed ranged from 16.7 to 43.0 per cent above the observed low group mean in four trials. Several factors may cause the differences. The factor under test, that is, nutritive value of the forage may be obscured by factors not controlled.

The collection of data in Experiment 2 was planned so that comparisons of replicated treatments of silage could be made. Three replicated

silage treatments in each trial met the requirements of this study. The data were studied by individual trials and for the two trials combined.

Trial 1

The average daily gains by groups of heifers (Table 17) ranged from 1.28 to 1.78 pounds. The treatment average daily gains were 1.58, 1.65

Table 17. Gain in Body Weight and Dry Matter Intake of Dairy Heifers Experiment 2, Trial 1

Silo No.	Daily[3] gain lb.	Daily DM intake lb.	Treatment and Amount/Ton
5[1]	1.78	15.9	Acetone 10 lbs.
6[2]	1.28	14.7	Acetone 10 lbs.
7[1]	1.60	15.5	Tylosin 2 grams
11[2]	1.76	16.5	Tylosin 2 grams
8[2]	1.71	14.5	None
12[1]	1.59	14.0	None

1. Replicate 1 group
2. Replicate 2 group
3. Average daily gain for first 56 days of 70 day period

and 1.55 for acetone, tylosin and untreated silage groups, respectively. Replicate averages were 1.66 and 1.58 pounds per heifer per day for replicates 1 and 2, respectively. The 0.08 difference between replicate means was in the same order as the differences (0.07, 0.03 and 0.10) among treatment means. Numbers of animals per group may account for these small differences compared to the 0.50, 0.16 and 0.13 differences between 2 groups fed 2 acetone, 2 tylosin and 2 untreated silages, respectively.

The averages of daily gains of heifers indicate that the direct-cut silages were similar in nutritive value.

Replicate difference was not significant (Table 18).

Table 18. Analysis of Variance of Gain in Body Weight of Dairy Heifers Fed Replicated Silages, Experiment 2, Trial 1

Source	Degree of freedom	Mean square	F ratio
Total	71		
Replicate (R)	1	0.0975	0.228
Treatment (T)	2	0.1515	0.354
Period (P)	1	0.6290	1.47
Breed	1	1.6093	3.76
R X T	2	0.7892	1.84
R X P	1	0.0889	
T X P	2	0.0056	
Error	60	0.4279	

The F ratio (0.228) was between the F ratios (0.102 and 0.461) of $P_{0.25}$ and $P_{0.50}$ that the observed means were different (Dixon and Massey, 1957). Similar probabilities were observed for the treatment effects.

Average dry matter intake per heifer per day varied less than did average body weight gains (Table 17). Mean dry matter intakes were 14.2, 15.1 and 16.0 pounds per heifer per day for untreated, acetone and tylosin treatment groups, respectively.

Period and breed components differed significantly (Table 19). The replicate variance was much less than treatment variance as shown by the F ratios. The replicate F ratio of 0.0064 may be compared to the F ratio of 0.004 and 0.016 for $P_{0.05}$ and $P_{0.10}$, respectively. Evidence of no difference is equivalent to that of significant difference ($P < 0.10$)

Table 19. Analysis of Variance of Replicated Silage Dry Matter Intake by Dairy Heifers, Experiment 2, Trial 1

Source	Degrees of freedom	Mean square	F ratio
Total	71		
Replicate (R)	1	0.070	0.0064
Treatment (T)	2	17.545	1.61
Period (P)	1	108.040	9.93**
Breed	1	38.550	3.55
R X T	2	7.365	0.68
R X P	1	5.010	0.46
T X P	2	5.725	0.53
Error	60	10.874	

** Indicates significance ($P < 0.01$)

and approaching significance ($P < 0.05$). The writer interpreted this observed performance of heifers to mean that dry matter intakes of replicated silages were more alike than expected in the case of random samples.

The daily gain and dry matter intake of animals fed replicated silage indicated that silage making was not variable during this test.

<u>Trial 2</u>

The group average daily gains, in body weight (Table 20) observed during the 56 day period (2-28 day periods) in Trial 2 ranged from 1.59 to 2.08 pounds, a difference of 0.47 pounds per heifer per day. The treatment averages were 1.70, 1.74 and 2.04 pounds per heifer per day for acetone, formalin and formalin-acetone treated silage groups, respectively. These data indicated no significant difference ($P > 0.05$) among treatments (Table 21). The observed replicate F ratio of 0.0003 indicates much smaller difference between the means than expected. The

Table 20. Gain in Body Weight and Dry Matter Intake of Dairy Heifers Experiment 2, Trial 2

Silo No.	Daily[3] gain lb.	Daily DM intake lb.	Treatment and Amount/Ton
3[1]	1.62	15.5	Acetone 7 lbs.
4[2]	1.79	15.3	Acetone 7 lbs.
5[1]	1.89	15.7	Formalin 3 lbs.
6[2]	1.59	14.5	Formalin 3 lbs.
7[1]	1.99[4]	15.2	Formalin 3 lbs. and Acetone 7 lbs.
8[2]	2.08	14.6	Formalin 3 lbs. and Acetone 7 lbs.

1. Replicate 1
2. Replicate 2
3. Average daily gain for first 56 days of 63 day period
4. Average of 5 animals

Table 21. Analysis of Variance of Gain in Body Weight of Dairy Heifers Fed Replicated Silages, Experiment 2, Trial 2

Source	Degrees of freedom	Mean square	F ratio
Total	69		
Replicate (R)	1	0.0001	0.0003
Treatment (T)	2	0.7566	2.48
Period (P)	1	1.8991	6.22*
Breed	1	4.7084	15.43**
R X P	1	0.8790	2.88
Error	58	0.3052	

*, ** Indicates significance ($P < 0.05$) and ($P < 0.01$), respectively

0.0003 F ratio approached the $P_{0.01}$ F ratio of 0.00016. Evidence for no difference between replicate daily gain means was stronger than that observed for Trial 1.

The range in observed average daily dry matter intake of six animal groups was 1.2 pounds per heifer in Trial 2 (Table 20) compared to 2.5 pounds per heifer in Trial 1 (Table 17). Treatment variance was less than replicate variance in Trial 2 (Table 22). The observed F ratio for

Table 22. Analysis of Variance of Dry Matter Intake by Dairy Heifers Fed Replicated Silages, Experiment 2, Trial 2

Source	Degrees of freedom	Mean square	F ratio
Total	69		
Replicate (R)	1	7.62	1.66
Treatment (T)	2	1.52	0.33
Period (P)	1	22.40	4.88*
Breed	1	6.39	1.39
Error	58	4.59	

* Indicates significance ($P < 0.05$)

replicate dry matter intake effect in Trial 2 did not support that of Trial 1 (Table 19). On the other hand, these comparisons may indicate that the measurement techniques (animal performance) used were inadequate for small differences. Differences in dry matter intake accounted for 25 per cent of the variation in daily gain in these studies.

Statistical analysis of the data was planned before the silos were filled. This plan included combining the data of the two silage feeding trials. Replicates extended over both trials (Tables 17 and 20), whereas treatments did not. The statistical analysis of the combined daily gain data of replicated silages indicated that less than 50 per cent of similar experiments would show differences between replicates (Table 23). These results, again, were interpreted to mean that on the average silage

Table 23. Analysis of Variance of Gain in Body Weight of Dairy Heifers Fed Replicated Silages, Trials 1 and 2

Source	Degrees of freedom	Mean square	F ratio
Total	141		
Replicate	1	0.0455	0.119
Treatment	5	0.65378	1.71
Period	1	0.1622	0.425
Breed	1	5.9703	15.65**
Error	118	0.3815	

** Indicates significance ($P < 0.01$)

of similar nutritive value was produced from alfalfa forage handled in the same way. Treatment differences were greater than replicate differences, which was expected if silage making is consistent. The combined dry matter intake data gave the same type answer although the difference between duplicates and treatments was not as great. (Table 24).

Table 24. Analysis of Variance of Dry Matter Intake by Dairy Heifers Fed Replicated Silages, Trials 1 and 2

Source	Degrees of freedom	Mean square	F ratio
Total	141		
Replicate (R)	1	3.09	0.397
Treatment (T)	5	7.632	0.98
Period (P)	1	115.03	14.78**
Error	118	7.7896	

** Indicates significance ($P < 0.01$)

These results indicate that silages of similar value are produced when the same conditions are maintained. Thus some factor(s) other than

random variation apparently caused the erratic results reported in the literature reviewed by (Barnett, 1954), (Brown, 1961), (Bender and Bosshardt, 1939), (Everett, 1963), (Hillman, 1959), (Watson, 1939) and (Watson and Nash, 1960). Further research is needed to determine the factor(s) that cause these erratic results. Additionally, the dependability of silage making for crops other than alfalfa should be determined.

Milk Production and Dry Matter Intake of Cows Fed Silages and Hay. Experiment 1 (1961-62)

Milk production and dry matter intake of lactating cows were used to measure the relative nutritive value of alfalfa silages. The supply of wilted silage was exhausted at the end of 60 days of the 90 day experimental period. Hay replaced the wilted silage for the remaining 30 days.

Average daily milk production per cow for the groups fed wilted silage-hay, acetone, and ethanol treated direct-cut alfalfa forage was 27.0, 28.6 and 29.4, respectively (Table 25). One cow assigned to the wilted, ethanol and acetone sequence of feeding (Table 2, Group a) dried-off before completion of the test. Milk production data of this cow were discarded for comparisons of the rations. However, the dry matter intake data for this cow were included in that comparison.

Significant differences ($P < 0.01$) in milk production were observed among periods and among cows treated alike (Table 26). Differences among rations were not significant. The differences among periods were ex-

Table 25. Milk Production, Forage Dry Matter Intake and Gain in Body Weight of Cows Fed Silage
Experiment 1

Silage	Daily milk production period			Trial average	Daily dry matter intake period			Trial average	Gain in body weight[1] period			Trial total
	1	2	3		1	2	3		1	2	3	
Wilted	35.6	27.2	19.8	27.0	30.5	36.1	26.1	30.9	39.8	41.0	17.9	98.4
Acetone	32.0	28.6	24.3	28.6	29.1	25.0	24.3	26.1	79.2	0.8	20.0	100.0
Ethanol	29.9	31.3	27.2	29.4	20.2	25.3	29.3	25.0	17.4	18.2	26.2	61.8

1. Gain in body weight per cow for 30, 30, 30 and 90 days for period 1, 2, 3 and trial, respectively

pected due to the normal decline in production. Also, the cows treated alike component was expected to show differences because of the wide range in production among cows intentionally grouped together.

Table 26. Analysis of Variance of Milk Production and Forage Dry Matter Intake by Cows Fed Silage, Experiment 1

Source	Degrees of freedom	Mean square	F ratio
	Milk Production		
Total	41		
Ration	2	20.535	0.446
Period	2	260.23	5.65**
Cows treated alike	8	531.87	11.55**
Replicate	1	171.78	3.72
Error	24	46.047	
	Dry Matter Intake		
Total	44		
Ration	2	149.58	16.99**
Period	2	24.865	2.83
Cows treated alike	9	16.43	1.87
Period X Ration	4	122.10	13.89**
Replicate	1	32.65	3.72
Error	27	8.788	

** Indicates significance ($P < 0.01$)

Average daily dry matter intakes for cows fed wilted silage-hay, acetone and ethanol treated forages were 30.9, 26.1 and 25.0 pounds, respectively (Table 25). Differences among rations were significant ($P < 0.01$). In contrast to the milk production of these cows, the differences in dry matter intake among periods and among cows treated alike were not significant ($P > 0.05$). The Period x Ration interaction could not be explained because cow groups were confounded with the Period x

Ration interaction in this experimental design. The difference in daily dry matter intake required to be significant ($P < 0.05$) was calculated (Snedecor, 1956) to be 2.0 pounds per cow per day. Dry matter intake was significantly greater for the wilted silage-hay ration than for either of the direct-cut silages. The 1.1 pounds difference in dry matter intake between acetone and ethanol treated silage groups was not significant.

The observed gain in body weight of individual cows during the 90 day experiment ranged from 6 to 192 pounds. The average 90 day gain in body weight for wilted silage-hay, acetone and ethanol treated silage groups was 98.4, 100.0 and 61.8 pounds per cow, respectively (Table 25).

Acetone and ethanol treated direct-cut alfalfa silages were not significantly different as measured by milk production and dry matter intake. These results were in agreement with the heifer growth data reported in this paper.

Spoilage in the wilted silage was high and spoiled silage was not easily separated from good silage. Moldy material was noticed dispersed throughout the silage, however, the animals readily consumed the moldy material. More than 12,000 pounds of material was discarded as spoiled, almost one-third of the 37,000 pounds removed from the silo.

Experiment 2 (1962-63)

Milk production, dry matter intake and body weight data were obtained from cows fed acetone preserved high moisture silage and companion hay in 1962-63. This was a part of the evaluation of measurement techniques and uniformity of silages made from direct-cut alfalfa forage.

Milk production of groups of cows (6 per group) fed acetone treated direct-cut alfalfa silage and companion hay was 47.4 and 47.1 pounds per cow per day, respectively (Table 27). In the same order, average daily fat corrected milk production was 42.7 and 43.4 pounds. Observed differences in milk production were not significant.

The cows consumed an average of 12.41 and 12.46 pounds of grain per cow per day and increased in body weight 0.53 and 1.55 pounds per cow per day for silage and hay groups, respectively. In the same order, forage dry matter intake was 19.8 and 29.1 pounds per cow per day (Table 27). Observed differences between silage and hay groups in body weight gain and dry matter intake were significant ($P < 0.01$).

The results of this test are in general agreement with many published reports that animals fed heavily wilted silage or hay consume more dry matter than animals fed high moisture silage (Brown, 1961), (Hillman, 1959), (Gordon *et al.*, 1960, 1961) and (Thomas *et al.*, 1959a, 1961a). The milk production data, also, agreed with those of Brown (1961) and Hillman (1959) which showed non-significant differences between groups fed silage and hay.

Cows fed high moisture silages in these experiments produced as much milk as cows fed wilted silage or hay. This writer would question any conclusion that the dryer forages were more valuable than high moisture silage because cows consumed more dry matter or gained more in body weight.

Efficiency of milk production was calculated using the assumptions: 56.6 per cent total digestible nutrients (TDN) for hay and silage dry matter (Morrison, 1956); 8.25 pounds TDN for maintainance of a 1250 pound

Table 27. Average Gain in Body Weight, Milk Production and Forage Dry Matter Intake of Cows Fed Silage and Hay, Experiment 2

	Milk produced per day period			Trial average	Dry matter intake per day period			Trial average	Trial average daily gain
	1	2	3		1	2	3		
Silage	49.5	46.8	44.5	47.7	17.2	21.6	22.6	19.8	0.53
Hay	48.6	46.6	43.2	47.1	28.0	30.0	30.3	29.1	1.55

cow (N. R. C., 1958); 3.53 pounds TDN per pound gain in body weight (Knott et al., 1934) and 75 per cent TDN for the grain mix fed. The calculated efficiency of milk production (Experiment 2) expressed as TDN per pound of fat corrected milk produced was 0.24 and 0.28 pounds for silage and hay groups, respectively. Silage appeared to be somewhat more efficient than hay in production of milk. A more useful figure for efficiency would be production per acre. Sufficient information was not collected during this study to make this comparison.

Milk Production vs. Growth as Measures of Forage Value

A great many research reports are available in which the measurement of productivity of silage was either milk production of cows or growth of young cattle. The review of literature indicated that milk production was variable and growth was usually somewhat less for animals fed silage compared to animals fed hay.

The applicability of observations from growth studies to milk production and vice versa is not known. McCullough et al. (1960) stored replicated silages and fed one replicate to cows and the other to heifers. Results failed to answer the question. A part of the 1962-63 silage studies reported herein was planned to obtain data on both growth and milk production from animals fed identical forages at the same time. The acetone treated alfalfa silage and companion hay previously described (Experiment 2, Trial 1) was fed simultaneously to lactating cows and dairy heifers. The observed performance of the hay group of heifers was likely affected by loss of the Jersey animal. For this reason, a missing plot value was calculated (Snedecor, 1956) and used in the mean

for the comparison.

The observed mean values of silage and hay groups for milk production by cows and growth for heifers apparently gave different answers (Table 28). Milk production of the cows was equal; whereas, growth was approximately 0.3 pounds per day more for the hay group of heifers. However, neither difference between hay and silage group means was significant ($P > 0.05$). This was interpreted to mean that both measures (milk and gain) showed no difference between well preserved alfalfa silage and companion hay. Non-significant differences ($P > 0.05$) were assumed to be due to chance and thus were not due to the feed. Body weight increase of the cows was, also, in the same direction as that of the heifers.

Dry matter intake by hay groups was higher than that of silage groups for both cows and heifers. These observations lend support to equivalence of milk production and body weight gain as measures of the relative feeding value of forages. More research is needed to determine if the two measures (milk and gain) are interchangeable for forages dissimilar in nutritive value. Well preserved, early cut, first crop alfalfa silage was an excellent forage for milking cows and growing heifers in these comparisons.

Chemical Quality of Silage

Measurement of the level of organic acids (lactic, propionic and butyric) as well as pH were made on silage samples taken at intervals after storage and at the time of feeding. Concentrations of acetone, formaldehyde and the alcohols particularly ethanol were determined on the

Table 28. Comparison of Silage and Hay for Milk Production and Growth, Experiment 2

Ration[1]	Milk Production		Trial average		Daily gain body weight	Forage dry matter intake	Concentrate consumed
	Preliminary	First 7 days	Actual	FCM			
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
				Producing Cows			
Silage	48.9	50.5	47.7	42.7	0.53	19.8	12.41
Hay	48.3	47.7	47.1	43.4	1.55	29.1	12.46
				Growing Heifers			
Silage					1.58	15.6	
Hay					1.85 (1.96)	18.8 (19.2)	

1. 12 heifers in silage group, other group, 6 animals per group
( ) Number in parenthesis average of five animals

same samples.

Composition (proximate) of the forages stored (Appendix Table 1) and fed (Appendix Table 2) indicates that the forages were of high quality.

Organic Acids and pH

Experiment 1

Butyric acid was observed in concentrations up to 3.7 milligrams per gram (mg./gm.) of fresh silage (Table 29). This level of butyric acid

Table 29. Average Organic Acid Content and pH of Silages Fed Dairy Cows and Heifers, Experiment 1

Silo No.	pH	Butyric	Propionic	Acetic	Lactic
		Milligrams per gram fresh silage			
			Trial 1		
3	4.3	1.2	0.1	6.6	15.2
4	4.7	0.0	2.0	2.8	7.5
5	4.8	3.7	2.4	11.9	13.5
6	4.4	1.3	0.6	9.1	16.9
7	4.6	0.3	1.3	12.2	10.4
8	4.5	0.6	0.6	10.6	16.7
			Trial 2		
3	4.6	0.3	0.7	11.0	19.1
4	4.6	0.0	1.0	4.2	17.5
5	4.6	0.3	0.5	12.7	19.0
6	4.6	0.0	0.7	10.3	19.3
7	4.7	0.2	0.6	8.3	20.3
8	4.6	0.0	0.3	7.9	22.9
			Milk Production Trial		
9[1]	5.0	0.0	0.0	3.6	4.8
10	4.7	0.2	0.1	11.7	21.4
11	4.8	0.2	0.1	12.5	17.1

1. Silo 9 average for periods 1 and 2 only, all other silos for three periods

represented 1.5 per cent of the dry matter. Other average values in Trial 1 were less than 1.3 mg./gm. silage. Butyric acid was observed in only three of 18 samples tested in Trial 2. In these three samples the concentration was less than 0.1 mg./gm. silage.

Average concentration of propionic acid in any silage was 2.4 mg./gm. of silage or less. This acid was found in most of the samples from silos 3 to 8 during both trials. In contrast propionic acid was observed in only 2 of 6 samples from Silos 10 and 11 (Table 29).

Lactic acid was observed in amounts of 10 to 21 and 5 to 23 mg./gm. in direct-cut and wilted silages, respectively (Table 29). Apparently depth in the silo influenced the concentration of this acid at both high and low moisture contents. The average concentrations were 14 and 17 mg./gm. silage for wilted and direct-cut silages, respectively. In the same order, acetic acid concentration was 6 and 10 mg./gm. silage.

Average pH values (Table 29) ranged from 4.3 to 4.8 except for Silo 9 which was 5.0. These values support the lactic acid data which indicated well preserved silages.

Experiment 2

The quantitative measurement of acids was not considered reliable below 0.1 mg./gm. of silage under the conditions employed, however, amounts as low as 0.02 mg. were detected. Butyric acid was observed in seven of 24 samples from Trial 1 and one of 12 samples from Trial 2 silages. Two of these samples had 1.0 mg./gm. silage (Trial 1, Silo 11 and 12). Other concentrations were below 0.10 mg./gm. silage.

Propionic acid was found in low concentrations (0.02 to 0.10 mg./gm. silage) only in Trial 2 Period 2 samples.

Lactic acid concentration averaged 18.6 milligrams per gram silage for 36 samples collected during the feeding Trials in Experiment 2 (Table 30). The concentration was higher in the lower levels compared to upper levels of the silos during Trial 1. Average acetic acid concentration in the 36 samples was 9.2 mg./gm. silage. The correlation coefficient of 0.076 indicated little relationship between these two acids for Experiment 1 and 2 combined.

Observed pH values ranged from 3.8 to 4.9 except for the first period samples from Silos 3 and 7 (Table 30). In the same order these two samples had observed pH values of 7.6 and 7.0. The silages were of good to excellent quality as measured by lactic acid and pH values if the two high values are disregarded.

Watson (1939) and Watson and Nash (1960) suggested that pH and lactic acid were related to quality of silage. In these studies, correlations between lactic acid (average concentration in fresh silage) and animal performance (trial group means) measured by body weight gain and dry matter intake (26 silages) gave statistically significant ($P < 0.01$) r values of -0.66 and -0.63, respectively. These negative correlations do not agree with the positive ones of Schmutz (1962) and McCullough (1961).

Acetone and Alcohols

Gas chromatographic analysis of the silage extracts indicated the presence of small quantities of formaldehyde in all silages. Quantitative measurements were not possible under the operating conditions used.

Table 30. Dry Matter, pH, and Acetic and Lactic Acid Content of Silages Fed Dairy Cows and Heifers, Experiment 2

Silo No.	Dry matter			pH			Acetic			Lactic		
	Period			Period			Period			Period		
	1	2	3	1	2	3	1	2	3	1	2	3
	%	%	%				milligrams per gram fresh silage					
					Trial 1							
3	20.8	23.3	25.6	7.6	4.3	4.3	3.3	7.8	9.7	3.6	12.4	25.6
4	23.1	23.4	23.6	4.4	4.3	4.3	11.8	8.8	9.5	14.8	22.4	26.4
5	25.7	26.9	26.8	4.9	4.4	4.4	5.5	11.0	14.2	17.2	22.8	22.0
6	24.9	24.8	26.0	4.3	4.6	4.4	8.1	12.0	15.1	22.4	16.0	27.4
7	25.5	26.6	28.0	7.0	4.3	3.9	2.8	5.4	3.9	6.4	18.4	23.0
8	23.3	23.9	24.1	4.4	4.3	4.2	6.1	10.8	11.0	14.0	24.8	19.4
11	23.2	25.9	26.4	4.3	4.2	3.8	5.2	7.2	6.2	12.8	26.0	32.0
12	22.3	19.6	24.0	4.4	4.2	4.0	4.7	11.4	7.3	10.0	21.6	27.2
					Trial 2							
3	25.1	23.8		4.1	4.2		6.3	8.2		23.2	26.4	
4	25.0	24.2		3.8	4.4		11.8	11.3		16.8	15.6	
5	23.7	23.7		4.4	4.5		12.3	15.5		9.0	12.8	
6	24.8	24.7		4.4	4.2		12.0	10.4		12.4	18.4	
7	24.3	25.0		4.2	4.1		11.6	9.5		14.2	21.2	
8	23.4	24.6		4.6	4.3		13.9	8.3		9.6	21.6	

Ethanol and isopropanol are reported together in this paper since these compounds could not be separated. Isopropanol was not expected in more than trace quantities, however equal "known" concentrations of isopropanol and ethanol produced almost equal measurements on the equipment used. Ethanol (Table 31) occurred in all samples in amounts of 0.1 to

Table 31. Ethanol-isopropanol and Acetone Content of Silages Fed Dairy Cows and Heifers 1962-63 (Milligrams Per Gram Fresh Silage)

Silo No.	Period 1 ETOH[1]	Period 1 Acetone	Period 2 ETOH[1]	Period 2 Acetone	Period 3 ETOH[1]	Period 3 Acetone
			Trial 1			
3	0.1	---	1.0	---	0.6	---
4	0.8	0.1	0.8	---	3.9	---
5	0.6	0.3	2.2	0.4	2.4	0.1
6	0.9	0.2	3.1	0.2	2.2	0.2
7	0.2	---	0.4	0.1	0.5	0.1
8	0.3	---	0.8	---	0.7	---
11	0.2	---	0.8	---	0.7	---
12	0.3	---	0.6	---	1.0	0.1
			Trial 2			
3	1.0	0.5	2.0	0.8		
4	0.9	0.2	2.1	0.3		
5	1.2	0.1	1.4	0.1		
6	1.1	0.1	2.0	0.3		
7	trace	0.1	1.8	1.5		
8	1.1	0.1	2.2	0.3		

1. Included ethanol and isopropanol

3.9 mg./gm. of fresh silage. The highest concentration occurred in samples of the ethanol treated silage (Silo 4, Trial 1) taken from lower levels in the silo. This compound may be produced or retained in larger quantities in lower parts of the silo. These amounts of ethanol are in agreement with those reviewed by Watson and Nash (1960).

Concentrations of acetone (Table 31) of less than 1.0 mg./gm. silage except for the acetone-formalin treated silage stored in Silo 7 (Experiment 2, Period 2) were observed. The observed 1.5 mg./gm. for Silo 7 silage may be compared to the 0.3 mg./gm. concentration in Silo 8. These forages were replicates, that is, harvested, stored and treated with the same amount of acetone and formalin. Apparently acetone did not disappear from these silages at the same rate. Acetone was found in concentrations of more than 0.1 mg./gm. only in silages that had been treated with acetone or stored underneath acetone treated silage. Morgan and Pereira (1962a, b) reported the occurrence of acetone in silage volatiles but gave no concentration figures.

Propanol was not found in any silage sample tested during these investigations.

Losses of Dry Matter During Storage

Runoff juices contained an average of 7.7 to 8.2 per cent dry matter (Table 32). A variable amount of sand was observed in the samples collected which may have affected the dry matter percentages, although visible sand was not included in the sample dried. Dry matter in runoff juices contained an average of 21.7 per cent ash. Little if any difference was observed between ash content of runoff from different silos. The observed dry matter and ash contents of runoff juices were about the same as reported by Watson (1939) and Watson and Nash (1960) for similar type crops.

Table 32. Runoff Losses From Direct-cut Alfalfa Stored in Upright Silos (1962)

Silo	Total input		Total runoff			Loss	
	Fresh lbs.	Dry matter lbs.	Fresh juice lbs.	Dry matter lbs.	%*	Total %	Dry matter %
3	110740	22557	20756	1685	8.1	18.7	7.5
4	121440	23283	23524	1811	7.7	19.4	7.8
5	131900	29584	20806	1640	7.9	15.8	5.5
6	136120	29713	20503	1579	7.7	15.1	5.3
7	115360	24449	21692	1785	8.2	18.8	7.3
8	112200	23468	21894	1778	8.1	19.5	7.6

* % dry matter in runoff juices

Total runoff (Table 32) ranged from 15.1 to 19.5 per cent of the fresh forage ensiled. This juice contained between 1560 and 1810 pounds of dry matter per silo, which was 5.3 to 7.8 per cent of the dry matter ensiled. Effects of additives on runoff losses could not be determined due to storage of more than one treatment per silo. Apparently one-third to one-half of the total dry matter loss was due to runoff. No silage was discarded as spoilage from the top of the silos.

The preservation of nutrients is of primary interest to the livestock farmer. The loss (total input minus silage fed) of direct-cut silage dry matter observed for Experiment 1, Trial 1 and 2 and Experiment 2, Trial 1 were 13.8, 16.8 and 16.8 per cent, respectively (Table 33). The "weighted" loss for direct-cut silages was 15.9 per cent of the stored dry matter. This loss may be compared with the 16.8 and 19.5 per cent reported as average losses from unwilted silages before and after 1938, respectively, by Watson and Nash (1960).

Table 33. Loss of Dry Matter by Forage Treatment* (1961-1963)

Silo No.	Experiment 1 Total dry matter Stored lbs.	Experiment 1 Total dry matter Removed[1] lbs.	Loss	Experiment 2 Total dry matter Stored lbs.	Experiment 2 Total dry matter Removed[1] lbs.	Loss %
	Trial 1			Trial 1		
3	15,944	14,568	8.6	11,728	8,628	26.4
4	20,030	15,686	21.7	11,607	9,336	19.6
5	16,330	13,581	16.8	18,910	15,880	16.0
6	16,546	15,012	9.3	19,461	16,478	15.3
7	17,950	14,928	16.8	12,923	10,746	16.8
8	17,714	14,592	17.6	12,103	9,736	19.6
11				11,751	9,436	19.4
12				9,215	9,081	1.5
	Trial 2					
3	16,441	13,221	19.6			
4	15,006	12,357	19.7			
5	15,281	13,063	14.5			
6	15,155	13,139	13.3			
7	14,182	15,795	+11.4			
8	17,690	14,152	20.0			

* See Tables 1 and 3 for treatment before ensiling
1. Included silage fed or considered as a quality suitable for feeding animals.

Observed losses from three wilted alfalfa silages were 21.7, 20.0 and +11.4 per cent, respectively. The latter obviously was due to a mistake of undetermined origin. Losses from the other two wilted silages were higher than losses reported by Gordon et al. (1961) for heavily wilted forage stored in similar silos. On the other hand, these losses are lower than reported by Bender et al. (1936).

The loss of dry matter from direct-cut alfalfa stored as silage was not excessive compared to reported losses, however a loss as great as

16 per cent should be of concern to researchers. More research is needed to determine the cause and workable methods to reduce this loss.

Temperature of Replicated Silages

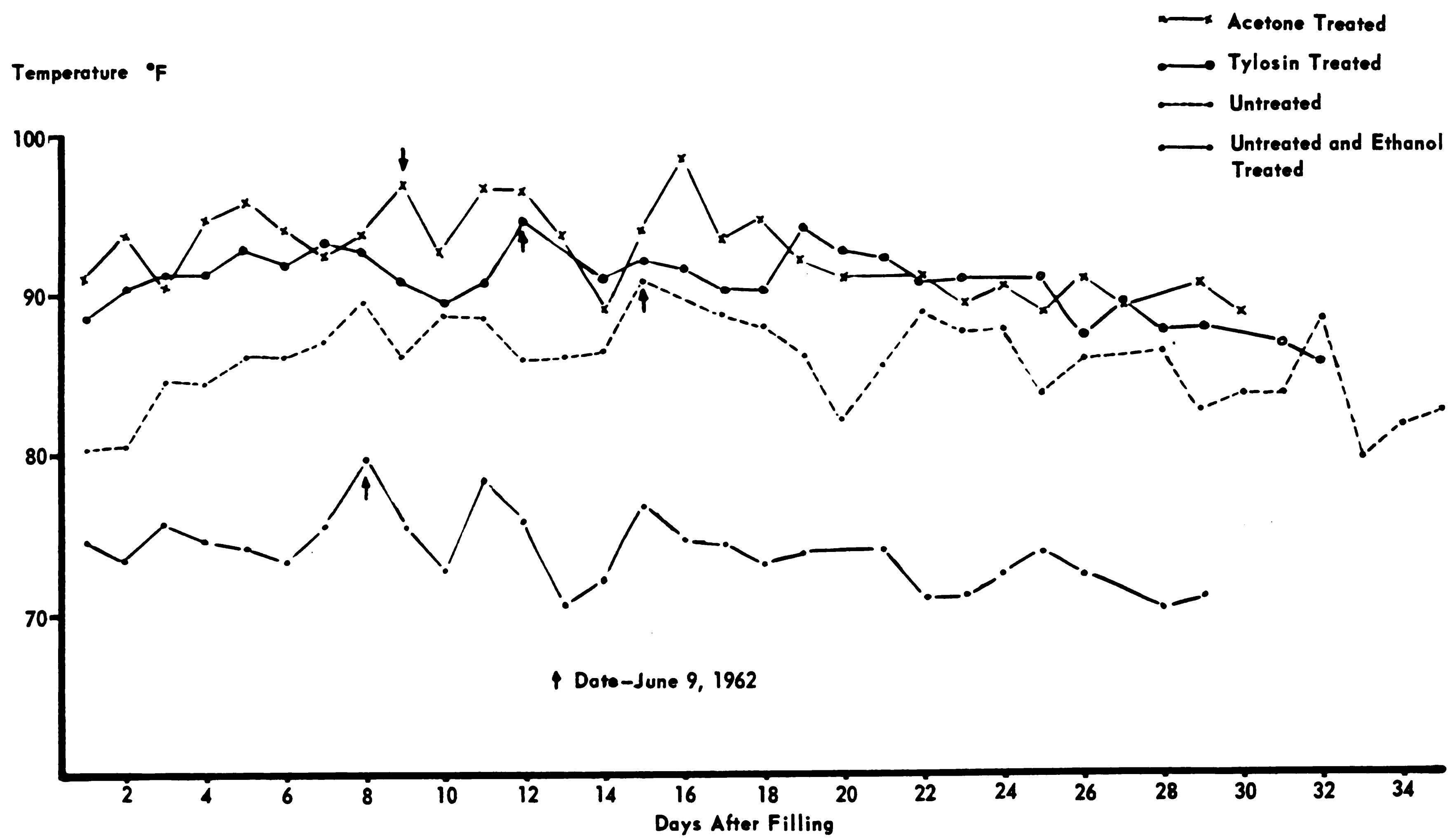
The temperature observations made from thermocouples placed at approximately 5 foot vertical intervals in upright silos indicated no consistent difference due to level of placement. Three of twenty-three thermocouples were apparently affected by factors other than silage temperature. Two (one each) were near the top of the forage in the 12' X 20' silos. No explanation was apparent for the low observations from the bottom thermocouple in Silo 7 compared to the other two in the same silo.

The averages of observations by day for silages treated alike (Experimental Procedure, Experiment 2, Trial 1) showed no consistent difference. The observations for the two silages treated alike were averaged. Similarly untreated (Silo 3) and ethanol treated (Silo 4) silage temperatures were averaged (ethanol-untreated). There were no apparent differences in temperature between these silages. Treatment was identical except for the ethanol addition.

The average daily values of temperature observation for acetone, tylosin, untreated and ethanol-untreated alfalfa silage showed that treatment effects were confounded by beginning temperature (Figure 1). Beginning temperature appeared to at least partially control maximum temperature. Gordon et al. (1959) observed similar effects from silages stored in two years.

The ethanol-untreated silage temperature increased slightly. The temperature increase in acetone, tylosin and untreated silages was less

Figure 1. Temperature of Silage by Day After Filling



than 10 degrees for each treatment silage. Peak temperature was reached within 8 days for all treatments and a slow decline in temperature occurred afterward. These results agreed with those of Gordon _et al_. (1959).

Treatment effects could not be separated from beginning temperature; however, as mentioned before, no consistent difference was observed between silages treated alike. These temperature observations further strengthened the animal performance data showing that silage making was uniform. Further research on the effect of temperature of forage at ensiling is needed to determine if this factor affects the resulting silage. Interestingly, the average daily gains of heifers fed the low temperature silage was lower than that of heifers fed the other silages. A relationship between filling temperature and average daily gain in body weight could not be concluded because of the insignificance of the differences in daily gains among treatment groups. Watson and Nash (1960) suggested peak temperature may be an indication of silage quality.

Indicators of silage quality are useless for improving a particular lot of silage. An indicator or group of indicators of silage quality must be related to factors that may be controlled before or at filling of the silo if such indicators are to be useful for improving the subsequent supply. Temperature of fresh forage may at least be measured in a practical operation. Control of the temperature of ensiled forage would be another problem.

SUMMARY

During a two year period a series of feeding trials were conducted to determine the relative value of alfalfa hay and first crop alfalfa silage pretreated by heavy wilting and/or addition of certain compounds. In the second year a study of the uniformity of silage making was conducted along with a further comparison of alfalfa hay and direct-cut silages with and without additives. Compounds, ethanol (95%), chloroform, formalin (37% formaldehyde), acetone, sodium metabisulfite, tylosin, and a mixture of acetone and formalin were each used in one or more trials. Selected hay and companion hay were used in 1961-62 (Experiment 1) and 1962-63 (Experiment 2), respectively.

Observed gains in body weight of dairy heifers in Experiment 1 Trial 1 ranged from 1.67 to 2.15 pounds per heifer per day when fed alfalfa hay, heavily wilted alfalfa silage, and ethanol, chloroform, formalin and acetone plus formalin treated and untreated direct-cut alfalfa silage. In Trial 2 similar hay, ethanol treated and untreated heavily wilted silage, and acetone, sodium metabisulfite and ethanol treated direct-cut silages produced gains on similar heifers that ranged from 1.06 to 1.47 pounds per heifer per day. Dry matter intake ranged from 13.5 to 17.6 and 12.0 to 14.6 pounds per heifer per day in Trial 1 and Trial 2, respectively. The faster gain in body weight by heifers fed wilted silages were not significantly different from other treatment group gains ($P > 0.05$) in either Trial 1 or Trial 2. In contrast, dry matter intake by the wilted group was significantly higher than three of the direct-cut silages in Trial 1; however, this observation was not re-

peated in Trial 2. Apparently animal performance was not consistently improved by the treatments used in this experiment.

Satisfactory gains in body weight and dry matter intakes by dairy heifers were observed due to feeding alfalfa hay, and ethanol, acetone and tylosin treated and untreated direct-cut alfalfa silages in Experiment 2, Trial 1. In Trial 2 of this experiment heifers were fed alfalfa hay, and formalin, acetone or acetone and formalin treated direct-cut alfalfa silages. Weight gains ranged from 1.37 to 1.96 and 1.67 to 2.12 pounds per heifer per day in Trial 1 and Trial 2, respectively. In the same order the observed range in dry matter intake was 14.1 to 19.6 and 14.7 to 18.5 pounds per heifer per day. Hay dry matter was consumed in significantly larger quantities than silage dry matter. This higher intake of feed was not reflected in significantly higher gains in body weight.

Alfalfa hay, heavily wilted alfalfa silage and direct-cut alfalfa silage were excellent feeds for growing dairy heifers in these feeding trials. Concentrations of organic acids, and pH values, also, indicated that the silages were well preserved.

Cows produced milk at approximately the same rate when fed heavily wilted alfalfa silage and acetone or ethanol treated direct-cut alfalfa silages. Similar results were observed when cows were fed acetone treated alfalfa silage and companion hay. Dry matter intake was higher from wilted silage and hay as compared to the corresponding direct-cut silages. Each cow in both experiments gained body weight during the experiments.

Replication of silages improved the "measurement" as shown by a decrease in range between high and low group means in Experiment 2, Trial 1

and 2. When the heifer body weight gains and dry matter intakes were statistically analyzed, replicated silages were more nearly alike than expected. The conclusion was drawn that silage making is highly uniform. Apparently pretreatment with ethanol, acetone, formalin, acetone and formalin, and tylosin failed to change the resulting silages. Organic acid concentrations and pH values, also, indicated high uniformity of the silage making process.

In a companion experiment, observed milk production by cows and body weight gain of heifers both indicated no difference between a direct-cut alfalfa silage and companion hay.

When alfalfa forage was stored as wilted or direct-cut silage an average of approximately 20 and 16 per cent of the ensiled dry matter, respectively, was lost. Some one-third to one-half of dry matter lost from direct-cut silage was found in the effluent juices.

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APPENDAGES

Table 1. Composition of Forages Stored

Silo No.	Dry Matter %	Ash	Crude fiber	Ether extract	Protein	N-Free extract
		% of dry matter				
			Experiment 1, Trial 1			
3	21.3	9.34	24.12	3.37	18.98	44.20
4	53.5	8.00	24.97	2.40	19.67	44.95
5	20.5	9.57	22.82	2.37	21.93	43.30
6	23.4	8.93	27.27	2.54	18.76	42.49
7	23.2	9.18	25.96	2.33	20.53	42.01
8	22.9	10.49	27.33	2.41	18.45	41.32
9	53.3	9.93	26.77	2.20	21.23	39.87
10	27.2	9.42	25.29	2.43	22.20	40.66
11	21.9	9.11	25.96	1.91	21.85	41.17
			Experiment 1, Trial 2			
3	23.5	9.34	27.16	3.22	18.13	42.15
4	21.6	10.07	23.43	2.90	20.10	43.50
5	24.4	9.18	26.39	2.72	18.60	43.11
6	21.7	9.56	25.26	3.02	19.72	42.44
7	56.2	8.55	30.80	2.18	17.10	41.37
8	52.0	9.08	28.32	2.23	19.55	40.82
			Experiment 2, Trial 1			
3	22.1	8.26	32.75	2.55	17.15	39.28
4	22.0	8.77	30.05	2.47	17.58	41.14
5	24.0	8.17	29.51	2.35	18.66	41.31
6	24.4	8.13	29.16	2.64	18.45	41.63
7	23.5	7.58	31.43	3.01	18.11	39.84
8	22.4	8.03	30.03	2.33	19.00	40.62
11	22.3	8.35	29.90	2.27	19.55	39.91
12	17.2	9.23	27.57	2.20	21.98	39.04
			Experiment 2, Trial 2			
3	18.3	8.49	26.24	3.61	21.58	40.08
4	17.0	8.33	27.66	2.96	22.37	38.67
5	20.1	8.13	29.80	2.45	20.06	39.54
6	18.2	8.52	25.90	2.89	21.55	41.14
7	19.2	8.32	24.78	3.31	20.35	43.22
8	19.5	8.43	25.18	2.79	20.37	43.23

Table 2. Composition of Forages Fed Dairy Cows and Heifers

Silo No.	Dry Matter %	Ash	Crude fiber	Ether extract	Protein	N-Free extract
		% of dry matter				
			Experiment 1, Trial 1			
3	24.3	8.48	27.41	4.78	19.34	40.00
4	50.7	8.19	25.84	3.39	20.14	42.43
5	24.7	8.38	29.87	5.46	19.83	36.46
6	24.5	8.52	31.30	5.26	18.58	36.35
7	25.2	8.07	29.96	5.28	19.23	37.47
8	24.8	8.23	33.20	5.57	17.75	35.26
Hay	93.0	6.87	36.15	1.75	16.73	38.49
9	54.9	8.01	25.88	3.39	22.35	40.36
10	28.1	8.60	29.32	3.98	20.97	37.14
11	24.9	8.76	27.48	5.10	21.90	36.76
			Experiment 1, Trial 2			
3	25.7	8.14	32.85	6.07	17.52	35.42
4	26.2	8.82	28.65	6.23	17.42	38.88
5	25.6	8.15	32.34	5.81	17.44	36.25
6	25.4	8.30	30.89	6.38	18.06	36.36
7	48.7	8.89	30.66	3.59	18.48	38.88
8	43.6	9.10	29.36	3.16	18.98	39.40
Hay	92.6	8.13	32.15	1.44	18.36	39.93
			Experiment 2, Trial 1			
3	22.4	9.48	33.09	3.87	16.44	37.12
4	22.7	8.97	33.10	4.12	16.00	37.81
5	25.8	8.59	30.73	4.33	17.75	38.60
6	24.9	8.63	31.24	4.34	17.56	38.23
7	25.5	7.73	33.74	3.85	17.44	37.24
8	23.4	7.76	33.64	4.77	17.44	36.39
11	23.9	8.03	31.35	4.54	17.38	38.70
12	23.3	8.59	32.06	4.78	18.06	36.51
Hay	87.2	7.98	31.58	2.17	16.19	42.08
			Experiment 2, Trial 2			
3	23.8	7.40	30.99	5.90	18.06	37.65
4	23.4	7.72	29.73	6.19	19.00	37.36
5	24.0	7.73	31.73	5.93	18.94	35.67
6	24.0	7.67	31.41	5.97	19.19	35.76
7	24.4	7.43	29.15	5.77	19.25	38.40
8	23.3	7.90	28.90	5.26	19.50	38.44
Hay	77.1	7.74	31.34	1.97	16.63	42.32

Table 3. Ethanol-Isopropanol, Acetone and Soluble Carbohydrates in Silage Samples 1962

Date* sampled	Dry matter		Ethanol + Isopropanol		Acetone		Soluble Carbohydrates		pH	
	%	%	milligrams per gram fresh silage							
				Trial 1						
Silo No.	3	4	3	4	3	4	3	4	3	4
Forage	22.1	21.5	0.2	3.2	0.10	0.10	19.4	19.6	6.0	5.8
6/9	23.2	23.4	1.0	5.4	0.10	0.10	6.3	6.7	4.1	4.1
6/15	26.8	24.7	0.9	4.9	0.1	----	7.4	6.6	4.1	4.2
6/22	23.0	25.7	0.2	5.2	0.1	0.2	4.6	7.6	4.7	4.1
6/29	23.8	23.7	0.8	4.2	0.10	----	5.5	5.6	4.2	4.2
7/6	23.4	22.4	1.1	4.0	0.1	0.10	5.5	6.1	4.2	4.2
Silo No.	5	6	5	6	5	6	5	6	5	6
Forage	23.3	23.9	0.7	1.3	0.4	0.9	13.3	21.8	5.4	5.7
6/9		25.5		1.6		0.8		7.4		4.2
6/14	28.8	27.6	1.2	1.4	0.4	0.8	8.8	7.2	4.1	4.2
6/22	28.6	27.8	1.3	1.3	0.5	0.6	8.6	10.2	4.0	4.0
7/5	26.2	26.6	1.1	1.9	0.9	0.7	10.8	11.4	4.0	4.0
Silo No.	7	11	7	11	7	11	7	11	7	11
Forage	23.1	21.9	0.3	0.8	0.1	0.1	6.8	14.8	5.2	5.5
6/5	25.5	24.4	0.8	0.6	0.1	0.1	12.8	9.0	3.9	4.0
6/12		26.4	1.0	0.5				8.4		3.9
6/19		26.2		0.6		0.1		8.2		4.0
6/25	23.1	26.1	0.5	0.3	0.1	0.1	7.6	8.0	4.2	4.0
7/3	25.8	23.3	1.4		0.3		14.0	8.3	4.0	4.0
Silo No.	8	12	8	12	8	12	8	12	8	12
Forage	21.8	17.3	0.7			0.1	15.5	10.0	5.2	5.9
6/2	23.4	24.1	0.3	0.5		trace	9.6	7.7	4.0	4.2
6/9	24.1	24.3	0.3			0.1	8.0	6.3	3.9	4.0
6/15	21.7	24.8	0.2				9.4	6.2	4.1	
6/22	27.0		0.9	1.4	0.1		9.5		4.0	4.3
6/29		20.2		trace		trace		4.8		5.4

Table 3. (continued)

Date* sampled	Dry matter		Ethanol + Isopropanol		Acetone		Soluble Carbohydrates		pH	
	%	%	milligrams per gram fresh silage							
					Trial 2					
Silo No.	3	4	3	4	3	4	3	4	3	4
Forage	18.7	17.9	1.2	0.7	1.0	1.0	14.9	14.0	5.7	5.7
6/1	20.6	20.3	1.0	0.5	0.5	0.7	5.1	4.8	4.1	4.1
6/9	21.2		0.7	0.7	1.5	1.9	4.7		4.0	4.1
6/14	18.5	19.2	0.5	0.8	0.9	0.9	6.3	6.0	4.0	4.1
6/23	20.2	22.0	1.2	0.8	0.7	0.8		4.4	4.1	4.2
6/29	24.0		0.9		1.0		12.4		4.0	
Silo No.	5	6	5	6	5	6	5	6	5	6
Forage	22.1	17.9	1.4	0.4	0.1	0.2	15.0	11.4	5.4	5.7
5/31	18.0	17.0	0.5	0.5	0.2	0.3	15.0	19.6	5.0	5.3
6/9	21.7	23.1	1.0	1.3	0.2	0.3	7.3	5.6	4.1	4.2
6/14	24.1	23.1	0.9	0.6	0.2	0.1	5.1	5.0	4.2	4.1
6/23	24.2	22.3	1.0	0.9	0.1	0.1	5.1	4.7	4.3	4.2
Silo No.	7	8	7	8	7	8	7	8	7	8
Forage	19.5	19.9	0.4	0.2	1.6	0.6	20.3	17.7	5.4	5.7
5/31	22.4	24.9	0.9	0.3	1.8	0.4	6.3	9.8	4.0	4.1
6/9	23.3	22.5	1.0	1.0	2.5	1.1	6.8	9.0	4.0	4.2
6/13		21.6		1.0		0.7		7.6		3.8
6/23	23.1	22.7	1.2	0.4	1.2	0.3	5.8	7.5	4.0	4.0
6/27	23.3	25.6	0.9	0.3	2.0	0.2	10.0	6.8	4.2	4.0

* Forage sample taken as loaded into silo

Table 4. Acetic and Lactic Acid in Silage Samples 1962[1]
(Milligrams per gram fresh silage)

Date* sampled	Acetic (Trial 1)		Lactic (Trial 1)		Date sampled	Acetic (Trial 2)		Lactic (Trial 2)	
Silo No.	3	4	3	4		3	4	3	4
Forage	0.8	0.9	0.2	0.2	Forage	0.7	0.6	0.3	0.3
6/9	3.2	3.9	18.0	22.0	6/1	2.7	2.8	18.6	18.0
6/15	4.7	4.9	22.9	25.6	6/9	2.9	3.4	24.2	22.4
6/22	9.5	6.7	10.0	21.5	6/14	3.5	2.2	24.0	24.0
6/29	7.1	0.7	21.9	19.2	6/23	2.7	4.1	24.3	25.4
7/6	5.4	5.6	18.0	17.6	6/29	5.5		37.2	
Silo No.	5	6	5	6		5	6	5	6
Forage	1.4	0.9	0.7	0.4	Forage	1.6	0.6	0.6	0.3
6/9	5.3	5.0		22.4	5/31	0.9	1.1	2.1	1.8
6/14	6.5	5.8	24.4	22.8	6/9	2.4	4.2	20.6	23.0
6/22		5.6	31.6	24.4	6/14	3.0	4.3	13.8	18.2
7/5	3.6	6.3	27.2	24.8	6/23	5.4	5.1	18.6	18.4
Silo No.	7	11	7	11		7	8	7	8
Forage	0.7	1.4		0.5	Forage	0.4	0.5	0.2	0.2
6/5	3.1	3.6	23.6	23.0	5/31	5.6	3.3	16.7	17.4
6/12		3.3		23.0	6/9	3.7	3.6	16.7	23.0
6/19		5.8		24.8	6/13		3.7		19.3
6/25	6.7	6.8	23.3	22.3	6/23	4.1	3.7	23.1	23.0
7/3	5.0		24.2	23.6	6/27	3.0	3.5	26.0	21.4
Silo No.	8	12	8	12					
Forage	1.4	0.5	1.1	0.2					
6/2	3.3	4.3	22.3	17.6					
6/9	5.8	3.9	19.8	19.9					
6/15	3.3		19.4						
6/22		7.4	27.3	17.4					
6/29		9.5		4.0					

1. See Table 3 for pH and dry matter content of these silages
* Forage sample taken as loaded into silo