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A COMPARISON OF ALFALFA HAYLAGE AND
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A COMPARISON OF ALFALFA HAYLAGE AND CORN SILAGE AND THEIR EFFECTS ON DIGESTIBILITY, FEEDLOT PERFORMANCE, AND ECONOMIC VALUE

By

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ABSTRACT

A COMPARISON OF ALFALFA HAYLAGE AND CORN SILAGE AND THEIR EFFECT ON DIGESTIBILITY, FEEDLOT PERFORMANCE, AND ECONOMIC VALUE

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One hundred twenty six British crossbred steers were used to evaluate the effects of alfalfa haylage and corn silage as roughage components of feedlot diets. Diets containing 1.12, 1.20, and 1.30 Mcals of NEg/kg were formulated using high moisture corn, alfalfa haylage and corn silage. Feedlot performance was similar for dry matter intake and average daily gain ($P< .05$), however steers consuming the alfalfa haylage were more efficient ($P< .02$) than the corn silage or combination fed groups. Carcass characteristics were also similar for treatment groups. Percent empty body protein ranged from 18.7% to 19.5% for roughage source and energy density treatments while percent empty body fat ranged from 32.7 to 34.4% across all treatments.

Economic indicators suggest that alfalfa haylage and corn silage are interchangeable dietary components without loss of performance. Availability, palatability, and cost of the roughage should be the primary concern when selecting dietary roughage components.

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Introduction

Alfalfa production in Michigan is second only to corn (3.15 million acres vs 1.05 million acres). Although alfalfa production has decreased in terms of acreage over the past five years, production per acre has increased by 17% and total production has increased approximately 11% (Michigan Agri. Stat., 1983). Research indicates that first year corn following three years of alfalfa increases corn yield on the average 20% (Black unpublished) therefore, future production could be even greater as corn-alfalfa rotation systems are implemented. Due to the lack of optimum weather conditions for hay, a considerable amount of alfalfa is often conserved as silage or haylage.

Corn and corn silage make up the bulk of the feed ingredients utilized by the feedlot industry in the Midwest. As alfalfa production increases this forage could become even more valuable as an alternative source of supplemental protein and minerals to the feedlot industry.

Most of the research conducted utilizing alfalfa haylage in feedlot diets has concentrated on the effect of dry matter at ensiling and performance of animals consuming the forage. Little data are available pertaining to corn silage and alfalfa interactions in high concentrate diets or the economic impact concerning these feedstuffs. Therefore the objectives of this study were to gain futher information on:

1) Differences in feedlot performance between animals consuming alfalfa haylage, a combination of alfalfa haylage and corn silage, or corn silage as roughage sources when steers were fed at three different energy levels.

2) Effect of treatments on carcass parameters and body composition.

3) The economic relationships between corn silage and alfalfa haylage when utilized in feedlot diets.

Review of the Literature

Most of the research conducted evaluating alfalfa haylage as a roughage source for feedlot cattle has dealt with determining appropriate dry matter levels at which alfalfa should be ensiled and the subsequent effect of animal performance related to varying moisture content. Very little current information is available on alfalfa haylage in comparison with corn silage in terms of nutrient digestibility and animal performance.

This review will cover the most important aspects of alfalfa in terms of ensiling techniques, fermentation patterns, and animal performance.

Silage Fermentation Characteristics

Thomas et al. (1980) reviewed the basic activities and changes in forage crops during fermentation for silage production. He stated that as oxygen is used up during plant respiration, homofermentative and heterofermentative lactate producing bacteria become dominant. These anaerobic bacteria produce lactate and acetate from fermenting water soluble carbohydrates. This fermentation reduces the pH in the silo to about four, thereby inhibiting further fermentation and preserving the crop. The decline in pH following ensiling depends on the buffering capacity of the forage, the maintenance of anaerobiosis in the silo, and the available carbohydrates for fermentation, which are directly influenced by the type of forage and ensiling technique.

Saccharolytic and proteolytic clostridial bacteria are also present in the silage when the moisture content is above 65 - 75% and may dominate the fermentation unless the pH is reduced and maintained between 4 - 4.5. These types of bacteria ferment sugars and lactate to butyrate and small amounts of other organic compounds. Their action, if left unchecked, increases silage pH and leads to putrefactive degradation. Clostridial type organisms can be reduced by maintaining correct (low) moisture content of the silage, pH in the silo, and using existing recommended silage making procedures.

Thomas (1978) stated that good quality silage can be produced by the following existing silage making procedures: 1) cut crop early, 2) wilt to 35-40% dry matter, 3) chop fine, 4) store forage in an air-tight silo, 5) distribute forage evenly, 6) fill the silo rapidly, 7) put wetter forage in the upper 1/5 of the silo to aid in compaction, and 8) seal the top of the silo with plastic. If these procedures are followed, a good fermentation should occur resulting in a high quality palatable feed resource.

Alfalfa Ensiling Patterns and Storage Losses

Forages can be preserved at various dry matter content to produce a high quality, palatable roughage source for livestock. The nutrient concentrations and values of the resulting forage can vary with harvesting and storage processes, which is dependent on the dry matter content of the forage harvested. These include, 1) direct-cut silage, 20-25% dry matter, 2) high moisture haylage, 30-35% dry matter, 3) low moisture haylage, 50-60% dry matter, and 4) hay, 85% dry matter. This section will review the nutrient changes occuring during the wilting and ensiling process and dry matter recovery from the fermented products.

Hawkins (1969) ensiled alfalfa at four dry matters, 22, 40, 45, and 80%. Extensive fermentation occured at the three lower dry matter contents but relatively little fermentation occured for the 80% dry matter hay-crop silage. Other investigators have also shown this trend of reduced fermentation as dry matter concentrations increase (Gorden, 1961 and 1965, Roffler et al. 1967, and Jackson and Forbes, 1970). In addition, the three lowest dry matter groups had significantly lower pH values than did the 80% dry matter silage.

Organic acid production in haylage tends to decline with increasing dry matter levels. Hawkins (1969) showed that total organic acid production ranged from 10.6% to 6.26% in 22% and 80% dry matter silages respectively, with lactic acid being the predominant organic acid produced. Gorden (1961) stated that acetic acid was the most predominant in direct-cut silages, while lactic acid was the predominant acid in all haylages. The diluting effects of high water concentrations on silage media should result in an osmotic pressure condition conducive for acetic acid production during fermentation. Sutton and Vettor (1971) also reported high acetic acid concentrations in direct-cut silages.

The type of nitrogen compounds of forages ensiled at different dry matters will vary considerable in form. Research has shown that as silage fermentation proceeds deamination and proteolysis occur resulting in higher concentrations of water soluble nitrogen and ammonia nitrogen for direct-cut silage and high moisture silage than for low moisture silage and hay. (Sutton and Vettor, 1971, and Gorden et al., 1961). Roffler et al. (1967) also showed that ammonia nitrogen constitutes a much greater proportion of the total nitrogen in wilted silages, indicating a more extensive protein breakdown occuring during the fermentation of wilted silage compared to low moisture silage. Hawkins (1969) also reported that water soluble non-protein nitrogen fraction of the resulting silage decreased as dry matter increased and that one-half of the total nitrogen in the direct-cut silage was found in this fraction.

Merchen and Satter (1983) investigated the compositional changes of fresh alfalfa and alfalfa wilted to 29, 40, and

66% before and after ensiling. Wilting and ensiling had little effect on total nitrogen content of alfalfa, but produced substantial changes in the profile of nitrogen containing compounds in the forage.

Roffler et al. (1967) reported that carotene content for wilted silage was higher than low-moisture silage which in turn was higher than hay. Gorden (1961 and 1965) also found a decreasing carotene content as forage dry matter increased.

Bodine (1983) also ensiled alfalfa at four different dry matters (38.8, 52.1, 57.8, and 65,8%). Linear and quadratic increases were significant for pH versus dry matter content. Temperature differences of the ensiled forages were not significantly different, however acid detergent insoluble nitrogen (ADIN) increased linearly with dry matter content of the forage. Also ADIN values did not increase significantly past 10 days, indicating most of the protein damage occured within the first 10 days of ensiling.

Researchers have also investigated nutrient composition of ensiled forages relative to hay from the same crop. Roffler et al. (1967) stated that hay was consistently lower in protein, ether extract, and ash, while Gorden (1961) found that hay was typically lower in ether extract and crude fiber. Alternatively Sutton and Vetter (1968) showed that crude protein values were similar for hay and low-moisture silage and about two percentage units higher in high-moisture silage.

McGuffey and Owens (1979) ensiled alfalfa at 34 and 43% dry matter and compared covered versus uncovered bunker silos. Dry matter recovery was greater for the 43% silage (94.9% vs 84.3% DM recovered) as dry matter from the 34% silage tended to decline with increasing storage time. Total nitrogen was greater for the high dry matter silage and in silage from the covered bunkers, but ammonia and non-protein nitrogen was highest for 34% dry matter silage.

Gorden (1961) found that by utilizing gas-tight silos, dry matter losses could be kept to a minimum of 4% to 8% for a conventional type silo. However, substantial losses occured if these precautions were neglected. Losses of 22 to 24% of the stored dry matter occured for direct-cut silage due to the fermentation process and spoilage.

Goodrich and Meiske (1966) compared haylage from air-tight silos and conventional concrete stave silos. Spoilage and fermentation losses were greatest in concrete stave silos, 8.65% vs 1.74% for the air-tight silos.

El Serafy et al. (1974) compared losses during harvesting and storage for alfalfa-brome forage conserved as hay, haylage , and silage. Dry matter losses during harvesting consisted of 25.4, 14.6, and 12.4% for hay, haylage and silage respectively. However dry matter losses during storage were greater for silage than for either haylage or hay (10.1 vs 8.8 and 5.3%).

Temperature Effects on Haylage Quality and Digestibility

The relative increase of haylage in ruminant diets has also increased the occurence of heat damaged protein in livestock feedstuffs. Researchers surveying this situation have concluded that from 30-90% of all haylage produced has undergone heat damage of some degree (Middleton and Thomas 1983;, Goering 1976). The resulting decrease in digestible protein of these preserved forages has become of economic importance. This review of the literature will concentrate primarly on quantifying the relative heat damage of haylage and the resulting impact on forage digestibility.

Research concerning temperature effects and their effect on silage quality has been studied as early as the 1920's. Amos and Williams (1922) noticed a great deal of variation in silage quality and the resulting performance of animals consuming these types of silages.

Today, the most common measure of heat damage in forages is the amount of insoluble nitrogen found in the acid detergent fraction (ADIN) of the forage. The increase in ADIN occurs from a nonenzymatic reaction, the Maillard reaction, (Hodge 1953) resulting in a dark colored nitrogenous polymer accumulating in the lignin fraction of the acid detergent fiber portion of the forages, (Van Soest 1965).

Gorden (1967) and Pierson (1971) compared fresh alfalfa that was chopped and allowed to ferment normally with alfalfa that was stored at an average temperature of 60 ^{o}C in the presence of oxygen. Results indicated that immediate heating was detrimental by increasing lignin and ADIN content. Reduced organic acids and a high pH was also indicated for heated silage.

As noted earlier, exposure to increased temperature increases the ADIN content of those forages. Yu (1977) conducted a trial to determine the quantitative changes of the ADIN fraction during the heating process. Dry alfalfa leaves, stems, and hay were compared to four wet forage samples (fresh alfalfa, stems, haylage and bromegrass-orchardgrass). Dry samples were heated at 95 ^{o}C to give a total heating unit of 1200 ^{o}C (degree-hours above 35 ^{o}C), but heating temperatures for the wet samples did not exceed 95 ^{o}C. Nitrogen in the stems was two times less soluble in acid detergent solution than leaf nitrogen. Quantitative changes of ADIN for dry samples were unaffected by heating at temperatures below 95 ^{o}C, but were significantly increased at temperatures greater than 100 ^{o}C. Alfalfa leaves tended to be more susceptible to heat damage than alfalfa stems. Wet samples showed a marked increase in ADIN content ($P<.05$), but was varied among forage types. Fresh grass was more susceptible to heating than fresh alfalfa, which tended to be more susceptible than alfalfa haylage or stems. In another experiment, the same investigator (Yu 1976), found that during the first 6 hours of heating the

ADIN content of alfalfa haylage increased four to nine times more rapidly than in fresh alfalfa or hay. However, at the end of the heating period the percent of total nitrogen converted to ADIN was greater for fresh cut alfalfa, haylage and hay respectively. He also concluded that hours heated above 70 ^{o}C or degree hours above 50 or 60 explained from 69% to 73% of the variation in ADIN when expressed as a percent of total dry matter or total nitrogen, and that measuring maximum temperature alone gave a relatively low determination coefficient for the ADIN fraction.

Goering and Van Soest (1973) examined the susceptibility of different forages to heat damage as affected by moisture, temperature and pH. Heat damage occured most frequently in moisture ranges of 20 to 70% and at temperatures as low as 60 ^{o}C for a 24 hour period. They also noted that as heating time increased the acid detergent fiber fraction increased at a greater rate than did the cell wall constituents, indicating an apparent decrease in hemicellulose as the browning reaction progressed. The pH of the media during heating was varied. Two and ten gram samples were placed in Erlenmeyer flasks at selected pH values and heated for a 24 hour period. Orchardgrass samples gave inconsistant results. The two gram samples with phosphate buffer had a higher incidence of browning, but browning was greatest for the acid buffered samples when the 10 g samples were used. Alfalfa substrate did not change during the 24 hr heating period. Hodge (1953) suggested that at a high pH, the browning reaction increased, but the rate is decreased. High dry matter silages with limited fermentation and high pH values should exhibit more heat damage than silages with a lower pH value. These results are consistent with Gorden, (1967).

Numerous studies have been done to explore the relationship between protein digestibility in forages and silages and their exposure to heat as well as heat influences on other dietary components. (Pierson 1971;, Thomas et al., 1972; Yu and Thomas 1975; Yu and Veria 1977). Research has shown that heating of some types of feeds increases protein utilization in ruminants (eg. soybeans, Glimp et al., 1967), by decreasing protein degradability in the rumen without affecting total protein bioavailablilty. However the opposite seems to be true regarding protein availability in forages that have undergone heating. Thomas et al., (1972) showed correlations of -.85, -.69, -.62, and -.74 between extent of heating and nitrogen, dry matter, organic matter, and total digestible nutrient digestibility respectively. Futhermore, they showed a correlation of .92 between heating and ADIN expressed as a percent of total nitrogen ($P<.01$). Nitrogen retention and nitrogen balance were also negatively related to ADIN and extent of heating.

Other researchers have shown similar results of decreasing protein and other macro-nutrient digestibility (Pierson 1971; Yu and Thomas 1975). Yu et al. (1977), and Yu and Veria, (1977) conducted a series of digestibility trials utilizing sheep. The proximate analyses constituents and neutral detergent fiber components were not affected by heating. Ether extract digestibility increased linearly while ADIN digestibility decreased linearly with increased heating periods. Total nutrient digestibility was unaffected in one trial but tended to decline in another due to the large fraction of indigestible protein bound in the ADF fraction.

Goering and Adams (1973) compiled samples of hay, hay crop silage, and corn silage and assayed them for ADIN content. Forty percent of the hay crop silages indicated some degree of heat damage, twelve percent of all hays sampled , while corn silage showed no significant evidence of heated damaged protein.

Goering (1976) conducted another study analyzing dehydrated alfalfa samples collected from all regions of the United States. Eighty-nine percent of all samples taken contained sufficient amounts of ADIN to indicate some protein damage. This constitutes a mean loss of 22-24% of digestible nitrogen in this product, which could be a significant factor in its contribution toward a balanced diet.

Middleton and Thomas (1983) compared the ADIN content of silage as affected by various conditions of temperature, oxygen availability, and dry matter content of the silage. ADIN values were three times greater for samples heated to 70 ^{o}C than that of samples exposed to the lower temperatures. Aeration of the samples increased ADIN content more for those samples stored at 38 ^{o}C than those stored at 55 ^{o}C, however, for samples stored at 70 ^{o}C, ADIN levels were not significantly increased by aeration. The overall correlation coefficient between aeration and ADIN was .93 ($P<.001$). Dry matter content had relatively little effect on ADIN content over the range used (25 - 59%).

Additives and Preservatives for Silage

Although no additives or preservatives were used in the forage preparation of this trial, the increasing number of commercial silage additives and their use suggest that a brief review of these compounds, and their subsequent effect on silage fermentation patterns and animal performance would be desirable.

Chemical additives or ingredients are added to the forage as stored in an attempt to improve or prevent degradation of the feed in addition to helping reduce nutrient variation in the forage.

Thomas (1978) divided silage additives into two categories, stimulants or modifiers of microbial activity, which can then be further broken down into four subdivisions, 1) inorganic chemicals, 2) organic chemicals, 3) cereals or cereal by-products, and 4) fermentation products or microbial inocula.

Silage stimulants consist primarily of some form of fermentable carbohydrate. Lactic acid formation begins with the release of cell sap, due to plant laceration, which provides a suitable substrate for microbial growth. Plants that contain low amounts of available carbohydrates can benefit from addition of a carbohydrate to provide a substrate for microbial growth, thereby aiding in initiating microbial production of lactic acid. Carbohydrate addition to legume crops such as alfalfa, which contain high levels of proteins and cations resulting in a buffering effect, may aid in decreasing the rate of decrease in pH thus shortening the time that proteolysis and respiration occur in the silo, this could increase the quality of the fermented forage. Typical carbohydrate forms that are added to silages include whey, molasses, glucose, and cereal grains.

Berger and Fahey (1981) and Merchen et at. (1984) ensiled direct-cut alfalfa with ground corn as the carbohydrate source to produce a high quality product. Ground corn added to legume forage as ensiled decreased final pH and ammonia nitrogen levels while increasing lactic acid concentrations, (Thomas, 1978). The addition of corn to alfalfa haylage also increased rate of gain when fed to steers (Berger and Fahey, 1981;, Berger et al. 1983; Nicholson and Macleod, 1966).

Microbial inocula of forage with lactic acid producing organisms at ensiling have been studied with variable and inconclusive results. O'Leary and Bull (1976) reported similar trends in respect to silage pH, lactic acid production and dry matter recovery between control and inoculated silage when using commercial cultures. However, when a lactobacillus culture was prepared from silage, the investigator found a more rapid reduction in pH and available carbohydrates in addition to a more rapid increase in lactic acid production during initial fermentation.

Waldo and Goering (1976) found no benefits in dry matter recovery or pH when commercial inocula were used in replicated silos.

Inorganic and organic acids used as silage additives can be categorized as microbial activity modifiers. Inorganic acids or mineral acid addition to silage inhibits clostridial growth by lowering the pH of the silage below 3.0, (Watson and Nash, 1960). This results in less ammonia nitrogen, proteolysis, lactic and acetic acids, with larger amounts of fermentable carbohydrates remaining in the silage. By reducing the pH to below 3.0 to 4.0, all enzyme activity and respiration is prevented thereby preserving the crop, but animal acceptability may also be reduced. Organic acids such as formic acid, propionic acid, and sodium isobutyrate have been added to silage to aid in increasing quality of the fermented product. Waldo (1977) reported that the addition of formic acid to direct-cut forage improved dry matter recovery, animal performance, and slightly improved energy digestibility, while reducing pH, total acids, ammonia nitrogen, and increasing soluble sugars.

Propionic acid and ammonium isobutyrate added to experimental silos have shown a reduction in temperature during the ensiling process , and the subsequent feeding of the material, (Huber and Soefono, 1976;, Yu and Thomas 1975). Acid treated haylage showed little difference in pH or lactic acid production but consistently showed reduced ADIN levels, thereby increasing available digestible protein.

These are just a few of the many compounds which are available for use a silage additives. Thomas (1978) concluded that if recommended procedures for silage production are followed, the addition of silage additives in the silage making process has limited value.

Alfalfa Haylage vs Corn Silage Diets

Henderson amd Newland (1965 and 1967) compared alfalfa haylage and corn silage diets utilizing various environmental and feeding systems. In 1965 steer calves were fed corn silage, alfalfa haylage, or corn silage plus alfalfa haylage diets with sufficient amounts of added concentrates to equalize daily gain across treatments. Comparisons of vitamins A and E, and covered housing vs partially covered housing were also conducted. No significant differences were found in animal performance within diets and across environmental parameters, but cattle full-fed haylage required additional concentrates (0.5%

of body weight per day) to equal gains made by the full-fed corn silage cattle. For the steers fed the combination diet, the additional concentrate needed to produce equal body weights amounted to 1% of body weight. This diet combination gave more efficient results in terms of feed per kg of gain than when each roughage source was fed alone. The combination diet appeared to be more palatable, resulting in consistently higher intakes coupled with slightly superior performance. In 1967 the same investigators compared alfalfa hay, low and high moisture haylage, and corn silage in yearling steer diets. Diets used a constant or varying grain content. Results showed that groups on the high moisture haylage gained at slightly greater rates with lower dry matter intakes (21.44 vs 22.88) than did the low moisture haylage groups. Corn silage fed steers with 1% body weight in added corn gained significantly faster than the haylage fed group. These findings are inconsistent with their previous findings.

Tolman and Guyer (1974) also reported an increase in performance by cattle receiving corn silage diets when compared to alfalfa haylage.

Other investigators utilizing diets balanced for protein, vitamins, and minerals reported no significant differences in feed to gain ratios and average daily gain when comparing corn silage with alfalfa haylage (Goodrich and Meiske, 1967; Windels et al., 1966; and Haarer et al., 1963).

Zimmerman et al. (1964 and 1965) conducted two trials comparing corn silage to alfalfa haylage in steer calf growing and finishing diets. During the first trial (1964) steer diets contained corn, limit-fed, and corn, full-fed , with corn silage plus soybean meal or alfalfa haylage as the roughage source. The first 140 days of this trial indicated similar results between diets, but during the finishing period steers receiving the haylage and corn diets outgained the corn silage fed steers by 19.5% for cattle receiving the full-fed corn and 17.1% for steers receiving limited corn. Similar results were noted in a second trial (Zimmerman, 1965). Haylage fed steers maintained a slight advantage in gain during the first 112 days of the trial, but over the remaining feeding period, performance declined for the corn silage fed cattle. Analysis of the entire experiment showed significantly greater gains for the haylage fed steers. Feed requirements per kg of gain were slightly lower for the haylage fed steers resulting in more economical gains.

Another group of investigators also reported superior gains for cattle fed alfalfa haylage over corn silage as a roughage source. Berger and Fahey (1981) compared: 1) direct cut alfalfa (24.7% DM) ensiled with ground corn, 2) wilted alfalfa (54.2% DM) ensiled with corn added at feeding time, 3) chopped baled alfalfa (87.1% DM) with corn added at feeding time, and 4) corn silage with an added protein supplement to serve as control. Steers fed the alfalfa diets gained, on the average, .28 kg per day more and required 11.3% less feed per kg of gain than those fed the corn silage diet. Efficiency of gain (kg gain per kg dry matter consumed) ranked in the following order: 1) direct cut silage, 2) alfalfa haylage, 3) alfalfa hay, 4) corn silage. Berger et al. (1983) using a similar design found no difference in performance between haylage, hay, and corn silage diets, but showed slightly superior gains fed the direct cut silage. In a second trial utilizing Charolais steers, cattle fed direct cut silage and haylage performed comparably but on the average, outgained the corn silage group by 26.6% while improving feed efficiency by 28%.

Nahara (1981) and Correa-Gumbe et al. (1985) conducted a series of trials comparing different proportions of alfalfa haylage (high vs low DM) and corn silage in high energy diets on feedlot performance. Steers showed no significant differences in gain and feed efficiency for any comparisons.

Animal Performance as Affected by Dry Matter Content of Hay Crop Silage

Animal performance whether it be live weight gain, reproductive performance, or lactation, has been directly related to the amount of dry matter consumed. Thomas (1980) stated that silage intakes are directly correlated with silage pH, silage ammonia concentration (% total nitrogen), lactic acid, acetic acid, and total organic acid

(% dry matter) implying that silage fermentation products are related to appetite regulation. Gorden (1961) found a highly negative correlation between silage dry matter consumption. and content of volatile organic acids and ammoniacal nitrogen ($r = -.62$. and $-.89$), while lactic acid content and pH showed poor correlations with dry matter consumption. As mentioned in a previous section, several studies have shown that acetic acid is a predominant acid in silage. Jackson and Forbes, (1970) concluded that the percentage of acetic acid present in silages was significantly ($P < .01$) and linearly related to voluntary intake ($r = -.056$). This relationship showed that for each increase of 1% of acetic acid in silage dry matter, daily dry matter intake was reduced by 6.66 g $\pm$ 1.91 g per kg $W^{0.73}$.

Wilkins (1971) comparing some seventy different types of silage made from various forage sources also positively correlated voluntary intake with silage dry matter, nitrogen and lactic acid (% total acids) . Again voluntary intake was negatively correlated with content of acetic acid and ammonia nitrogen.

Farhan and Thomas (1978) studied the effect of partial neutralization of silage by the addition of sodium bicarbonate, and the possible subsequent improvement in animal intake. However, cows fed bicarbonate treated silage showed intake depression of silage organic matter which was statistically significant for those cows receiving a high level of bicarbonate. Sheep showed only slight non-significant depression in intake of organic matter when fed the bicarbonate. With ingestion of bicarbonate, both cows and sheep showed increases in water consumption.

Several other studies have confirmed that as forage dry matter prior to ensiling increases daily dry matter intake of the resultant silage increases with a subsequent increase in animal performance (Thomas et al., 1961; El Serafy et al. 1974; Hammes, et al. 1974; Hinks et al. 1976; and McGuffey and Owens 1979).

Thomas (1961) found that consumption was linearly and positively related to dry matter content of the silage. However this was shown to be a secondary relationship, since changing the dry matter content of silage or hay (by addition of water) did not change the rate of consumption. It was concluded that the dry matter content of the forage when ensiled and the resulting fermentation process are very important factors in determining the rate of consumption of the resulting silage.

Hammes, et al., (1974) studied the value of high silage rations in beef cattle producton systems. They found that by lowering the moisture content of the forages before ensiling improved the feeding quality of the silage. Dry matter intakes for low moisture silage were 48% higher than for high moisture silage, and average daily gains were 0.35 kg higher than for steers fed only high moisture silage.

Other groups of investigators have supported the same concept of increasing dry matter intake with increasing silage dry matter content, however in their studies animal performance did not change significantly (Gorden et al. 1961 and 1965; Neidermeir et al. 1961; and Thomas 1969).

Roffler et al. (1967) feeding dairy cows alfalfa conserved as hay, low moisture silage or wilted silage showed that low moisture silage ranked first in supporting fat-corrected milk production, wilted silage second and hay last. However, fat test of cows fed wilted silage was greater than that of cows fed low moisture silage which in turn was greater than cows fed hay.

Morgan et al., (1980) showed no differences in voluntary intake by sheep ingesting fresh or wilted rye-grass silage. These researchers concluded that the high intake of fresh silage is noteworthy, as these results cast grave doubt on the widely held view that fermentation acids particularly lactate are pre-eminent in governing the voluntary intake of silages.

Effect of Alfalfa Haylage on Nutrient Digestiblity

Research on nutrient digestibility of alfalfa has been variable. Roffler (1967) conducted three succesive trials to determine digestibility of hay, low moisture haylage, and wilted silage. For the first two trials hay and wilted silage showed a clear advantage over low moisture silage in terms of digestibility. However, in the third trial digestibility coefficients for dry matter, cellulose and energy were greater for low moisture silage or hay. No differences occured in chemical components of the forage.

One group of researchers has found that dry matter digestibility of high moisture hay-crop silage was significantly greater than that of low moisture haylage or hay (Gorden et al.,1961 and 1963; Jackson and Forbes, 1970).

Other investigators have stated that no differences occur in the digestibility of dry matter and energy for hay, haylage, or silage (Neidermeier et al., 1961; Byers, 1964; Hammes et al.,1964; Gorden et al. 1965; Hawkins, 1969; El Serafy et al., 1974; Hinks et al., 1976; and McGuffey and Owens, 1979). Still yet another investigator reported improved digestibilities for low moisture haylage as compared with high moisture haylage (Roffler et al. 1967).

Sutton and Vetter (1971) stated that nitrogen and dry matter digestibilities were significantly greater for hay versus fermented forages and in turn high moisture haylage digestibility was greater than that of low moisture haylage. Cellulose digestion in lambs was greatest for high moisture haylage and lowest for lambs fed hay. Rumen ammonia levels for hay was significantly greater than the fermented forages, but no differences in rumen ammonia occured between the fermented forages.

Hawkins (1969) reported that rumen ammonia concentrations at feeding time were significantly less for sheep fed 22% dry matter haylage ($P<.05$), but increased to be significantly greater 6 hours post feeding. VFA concentrations at feeding time were greatest for sheep fed 80% dry matter haylage, intermediate for sheep in the 40 and 45% dry matter haylage, and least for sheep fed the 22% dry matter hay-crop silage. Roffler (1967) showed similar trends in VFA production for cows fed hay or silage, however he showed significantly higher porportions of butyric acid and significantly lower concentrations of acetic and propionic acids after ingestion of wilted haylage compared to low moisture silage or hay.

Hinks et al. (1976) reported that ME intakes were significantly less for fresh forage compared to wilted silage, this agrees with results of Jackson and Forbes (1970), but gross energy digestibility was similar between forages (Hinks et al. 1976 and Nahara 1981).

El Serafy et al. (1974) fed steer calves alfalfa-brome hay, haylage or silage as their only source of dietary energy. Ruminal pH values were least for the silage-fed steers and greatest for those fed hay with haylage giving an intermediate pH value (6.26, 5.98, and 5.72). Ruminal acetate to proprionate ratios were 5.2:1 for steers fed hay, 5.6:1 for steers fed haylage and 4.5:1 for those fed silage. Crude protein digestibilities decreased with increasing moisture content (77.3, 74.2, and 71.7).

Merchen and Satter (1983b) fed lambs low moisture silage (47% DM) or hay (87% DM) reported slight differences in rumen pH (6.76 for hay and 6.93 for low moisture silage), yet differences were very consistent and highly significant. Nitrogen intakes were lower for the hay-fed animals, however flow of nonammonia nitrogen to the duodenum was identical regardless of type of forage fed. Intakes of total, essential and nonessential amino acids except arginine, serine, and proline were significantly greater when low moisture silage was fed. Flow of total and all individual amino acids at the duodenum were equal irrespective of the diet.

Dowe et al. (1955) investigated the effects of corn-alfalfa hay ratios on nutrient digestibility by cattle. They compared ratios of 1:1, 2:1, 3:1, 4:1, and 5:1 to determine dry matter, crude protein, crude fiber, ether extract, and nitrogen free extract digestibility. Apparent digestibility of the dry matter and ether extract increased as the corn in the rations increased. Coefficients of digestibility for nitrogen free extract, crude fiber, and crude protein were similar for all rations. When digestibility coefficients for the nutrients studied were analyzed statistically, the differences in apparent digestibility of the nutrients between ratios were not significant.

Rumpler (1983) working with Holstein steers evaluated the digestibility of low moisture haylage (45% dry matter) and high moisture haylage (30% dry matter) fed alone or with high moisture corn added at 30% of total dry matter consumed. Apparent digestibility of dry matter was similar.

However in diets with added corn, the digestion of organic matter reaching the lower gut was much higher that diets without added corn. Nitrogen digestibility between diets also showed no significant differences, but the addition of high moisture corn tended to shift the site of digestion of nitrogenous components of the diet to the lower gut. Dietary nitrogen reaching the lower gut was not only increased, but nitrogen digestibility in the lower tract also increased (50.3 vs 58.6, and 50.6 vs 54.6) when corn was added. The same investigator (Rumpler, 1983) stated that total tract digestion of ADF tended to be reduced. When haylage was fed alone approximately 10% of the ADF digestion occured post-ruminally, but upon addition of corn, rumen ADF digestion constituted virtually all the ADF digestion. Merchen and Satter (1983) also reported similar findings utilizing dairy cows in site and extent of digestion of the various dietary components.

Effects of Alfalfa Haylage on Carcass Parameters

Shoemaker et al. (1964) obtained detailed carcass cutout data on steers that were fed alfalfa haylage or corn silage as roughage sources in addition to receiving limit-fed or full-fed corn. Haylage fed cattle on the full-fed system produced carcasses that graded significantly higher than their corn silage fed counterparts, however, the corn silage fed steers yielded carcasses with more total retailable product. There were no other significant differences between the two treatments, with both treatments producing similar carcasses in most respects. In another study, Zimmerman et al. (1965) found that while dressing percentage differences were small and non-significant, steers fed corn silage produced carcasses that were significantly greater in both carcass quality grade and overall carcass grade when compared with haylage-fed steers.

Henderson and Newland (1966) examined carcasses produced by steers fed low or high moisture haylage with constant or varying levels of concentrates coupled with another similar trial in 1968 utilizing alfalfa hay and corn silage as additional treatments (Henderson and Newland, 1968). Carcass measurements were similar between all types of roughages, but carcasses from the first trial displayed a slight fat discoloration. When comparing constant versus varying levels of concentrates, results were insignificant. The first trial indicated differences approaching significance ($P<.01$) in favor if the constant grain fed group for carcass grade and marbling. This group graded one third of a grade higher (middle choice vs low choice) and scored a point higher on marbling (modest vs modest plus). The second trial only produced small, non-significant differences in carcass grade and marbling scores, with both favoring the varying level of grain feeding system. Rib-eye area and dressing percent showed statistical significance in favor of the constant-fed grain group. The same investigators (Henderson and Newland, 1966) also tested the influence of added protein to feedlot diets containing haylage and the subsequent effect of carcass measurements. In appraising differences in carcass traits, the added protein group averaged 2.3 mm greater external fat cover and dressing percentage increased by .9%. Both of these values proved to be significant. Cattle fed the additional protein also indicated slightly higher marbling scores, but the differences did not prove to be significant. Combining all carcass traits, apparently the added protein group possessed a slightly higher degree of finish.

El Serafy et al. (1974) conducted a trial studying the effect of alfalfa-brome forage ensiled at different dry matter levels and the subsequent performance of calves utilizing these feeds as their only energy source. They concluded that carcasses from steers fed silage (41.8% DM) tended to be fatter than those fed either haylage (50.8% DM) or hay (86.6% DM), and that empty body weight gains were least for the steers consuming silage.

Nahara (1981), and Correa-Gumbe et al. (1985) conducted similar trials utilizing alfalfa at various dry matter content, by feeding relatively high concentrate diets to feedlot animals and comparing alfalfa haylage or corn silage fed to steers as roughage sources. Neither investigator showed significant differences in physical carcass parameters or chemical composition parameters utilizing the 9th, 10th, and 11th ribs from each carcass.

Materials and Methods

Forage Preparation

Alfalfa-orchardgrass was harvested the first week of August, 1982. The forage was mowed and crimped using a model 1492 New Holland haybine, and allowed to wilt for approximately twenty-four hours (45% dry matter). The alfalfa was then choppped with a model 392 New Holland forage harvester to a theoretical length of .65 to .95 cm. It was then ensiled in two 15.24 m by 3.66 m concrete stave silos.

Corn silage was harvested using standard harvesting procedures and ensiled in a 18.29 m by 9.14 m concrete stave silo.

Forages were stored nine months prior to the beginning of the feeding trial. As the silos were opened, all spoiled, moldy or dark material was discarded. Dry matter, crude protein, acid detergent fiber and acid detergent insoluble nitrogen determinations were conducted on the forage samples compiled throughout the feeding trial. Results of those analyses are given in Table 1.

Feeding Trial

A trial was designed to evaluate the effect of different silages on feedlot performance and carcass parameters of

Table 1. Corn Silage and Alfalfa Haylage Characteristics

	CS	AH
Dry Matter %	33.4	42.0
Crude Protein %	7.0	16.0
ADF (% DM)	24.9	37.0
ADIN (N/DM) [a]	0.10	0.17

a Expressed as nitrogen as a % of dry matter.

yearling feedlot steers. One hundred thirty Hereford-Angus crossbred steers were obtained for this trial.

One hundred twenty six steers (336 kg) were randomly allotted to eighteen pens (two pens per treatment) in a completely covered slatted floor barn at the Michigan State University Beef Cattle Research Center. The remaining four steers were slaughtered to obtain initial body composition, utilizing the 9th, 10th, and 11th rib analysis procedure (Hankins and Howe, 1946).

Diets consisted of high moisture corn (70% dry matter) as a concentrate source with 1) corn silage, 2) alfalfa haylage plus corn silage (1:1 DM ratio), or 3) alfalfa haylage. Composition of diets are shown in Table 2.

Corn silage was assumed to contain 50% grain, therefore diets containing corn silage were adjusted accordingly.

Three energy levels were used per dietary treatment, (1.12, 1.21, and 1.30 Mcals of NEg per kg of dry matter) providing diets that contained 65, 75, and 85% grain. All

Table 2. Feed Ingredients in Diets

Ingredient	Roughage Source								
	CS[a]			CS + AH[b]			AH[c]		
% Grain in Diet	65	75	85	65	75	85	65	75	85
	% Diet Dry Matter								
High Moisture Corn	20.3	43.3	63.3	46.3	60.3	73.3	58.3	68.3	78.3
Corn Silage	70.0	50.0	30.0	23.5	16.5	10.0	---	---	---
Alfalfa Haylage	---	---	---	23.5	16.5	10.0	35.0	25.0	15.0
Supplement[d]	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
% Dry Matter	39.4	43.6	52.8	46.3	52.8	58.0	51.4	56.6	61.8
% Crude Protein	11.5	11.5	11.0	12.6	11.7	11.4	12.5	12.4	11.3

[a]Corn Silage (33.5% dry matter)
[b]Corn Silage + Alfalfa Haylage
[c]Alfalfa Haylage (42% dry matter)
[d]Supplement - composition given in Table 3.

Table 3. Ingredients in Supplements

Ingredient	Roughage Source								
	CS			CS + AH			AH		
% Grain in Diet	65	75	85	65	75	85	65	75	85
	% Diet Dry Matter								
Urea	20.8	18.6	15.8	8.2	9.2	10.3	1.4	4.5	7.2
Limestone	4.4	7.6	9.8	1.6	4.1	9.0	--	2.9	8.4
Dicalcium Phosphate	1.7	--	--	--	--	--	--	--	--
Premix[a]	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
TMS[b]	3.6	3.8	3.7	3.8	3.8	3.9	3.5	3.8	3.6
Ground Shelled Corn	64.0	65.0	66.7	83.1	79.8	73.4	93.5	86.6	78.1

[a]Premix contains Rumensin 60 - 30%
Selenium 90 - 52%
Vitamin A - 8%
Vitamin D - 10%

[b]Trace Mineral Salt

diets were calculated to be isonitrogenous at a level of 12% crude protein.

Supplements were calculated to balance the diets for protein, calcium, phosphorus, and selenium. Calcium to phosphorus ratios were maintained at a minimum of 1.2:1. Ground shelled corn was utilized as a carrier for supplement ingredients. Supplements were fed at a level of .45 kg per head per day, assuming 7.2 kg dry matter intake per day. Composition of supplements are shown in Table 3. Supplements also contained rumensin (250 mg / head / day), selenium 90 premix (.1 mg / kg diet), vitamin A (2200 IU / kg diet), and vitamin D (246 IU / kg diet).

Management Procedures

After arrival at the MSU Beef Cattle Research Center all steers were eartagged, tattooed, wormed and implanted. Injections for IBR, PI3, hemophillis somnus, and vitamins A and D were also administered. The steers were then used to conduct a six week feedlot study prior to the beginning of the silage trial.

Animals were weighed on two successive days after the above trial, with the average of the two weights comprising the initial weight for the feeding trial. Animals were weighed every twenty-eight days for four periods during the 112 day feeding trial.

Steers were fed once daily. Feedsheets were updated on a daily basis, recording individual ration components for each pen. Complete diet samples and individual dietary component samples were taken weekly and then composited on a biweekly basis. Samples were frozen for future dry matter and crude protein analyses. Dry matter and crude protein values are reported in Table 2.

Carcass Evaluation

At the termination of the feeding trial two animals per pen (four per treatment) were randomly selected for slaughter. Animals were shipped to Ada Beef Co. Ada, Michigan for slaughter.

Carcasses were allowed to chill for twenty-four hours prior to data collection. Hot carcass weights, rib-eye area, 12th rib fat thickness, and kidney, pelvic, and heart fat were measured for subsequent determination of yield grade. Carcass quality grades were also determined.

The 9th, 10th, and 11th rib section from the left side of each carcass (Hankins and Howe, 1946) was removed and frozen (-20 C) for future body composition analysis. The soft tissue portion of the rib was separated from the bone and each component was weighed. The meat samples were then ground five times through a 3.2 mm screen to ensure a homogenous mixture of fat and lean. Ground samples were subsampled (450 g) amd frozen (-20 C) for future analyses of moisture, fat, and protein. Crude protein (N x 6.25) was determined by digesting 1 to 1.2 g of wet sample by the Technicon Block Digestion Auto-Kjeldahl System. An oven dried sample was used for fat analysis using the Goldfish apparatus.

Daily protein and fat gains were estimated from equations derived by Hankins and Howe (1946) for percent carcass fat and protein, and Garrett and Hinman (1969) for estimation of empty body composition. The following equations describe calculations utilized for this procedure:

$$\% \text{ carcass protein} = .66\ (\% \text{ rib protein}) + 5.98$$

$$\% \text{ carcass fat} = .77\ (\% \text{ rib fat}) + 2.85$$

Empty body composition:

$$EBP = .772\ (\ \% \text{ carcass protein}\ ) + 4.465$$

$$EBF = .9246\ (\ \% \text{ carcass fat}\ ) - 6.647$$

$$EBW = 1.362\ (\text{ hot carcass wt. kg}) + 30.30$$

where:

EBP = empty body protein

EBF = empty body fat

EBW = empty body weight.

Percent carcass protein and fat were determined for the initial slaughter steers. Those values along with a predicted dressing percent were utilized to estimate daily fat and protein gain. Initial empty body weights for the final slaughter animals were predicted for the final slaughter steers and individual protein and fat gains were estimated.

Initial hot carcass weights and empty body weights were calculated using the following equations:

Initial hot carcass weight =

(initial dressing %)(initial live weight)

Initial empty body weight =

1.362 (initial hot carcass wt.) + 30.30.

Equations for predicting initial empty body protein and fat (kg) are as follows:

Initial empty body protein (kg) =

(initial empty body wt.)(initial empty body protein %)

Initial empty body fat (kg) =

(initial empty body wt.)(initial empty body fat %).

Protein and fat gains were determined using the following equations:

$$\text{Protein gain} = \frac{(\text{EBP \%})(\text{EBW at slaughter}) - \text{IBP (kg)}}{\text{days on feed}}$$

where: EBP % = empty body protein %

EBW = empty body weight

IBP = initial body protein (kg)

$$\text{Fat gain} = \frac{(\text{EBF \%})(\text{EBW at slaughter}) - \text{IBF (kg)}}{\text{days on feed}}$$

where: EBF % = empty body fat %

EBW = empty body weight

IBF = initial body fat.

Digestibility Trial

Four Holstein steers (262 kg) were utilized in a four by four latin square design to determine the effects of increasing grain content on alfalfa haylage diet digestibilities.

The animals were housed in individual stalls (1.83 m x 2.13 m) at the Michigan State University Beef Cattle Research Center Metabolism Room. Each pen contained a separate feeder, with an automatic waterer located between each pen.

Fresh feed was provided on a daily basis with animals being fed once daily. Ad libitum intakes were obtained during a fourteen day adaptation period and feed intakes were reduced to 90% ad libitum for each 3 day collection period.

Diets

The diets consisted of alfalfa haylage fed alone or alfalfa haylage and high moisture corn (corn fed at 65, 75, or 85% of diet dry matter). The three diets containing corn were the same diets as the feedlot trial using alfalfa haylage as a roughage source. The alfalfa haylage diet served as a control. Diets and supplemental components are reported in Tables 5 and 5a. Supplements utilized for these diets were also the same as used for the feedlot trial.

Chromic oxide was used as the dietary indigestible marker for the study. To prepare this, 44.7 kgs of ground shelled corn were throughly mixed with 0.7 kg of chromic oxide. This mixture was fed daily at a level of 200 g per head per day, starting seven days prior to the collection period.

Sampling and Collection Procedures

After a minimum fourteen day adaptation period, fecal grab samples were taken over a three day period. Samples were taken every six hours with one four hour interval per day (Table 4). This system of fecal collection was utilized to reduce sample variation while maximizing the number of individual samples. Feed samples were then composited, subsampled and frozen for latter analysis.

Table 4. Fecal Collection Intervals

Day 1	Day 2	Day 3
6 am	4 am	2 am
12 pm	10 am	8 am
6 pm	4 pm	2 pm
12 am	10 pm	8 pm

Feed and fecal samples were then dried and ground through a

Table 5. Digestibility Trial: Ingredients in Diets (100% DM)

% Grain in Diet	0	65	75	85
	% Diet			
High Moisture Corn	--	58.3	68.3	78.3
Alfalfa Haylage	96.7	35	25	15
Supplement	3.3	6.7	6.7	6.7

Table 5a. Digestibility Trial: Ingredients in Supplements (100% DM)

% Grain in diet	0	65	75	85
	% Supp.			
Urea	--	1.4	4.5	7.2
Limestone	--	--	2.9	8.4
Calcium Sulfate	--	0.3	0.9	1.4
Dicalcium Phosphate	11	--	--	--
TMS	7.6	3.5	3.8	3.6
Premix	2.7	1.3	1.3	1.3
Ground Shelled Corn	78.2	93.5	86.6	78.1

Wylie Mill using a one millimeter screen. Samples were analyzed for dry matter, crude protein, organic matter, acid detergent fiber, and neutral detergent fiber. Fresh feed and fecal samples were used to determine nitrogen content.

After termination of the digestibility trial, the four steers used in the trial plus four Holstein steers fitted with rumen cannulaes were used to collect rumen fluid. Samples were taken at 0, 2, 4, 8, and 12 hours post-feeding. A vaccuum pump system was utilized to collect samples from the non-cannulated animals. Rumen samples were strained through two layers of cheesecloth and one ml of mercuric cloride was added to nineteen ml of rumen fluid at the time of collection. The liquid was used for ammonia and VFA determinations.

Chemical Analyses

Dry Matter: Dry matter determinations were made for all samples by oven drying at 60 C for 48 hours.

Crude Protein: Crude protein values (6.25 x N) were obtained for feed and feces using the Technicon Block Digestion Auto-Kjeldahl system.

Acid detergent Fiber: Approximately one gram of dried feed or feces sample was used to determine ADF content. The Van Soest procedures were utilized for these analyses (Van Soest, 1963; Van Soest and Wine , 1967).

Neutral Detergent Fiber: NDF values were obtained by the procedure according to Goering and Van Soest (1970).

Organic Matter: Organic matter determinations for feed and fecal samples were performed by ashing approximately two grams of dried sample (% OM = 1- % ash).

Chromium analyses: The chromium content of dried feed and fecal samples were determined by digestion utilizing nitric and perchloric acid as a digestion catalyst, followed by atomic emission spectrophotometry. An I. L. 453 Atomic Absorption/Emissions Spectrophotometer was used for chromium detection.

Volatile Fatty Acid analyses: After the addition of mercuric chloride to the rumen contents, five ml of rumen contents were added to one ml of 25% metaphosphoric acid. Samples were allowed to stand for thirty minutes, then they were centrifuged at 15000 x G for fifteen minutes (Erwin et al, 1961). The supernatant was removed and analyzed using a Hewlett-Packard gas-liquid chromatograph (Mode 15840). The column used for the analysis consisted of a stainless steel tube containing a chromasorb column of 10% SP 1200 and 1% H_3PO_4 80/100 WAW mesh.

Rumen ammonia: The supernatant rumen fluid as prepared for VFA analyses was then analyzed for nitrogen content by the Technicon Auto-Analyzer, using standards of 0, 20, 50, 100, and 200 ppm values.

Economic Analysis

An economic analysis compared the incorporation of alfalfa haylage or corn silage into feedlot diets utilizing the Telplan 44 computer simulation program. This program develops least-cost rations for beef cattle, indicative of feed sources used, price of feed, and animals nutrient requirement. Computer outputs provide a ration balanced for the animals nutrient requirement, the estimated chemical composition of the diet, and projected animal performance based on the net energy content of the diet. The computer outputs also provide the cost of the diet on a per head per day basis, the upper and lower bounds of the feed sources utilized in the diets, and the shadow prices of the feed ingredient not utilized in the diet.

For this simulation, an average framed yearling steer model was used. Environmental conditions include, animals in an outside lot with mounds, bedded during adverse weather. Growth stimulants (implants and feed additives) were also included in the model. The basic design was for the model to provide a diet utilizing corn, corn silage, alfalfa haylage, and minerals. A list of feed sources used is provided by Table 6.

Corn was incorporated into the simulation at five different price levels ($2.00/ bu to $4.00/ bu at intervals of $.50/bu). The corn silage price was determined by the following equation:

$$\$ \text{ Corn silage/ton} = (\text{bu corn/ton})(\$ \text{ corn/bu}) + \$8.00$$

Supplement ingredients were based on current price levels (July , 1984) and are listed in Table 7.

Two types of corn silage, differing in energy content and alfalfa haylage harvested at three stages of maturity were utilized in this analysis. This procedure was used to try to determine differences in diet formulation and the relative costs, in addition to accessing the basic nutrients that were supplied by a previous feed source.

Table 6. Feed Ingredient Composition For Economic Simulation

	NEg[c]	% CP	% Ca	% Ph
Shelled Corn	1.47	10.0	0.03	0.04
Corn Silage[a]	0.99	8.0	0.28	0.21
Corn Silage[b]	1.05	8.0	0.28	0.21
Alfalfa Haylage				
pre-bloom	0.88	19.4	1.25	0.30
early bloom	0.59	18.4	1.25	0.23
medium bloom	0.39	17.1	1.25	0.22
Urea	---	281.0	---	---
Limestone	---	---	32.0	---
Dical	---	---	23.0	18.0
TMS	---	---	---	---

[a] 5.4 bushels corn per ton corn silage (as-fed)

[b] 6.7 bushels corn per ton corn silage (as-fed)

[c] Mcals of NE per kg of feed (DM basis)

Table 7. Feed Prices used for Economic Simulation

Feed	Price
Shelled Corn	\$2.00 - \$4.00/bushel
Corn Silage/ton (as-fed)	(bu corn/ton) (\$ corn/bu) + \$8
Alfalfa Haylage	variable
Urea	\$14.00/cwt.
Limestone	\$7.00/cwt.
Dical	\$25.00/cwt.
TMS	\$10.00/cwt.

Results and Discussion

Feedlot Performance

As stated in an earlier section, (Table 2) diets fed throughout this trial consisted of high moisture corn, corn silage, and alfalfa haylage. The design of this study (3 x 3 factorial) allows for the evaluation of 1) differences in animal performance relative to the type of roughages utilized in each particular diet, 2) for the variation due to the energy content of the diet, and 3) effects due to the interaction of the roughage sources and energy levels.

Steer performance data for all dietary treatments are given in Table 8. Mean average daily gain (ADG) of the nine rations fed were similar ($P < .05$), however trends did exist. Animals consuming the alfalfa haylage diets gained slightly faster than those animals consuming the combination diet (1.13 vs 1.11 kg/day). Cattle receiving corn silage as a roughage source gained slower than the animals consuming the haylage or combination diets (1.06 vs 1.13 and 1.11 kg/day). These means approached significance ($P < .13$).

Differences among grain percentages (energy content) were similar to the variation in roughage sources. The animals on the low energy (1.12 mcals/kg DM) gained less than the animals consuming the higher energy diets (1.06 vs 1.12 and

Table 8. Feedlot Performance

	Roughage Source								
	CS			CS+AH			AH		
% HMC	65	75	85	65	75	85	65	75	85
# Steers	14	14	14	14	14	14	14	14	14
Initial weight (kg)	339	343	334	333	341	331	333	334	335
Final weight (kg)	452	466	455	454	469	456	456	458	467
Dry matter intake (kg)	6.9	7.3	7.2	7.2	7.5	6.9	6.9	7.1	6.8
Average daily gain (kg)	1.01	1.10	1.08	1.08	1.14	1.12	1.10	1.11	1.18
Feed/gain	6.9	6.7	6.6	6.6	6.6	6.0	6.3	6.3	5.8

Table 3. Feedlot Performance as Affected by Roughage Source or Energy Source.

	Roughage			Energy[a]			
	CS	CS+AH	AH	1.12	1.21	1.30	SE
Dry matter intake	7.1	7.1	6.9	7.0	7.2	6.9	.32
Average daily gain	1.06	1.11	1.13	1.06	1.12	1.13	.17
Feed/ gain	6.8[b]	6.4[b]	6.2[c]	6.6	6.6	6.2	.41

[a] Mcals of energy per kg of dietary dry matter

[b] Means with the same superscript differ ($P < .1$)

[bc] Means with different superscript differ ($P < .01$)

1.13, ($P < .2$). Performance data as affected by energy level or roughage source are shown in Table 9.

Feed utilization (feed per kg of gain) varied significantly between treatment groups ($P < .05$). Steers consuming the alfalfa haylage were 4% more efficient than the animals on the combination diet (6.2 vs 6.4) and 9% more efficient than steers consuming corn silage (6.2 vs 6.8). Berger and Fahey (1981) also reported an increase in feed efficiency for animals consuming alfalfa haylage.

Dry matter intakes (DMI) were similar across all dietary treatments, however the moderate energy level (1.2 Mcal of Neg/kg diet) showed an increase in dry matter intake (7.2 vs 7.0 and 6.9 kg DMI for the moderate, low and high energy diets respectively). Dry matter intakes for roughage sources were 7.1, 7.1, and 6.9 kg per day for the corn silage, combination, and alfalfa haylage diets respectively. These results are inconsistent with Henderson and Newland (1965) who reported an increase in dry matter intake when corn silage and alfalfa haylage were combined as the roughage component. They also reported a small increase in performance for this combination than when either roughage was fed alone.

As mentioned in an earlier section, animals were weighed and intake data was updated every twenty-eight days over 4 periods. Dry matter intakes, average daily gains, and feed utilizations were calculated for each of these four periods. Performance data for dietary treatments are reported in

Table 10. Figures 1 through 6 show graphically differences in performance as affected by energy level or type of roughage fed.

Animal performance was similar among the three roughage sources and across energy concentrations for periods one, two, and four. Corn silage fed steers showed a slight advantage in feed efficiency and daily gain for these periods, however no statistically significant differences could be detected. Period three however indicated a drastic reduction in daily gains and feed utilization, while dry matter intakes were unaffected. Steers consuming corn silage were 50% less efficient than the alfalfa haylage fed steers (13.6 vs 6.8 kg DMI/kg gain) and gained 53% slower (0.53 vs 1.09 kg/day) than the haylage fed steers. Cattle receiving the combination roughage source also showed a decline in performance but not nearly as dramatic as the corn silage fed animals.

Although daily temperatures during this period were unseasonably hot for this time of year (July - August, 1983), the reduction in animal performance could also be attributed to a decline in quality (grain content) of the corn silage. Zimmerman (1964) showed a similar decline in performance for corn silage fed cattle when compared to cattle receiving an alfalfa corn diet. A decline in corn silage quality (spoilage) was also attributed to this difference. However, Zimmerman (1965) in a repeat of the first trial again showed a decrease in animal performance

Table 10. Feedlot Performance for Individual Periods

Roughage	CS			CS + AH			AH		
% Grain	65[d]	75[e]	85[f]	65	75	85	65	75	85
Period 1									
DMI[a]	6.5	6.6	6.5	6.8	7.5	6.1	7.5	6.4	6.5
ADG[b]	1.19	1.32	1.42	1.41	1.47	1.18	1.36	1.22	1.30
F/G[c]	5.5	5.2	5.3	4.8	5.1	5.6	4.7	6.3	5.0
Period 2									
DMI	6.9	7.0	7.2	7.3	7.9	7.5	7.6	7.4	6.8
ADG	1.43	1.10	1.48	0.88	0.87	1.46	1.22	1.26	1.10
F/G	4.9	7.1	5.2	8.1	10.5	5.1	6.0	5.3	6.2
Period 3									
DMI	7.0	7.1	6.7	7.2	7.0	7.3	6.7	6.4	7.4
ADG	0.44	0.77	0.54	1.07	1.20	0.89	0.95	1.09	1.25
F/G	16.9	10.4	13.5	6.6	6.1	8.4	7.6	6.7	5.9
Period 4									
DMI	7.5	7.6	7.6	8.1	7.6	7.4	6.8	6.7	6.7
ADG	0.96	1.20	0.87	0.94	1.01	0.94	0.89	0.67	1.09
F/G	7.8	6.8	7.8	8.0	7.9	7.1	8.5	8.4	6.3

[a] Dry Matter Intake (kg)

[b] Average Daily Gain (kg)

[c] Kg Feed per kg of gain

[d] 1.12 Mcals of NEg per kg of DM

[e] 1.21 Mcals of NEg per kg of DM

[f] 1.30 Mcals of NEg per kg of DM

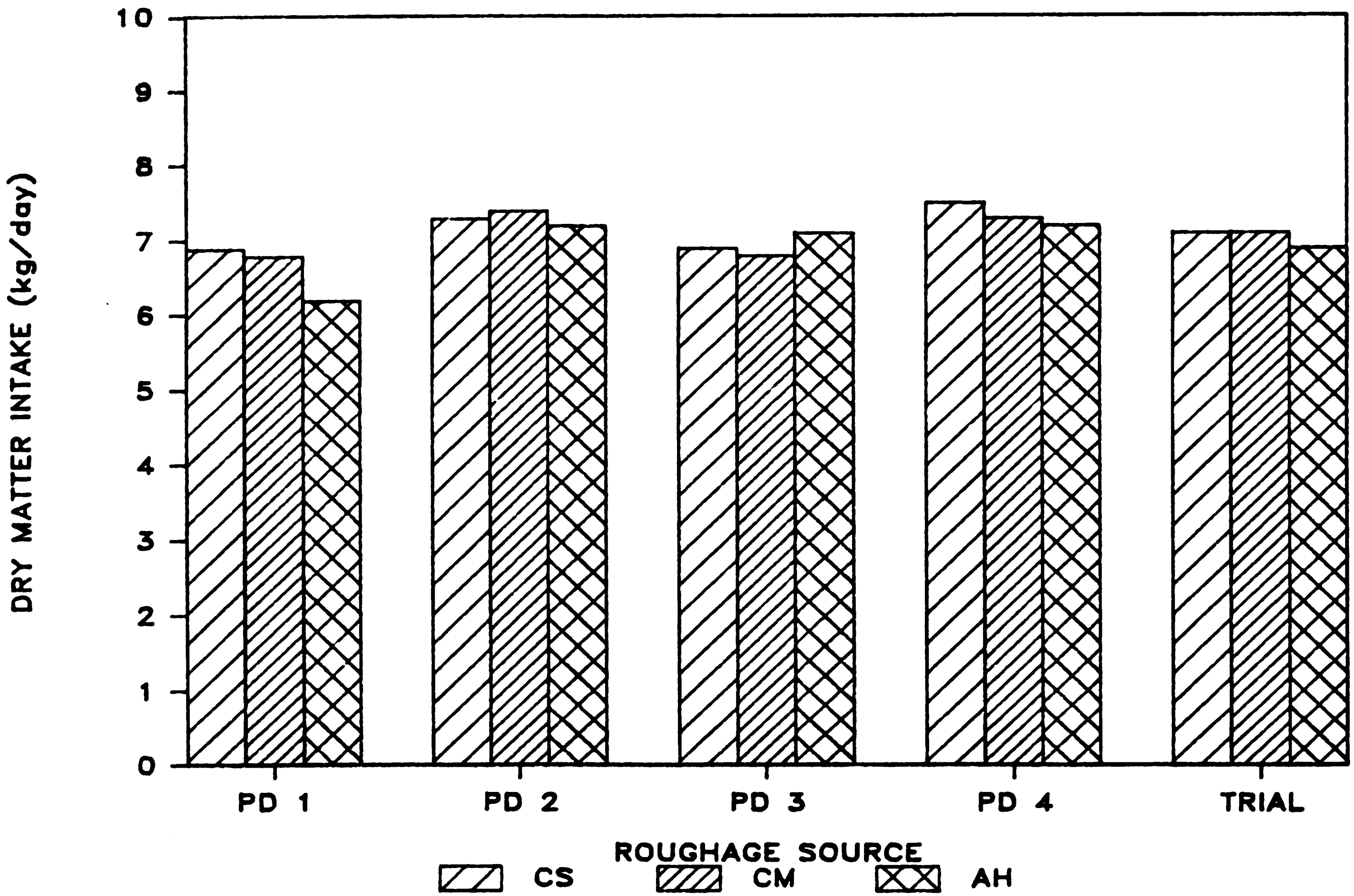

Figure 1. Dry matter intake during four periods and total trial for steers fed the three forages (CS = corn silage, CM = corn silage + alfalfa haylage, AH = alfalfa haylage).

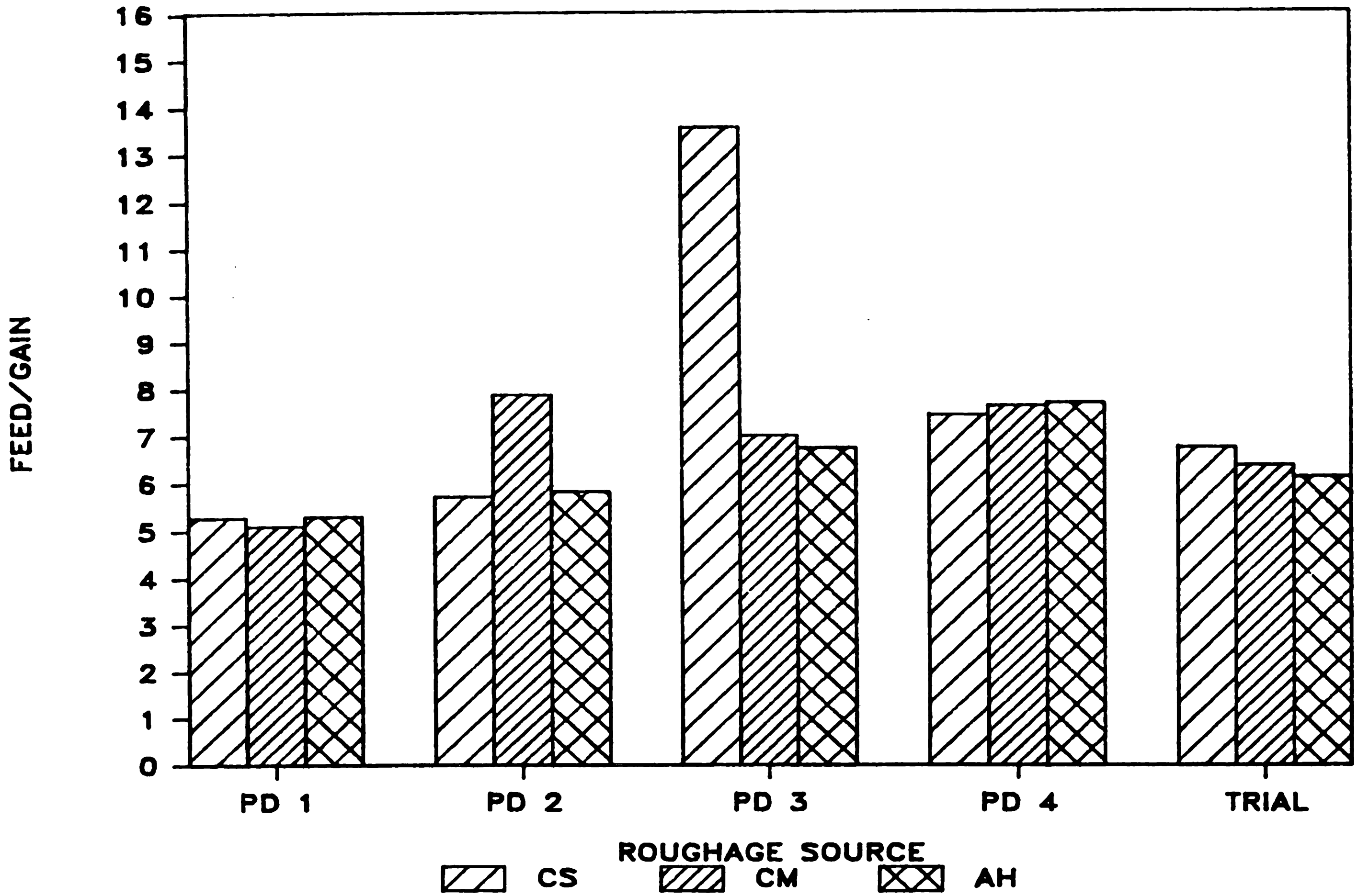

Figure 2. Feed/gain during four periods and total trial for steers fed three forages (CS = corn silage, CM = corn silage + alfalfa haylage, AH = alfalfa haylage).

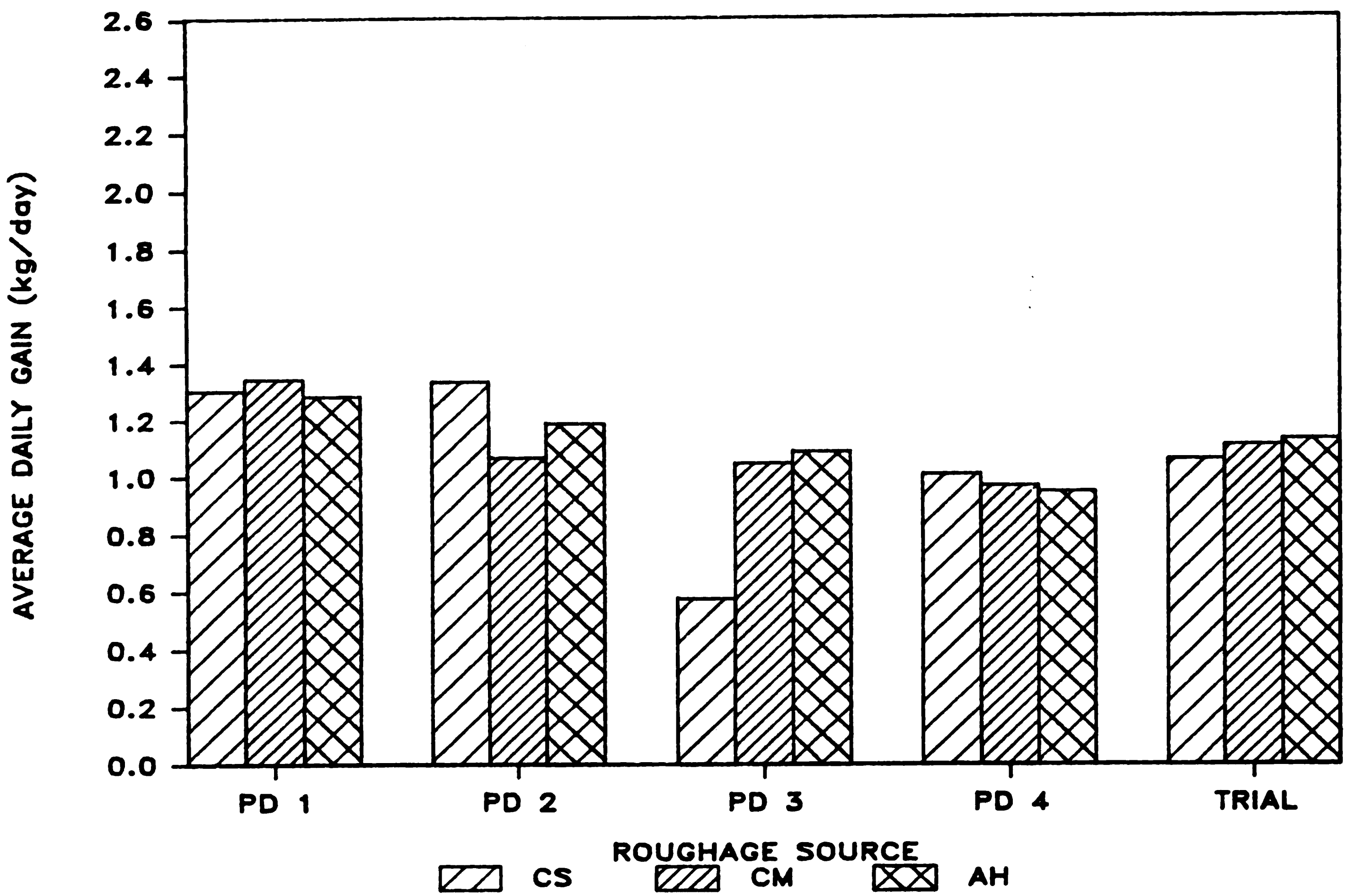

Figure 3. Feedlot gains during four periods and total trial for steers fed three forages (CS = corn silage, CM = corn silage + alfalfa haylage, AH = alfalfa haylage).

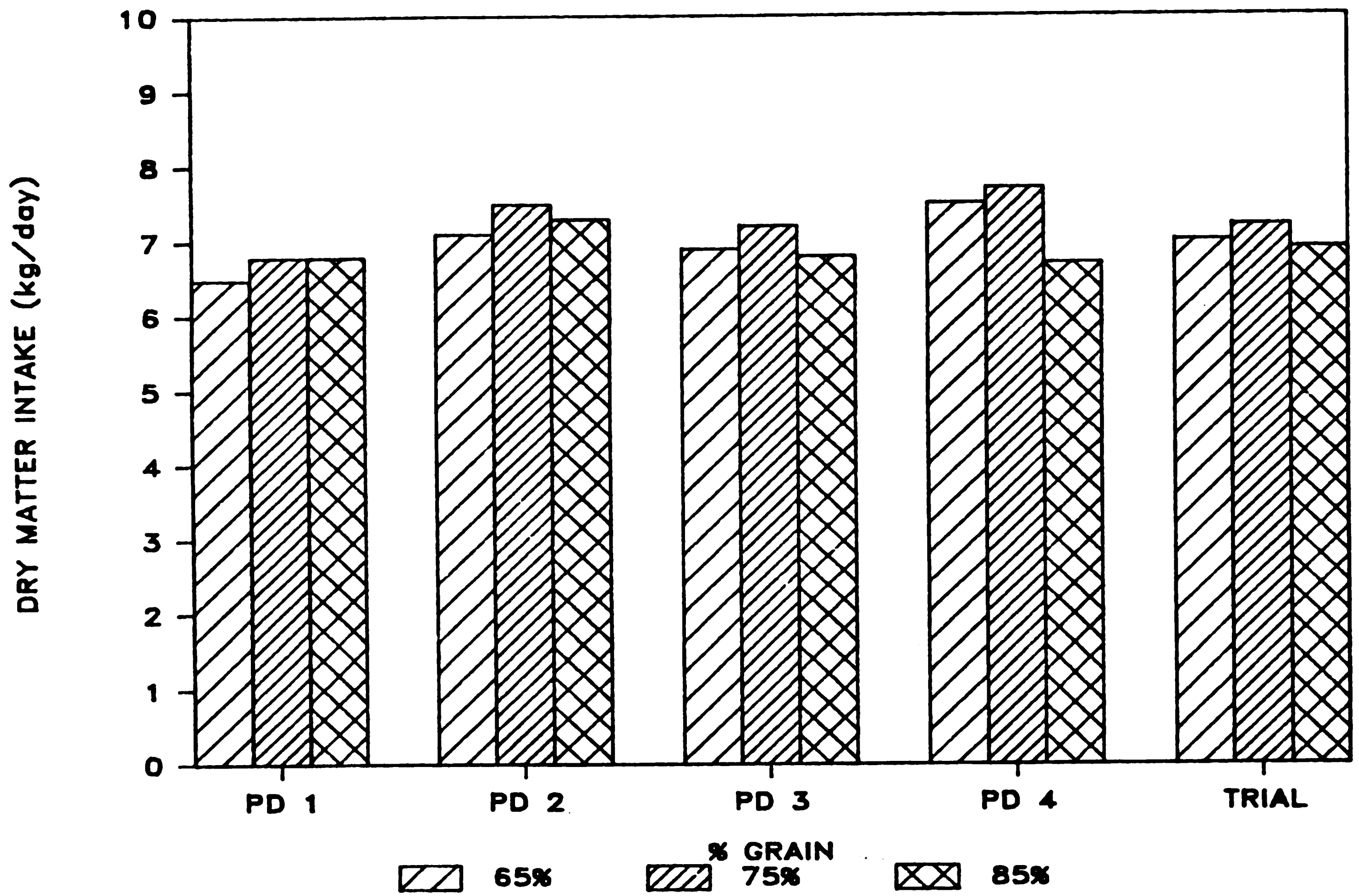

Figure 4. Dry matter intake during four periods and total trial for steers fed diets containing three concentrations of corn.

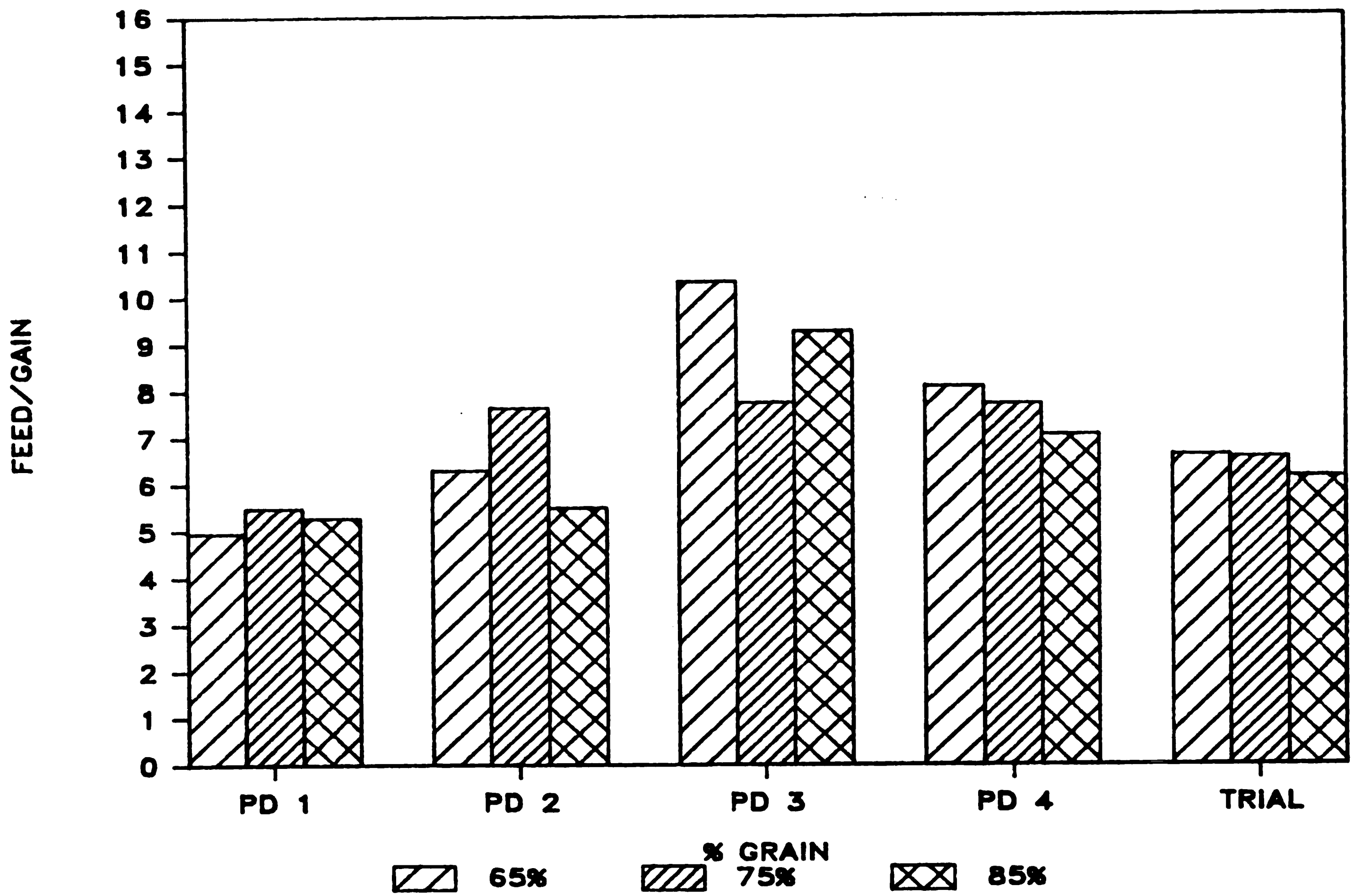

Figure 5. Feed/gain during four periods and total trial for steers fed diets containing three concentrations of corn.

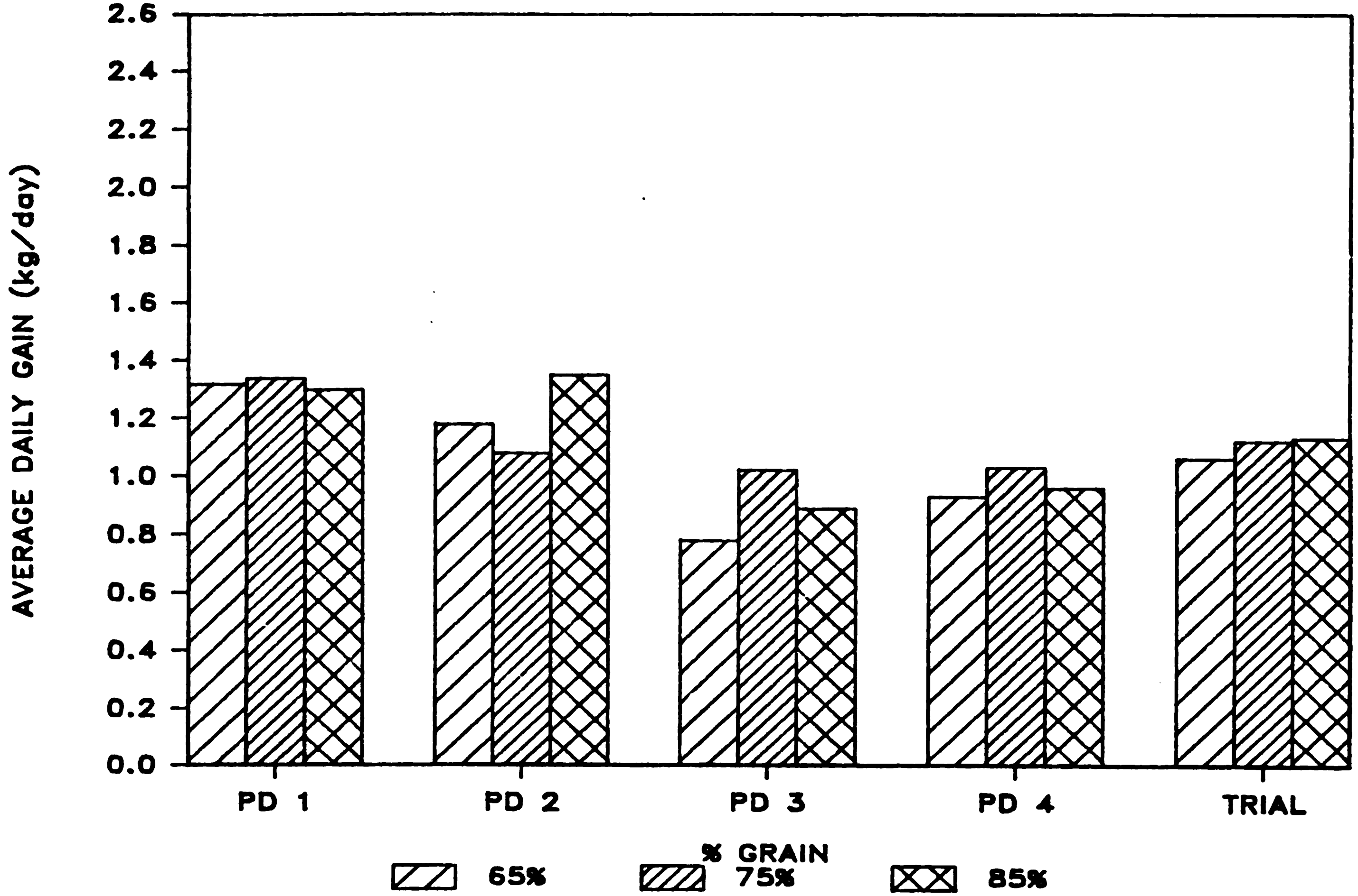

Figure 6. Feedlot gains during four periods for steers fed diets containing three concentrations of corn.

for corn silage fed steers when compared to animals receiving alfalfa haylage. Corn silage quality could not be attributed to these results as the silage was kept fresh by ensiling in an air-tight silo.

Carcass Characteristics

No significant differences in carcass parameters were detected for animals consuming the various roughage sources or energy levels (Table 11). Corre-Gumbe et al. (1985) and Nahara (1981) also showed no differences in carcass parameters for steers consuming high concentrate diets fed alfalfa haylage or corn silage as a roughage source.

Empty body protein and empty body fat as a percent of empty body weights were also non-significant for steers fed different silage or energy concentrations (Table 12). The combination roughage diet (CS + AH) did produce slightly less protein in the carcass (18.75 vs 19.39 and 19.39%) and slightly higher fat content (34.34 vs 33.23 and 33.54% empty body weight) than those fed the single silage feeds.

The alfalfa haylage fed steers tended to have more protein accretion per day than the steers fed the corn silage or the combination roughage diets (0.11 vs 0.07 and 0.09 kg/day). These results were not statistically significant. Protein accretion rates per day as affected by energy levels were almost identical, 0.08, 0.09, and 0.09 kg per day for corn silage, combination, and alfalfa haylage

Table 11. Carcass Performance as affected by Roughage Source or Energy Level

	Roughage			Energy[b]		
	CS	CS+AH	AH	1.12	1.21	1.30
Hot carcass wt. (kg)	286	297	287	281	299	289
Dressing %	61.2	63.0	61.7	61.1	62.7	62.0
Fat thickness (cm)	1.60	1.79	1.58	1.61	1.64	1.72
Ribeye area (cm^2)	76.24	75.26	76.97	73.81	79.41	75.27
Yield grade	3.20	3.55	3.21	3.32	3.19	3.46
Quality grade[a]	10.1	10.2	9.9	10.0	9.8	10.4

[a] 10 = low choice

[b] Mcal of energy per kg of diet dry matter

Table 12. Mean Empty Body Protein and Fat Content when Steers were Fed Three Roughage Sources and Three Energy Levels.

	Roughage			Energy[a]			
	CS	CS+AH	AH	1.12	1.21	1.30	S.E.
Carcass Protein %	19.34	18.85	19.33	18.84	19.30	19.03	
Carcass Fat %	36.64	38.19	36.97	37.50	36.15	37.91	
Empty Body Wt. (kg)	402.90	417.80	404.50	397.10	420.30	407.80	
Empty Body Protein %	19.39	18.75	19.39	19.02	19.55	19.15	
Empty Body Fat %	33.23	34.34	33.54	33.94	32.77	34.41	
Empty Body Protein Gain (kg/day)	0.07	0.09	0.11	0.08	0.09	0.09	.058
Empty Body Fat Gain (kg/day)	0.58	0.67	0.61	0.60	0.61	0.65	.16

[a] Mcals of NEg per kg of diet dry matter

respectively (Table 12). Fat deposition per day was also very similar between forage and energy treatments. The combination diet produced the highest level of fat accretion (0.67 vs 0.58 and 0.61 kg/day) but again at non-significant rates.

Corre-Gumbe et al. (1985) and Nahara (1981) fed similar diets, and obtained essentially the same values for fat and protein deposition per day that were obtained for this trial. All these results indicated that body composition of steers are unaffected by types of silages consumed and when nutritional requirements are met,then primary nutrients are utilized similarly.

Digestibility Trial

Digestibility coefficients for dry matter, organic matter, crude protein, neutral detergent fiber, and acid detergent fiber were determined for the four diets consisting of alfalfa haylage alone and alfalfa haylage with 65, 75, or 85%, high moisture corn.

Table 13 contains the chemical analysis of the diets utilized for this trial. Dry matters ranged from 43.1% for the alfalfa haylage diet to 59.2 % for the diet containing 85% grain. Organic matters varied the least with the alfalfa haylage diet containing 89.7% OM, and 97% OM for the high corn diet.

The three diets containing the added corn were calculated

Table 13. Chemical Composition of Four Diets Fed in Digestion Trial

Item	Alfalfa Haylage	Alf. Hayl. + 65% Corn	Alf. Hayl. + 75% Corn	Alf. Hayl. + 85% Corn
Dry Matter %	43.1	52.2	55.7	59.2
Organic Matter	89.7	94.6	95.4	97.0
Crude Protein	13.1	11.2	11.5	11.2
Neutral Detergent Fiber	44.0	30.3	28.6	23.0
Acid Detergent Fiber	29.4	17.5	14.2	9.7

to be isonitrogenous, and contained crude protein levels of 11.2 to 11.5% crude protein. The alfalfa haylage diet contained 13.1% crude protein. The lower value for crude protein for this haylage diet compared to the protein content of the same forage as shown in Table 1, was due to the addition of ground corn used as a carrier for the supplement and marker in this digestion trial. Neutral detergent fiber (NDF) content ranged from 44 to 23% while the acid detergent fiber (ADF) fraction ranged from 29.4 to 9.7% for the haylage diet and high grain diet respectively.

Generally, different levels of dry matter intake alter digestibility. Due to the variation of dry matter of these diets and the variation in energy density, maintaining equal dry matter intakes would not provide an accurate accessment of diet digestibilities and subsequent animal performance in feedlot situations. For this trial ad libitum intakes were established for each animal and intakes were reduced to 90% ad libitum for the collection period to ensure total consumption of the marker.

Animal intake and apparent digestibility coefficients are reported in Table 14. Intakes for these diets ranged from 4.6 kg for the steers consuming only alfalfa haylage to 6.3 kg for the diet containing 85% grain. Intakes for the 65 and 75% grain diets were similar, ranging from 5.6 to 5.7 kg per day respectively.

Dry matter and organic matter digestibilities increased with increasing grain content. Digestibility of dry matter

Table 14. Apparent Digestion Coefficients for Steers Fed the Four Alfalfa Haylage and Corn Diets.

Item	Alfalfa Haylage	Alf. Hayl. + 65% Corn	Alf. Hayl. + 75% Corn	Alf. Hayl. + 85% Corn	S. E.
Dry Matter Intake (kg/day)	4.6	5.6	5.7	6.3	
	% Digestibility				
Dry Matter	54.9[a]	58.8[b]	62.0[c]	64.9[c]	1.5
Organic Matter	55.1[a]	60.2[b]	63.0[c]	64.9[c]	1.5
Crude Protein	48.1[a]	43.3[b]	48.1[b]	55.5[c]	1.7
Neutral Detergent Fiber	34.1	35.3	40.5	36.6	3.7
Acid Detergent Fiber	34.3	32.1	38.9	28.9	4.3

[abc] Means in the same row bearing different superscripts differ ($P < .01$)

from alfalfa haylage was significantly less ($P < .01$) than the diet containing 65% added corn (54.9 vs 58.8%). Digestibility of dry matter was greater for diets containing 75 and 85% corn than for the diets containing the two higher corn levels (58.8 vs 67.0 and 64.9%, $P <.01$).

Digestibility of organic matter were similar to that for dry matter. The haylage diet had significantly lower organic matter digestibility than the 65% grain diet which in turn was less digestible than the 75 and 85% grain diets ($P<.01$). Rumpler (1984) fed alfalfa haylage at two dry matter contents with or without added corn (30% of total dry matter), and showed similar increases in dry matter and organic matter digestibilities (59.1 vs 65.8% for 29% DM haylage and 61.7 vs 68.4% for 60% DM haylage). These differences due to silage or corn level were not significant.

Crude protein digestibilities also varied considerable between diets. The high grain diet had the greatest digestibility ($P < .01$). Digestibility of protein for the alfalfa haylage and the 75% grain diets were identical (48.1%), and both were significantly greater than that for the 65% grain diet. The lower digestibility coefficient for this diet is somewhat difficult to explain, but could be attributed to negative associative effects. Dowe et al. (1955) also reported inconsistent patterns in apparent crude protein digestion in steers with increasing ratios of corn to alfalfa hay. These data also indicate a negative associative effect for steers consuming diets containing corn and alfalfa hay fed at a ration of 3:1 when compared to ratios of 1:1 and 2:1 (58.5 vs 61.7 and 63.0% apparent crude protein digestibility for ratios of 3:1, 1:1, and 2:1 respectively). Digestibility of crude protein tended to recover for steers fed diets containing corn and alfalfa at ratios of 4:1 and 5:1 (58.5 vs 61.4 and 62.5 for ratios of 3:1, 4:1, and 5:1 respectively). Differences between ratios were not significant.

Rumpler (1984) also noted a decrease in total tract digestibility of nitrogen as corn was introduced into the diet. These differences were statistically insignificant. Rumpler (1984) reported an effect on site of nitrogen digestion with the addition of high moisture corn. The addition of corn to the diet tended to shift the site of digestion of the nitrogenous components, therefore making more of the dietary nitrogen availible to the lower gut. Not only was more of the dietary nitrogen reaching the lower gut but nitrogen digestibility coefficients were greater when corn was included in the diet.

Digestibility of ADF and NDF in these four diets ranged from 30 to 40%, and differences in each, due to diet, were not significant. Digestibility of ADF and NDF tended to increase slightly as the grain content of the diet increased, except for the high grain diet. The increase in passage rate and fecal flow for steers fed the 85% corn diet may have caused a decrease in ADF and NDF digestibility when

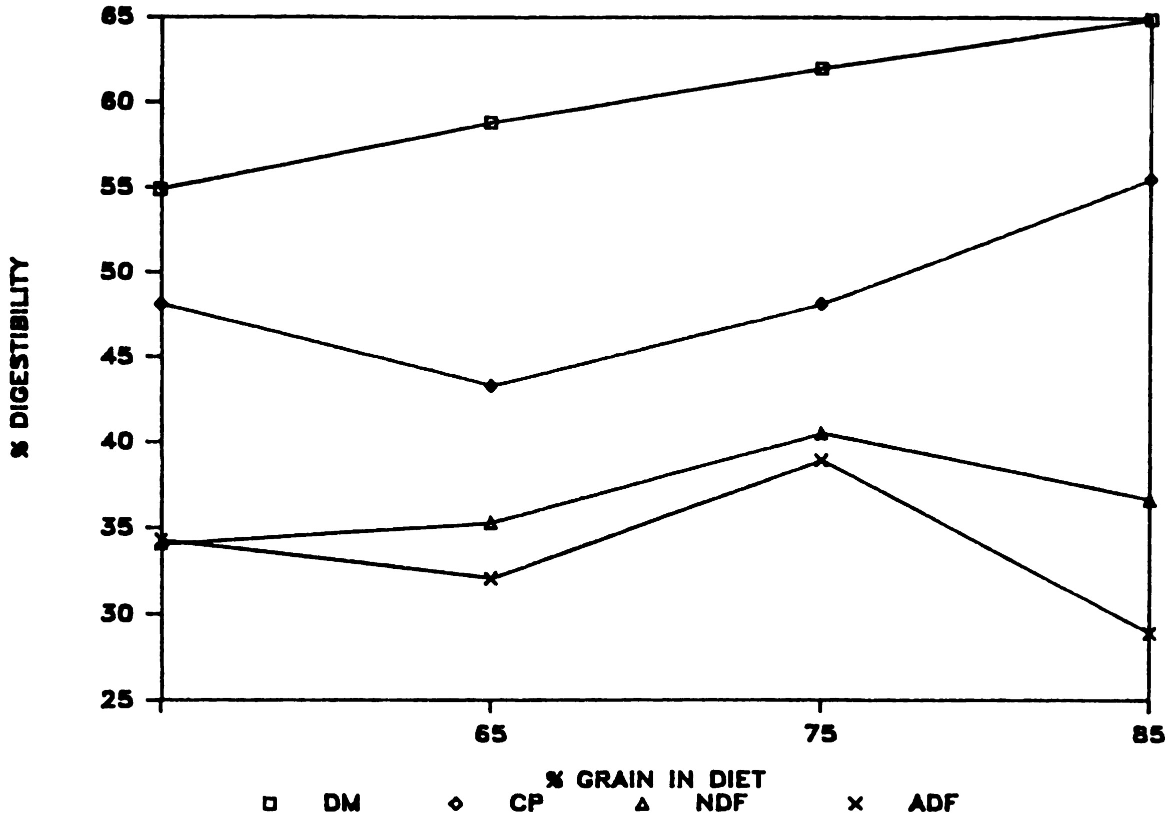

Figure 7. Apparent nutrient digestitility as grain content increases in the diet.

compared to the 75 and 85% diets. Rumpler (1984) reported a trend of decreasing ADF digestibilities with the addition of high moisture corn. Rumpler (1984) also stated that when alfalfa haylage was fed alone, 10% of the total ADF digestion occured post-ruminaly, but with the addition of corn, ruminal digestion of ADF constituted virtually all of the ADF digested.

In summary, digestion coefficients for dry matter and organic matter increased as the grain content of the diet increased. This occured even though diet intake also increased simultaneously. Diets containing 75 and 85% grain were not significantly different but indicated higher digestibilities than for the low grain diet. This indicates that as dietary energy is increased by this large addition of corn, any associative effects were diminished. Protein digestibilities were greatest for the 85% grain diet, lower but similar for the 75% grain diet and the alfalfa haylage diet, least the low grain diet. Fiber digestibility showed no significant differences among diets. The changes are depicted in Figure 7.

These results verify results from the feedlot performance trial. Virtually no differences in performance occured for the two higher energy diets (1.12 and 1.30 mcals/kg DM) with only a small decline in performance for the lower energy diet.

Economic Analysis

The primary objectives of these analyses were to develop price relationships between corn silage and alfalfa haylage. Due to the great differences between these two feed sources and the variation of quality among silages of the same type, such a relationship could not be determined on a simplistic basis.

Alfalfa is an excellent source of protein and calcium. Energy content of alfalfa varies greatly as the maturity of the forage increases, with a sizeable difference between pre-bloom and medium-bloom alfalfa (0.83 vs 0.68 mcals of NEg/kg of forage, N.R.C., 1984). When compared with basic corn-corn silage diets, alfalfa provides an excellent source of nutrients such as protein and calcium, which are deficient in the corn-corn silage diet.

From a least-cost standpoint, high quality alfalfa may be incorporated into feedlot diets by decreasing the amount of corn silage required in the diet and replacing one or more supplemental products (dicalcium phosphate, limestone, urea).

For these analyses two types of corn silage were used (varying in energy content) and three types of alfalfa (pre-bloom, early-bloom, and medium-bloom). Corn prices ranged from $2.00 to $4.00 per bushel with $0.50 increments while mineral and protein costs were held constant.

Results of the computer simulation are given in Tables

Table 15. Price Relationship between Alfalfa and Corn/Corn Silage

Mcals energy kg diet DM	Alfalfa %diet DM	Corn Price per bushel				
		2.00	2.50	3.00	3.50	4.00
1.12 Mcals						
$ Alfalfa/ton DM	12	70.40	77.20	84.00	91.20	98.00
	21	67.60	74.80	80.12	88.40	94.80
	29	64.40	70.40	76.80	84.00	89.60
	59	53.20	58.00	64.40	69.60	75.20
1.21 Mcals						
$ Alfalfa/ton DM	25	67.60	74.40	80.12	88.40	94.80
	26	64.40	70.40	76.80	84.00	89.60
	44	52.80	58.00	64.40	69.60	75.20
1.30 Mcals						
$ Alfalfa/ton DM	23	68.00	74.64	80.12	88.40	94.80
	29	56.00	61.60	68.00	74.40	80.00

Corn Silage - 5.4 bu corn/ton corn silage (As-fed)
Price corn silage - (bu corn/ton CS)($ corn/bu) + 8

Table 16. Price Relationship between Alfalfa and Corn/Corn silage

Mcals energy kg diet DM	Alfalfa %diet DM	Corn Price per bushel				
		2.00	2.50	3.00	3.50	4.00
1.12 mcals						
	18	76.80	84.40	91.60	98.40	105.60
	23	74.80	81,60	88.40	94.80	102.40
	30	70.40	77.60	84.40	90.40	97.60
	59	59.20	65.60	71.60	77.20	83.60
1.21 Mcals						
	25	73.60	80.40	88.40	94.80	102.00
	27	70.40	77.60	84.40	90.40	97.60
	44	59.20	65.60	71.60	77.20	83.60
1.30 Mcals						
	23	73.60	80.80	88.40	94.80	102.00
	29	62.00	69.20	75.20	88.00	87.60

Corn silage - 6.7 bu corn/ton corn silage (As-fed)

Price corn silage - (bu corn/ton CS)($ corn/bu) + 8

15 and 16. The least-cost analyses utilized the lower priced corn silage (5.4 bu corn/ton corn silage) over the higher priced, higher energy corn silage (6.7 bu corn/ton corn silage). However analyses were conducted and are reported for both corn silage types at the three dietary energy levels used in this experiment.

The pre-bloom alfalfa was utilized in this model, as the higher maturity forage did not provide an adequate nutrient composition that could be used in the least-cost diets.

As the price of corn increases or decreases the price in which alfalfa is incorporated into the diet also increases or decreases proportionately.

For the low energy diet (1.12 mcals/kg dietary DM) alfalfa can be incorporated into the diet at four levels, 12, 21, 29, and 59% of the total dietary dry matter. Dicalcium phosphate is first replaced by alfalfa as a source of phosphorus. Limestone and urea are then priced out of the diet followed by the complete elimination of corn silage in the diet. Figures 8 and 9 show graphically the price/resource maps of the incorporation of alfalfa into the diets.

Alfalfa is incorporated into the moderate energy diet (1.12 mcals/kg of dietary DM) at three levels (25,26, and 49% of the diet dry matter). Dicalcium phosphate is not required for this diet as the corn portion of this diet provides sufficient phosphorus to meet the animals nutritional requirement. For this diet the calcium and

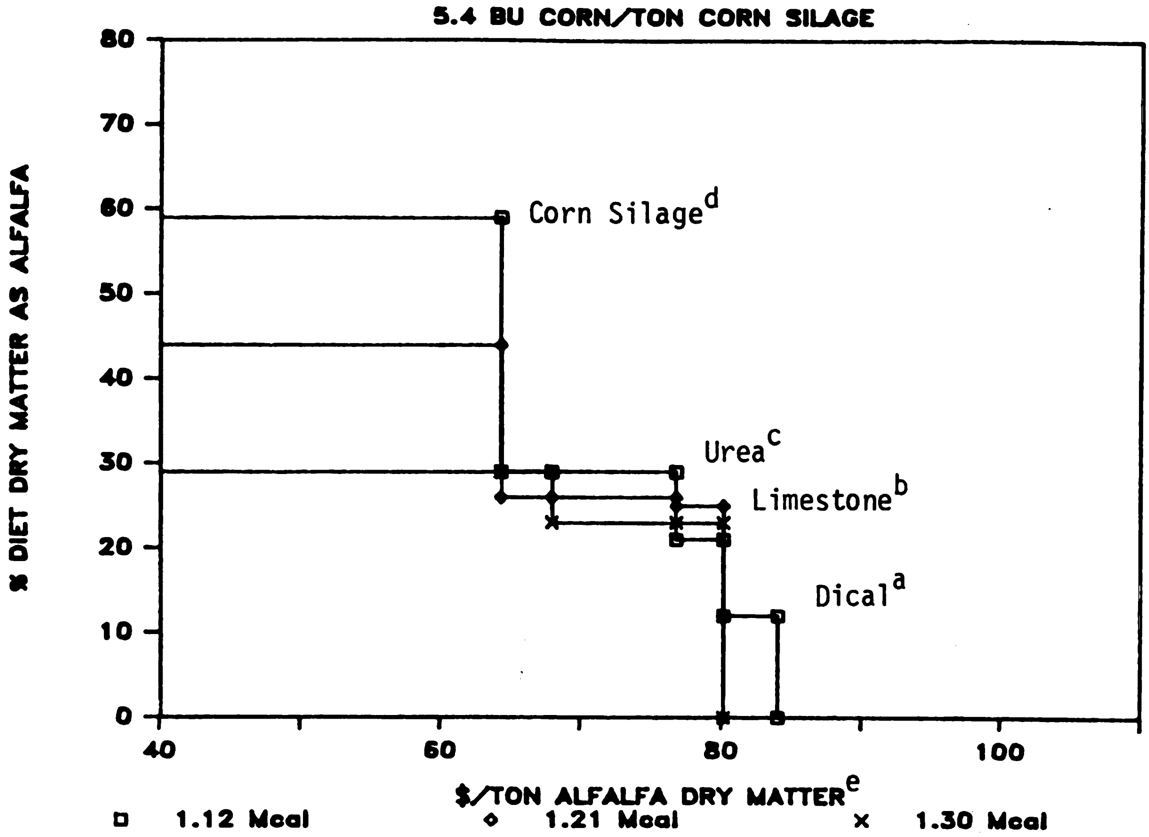

Figure 8. Price/Resource Map of the incorporation of alfalfa into a corn-corn silage diet, based on corn priced at $3 per bushel.

Low Energy Diet (1.12 Mcal of NEg/kg DM)

[a] Alfalfa (80.13 - 84.00/ton DM) is added to the diet (12% of diet DM) replacing dicalcium phosphate as a phosphorus source.

[b] Alfalfa ($76.80 - 80.12/ton DM) is added to the diet (21% of diet DM) replacing limestone as a calcium source.

[c] Alfalfa ($64.40 - 76.80/ton DM) is added to the diet (29% of diet DM) replacing urea as a protein source.

[d] Alfalfa ($64.40/ton DM) is added to the diet (59% of diet DM) replacing corn silage.

[e] Specific prices for alfalfa as it is incorporated into diets containing three energy concentrations and five corn prices are reported in Table 15.

As alfalfa is incorporated into corn-corn silage diets, replacing more expensive nutrient supplements, corn silage is reduced accordingly to maintain a constant nutrient composition.

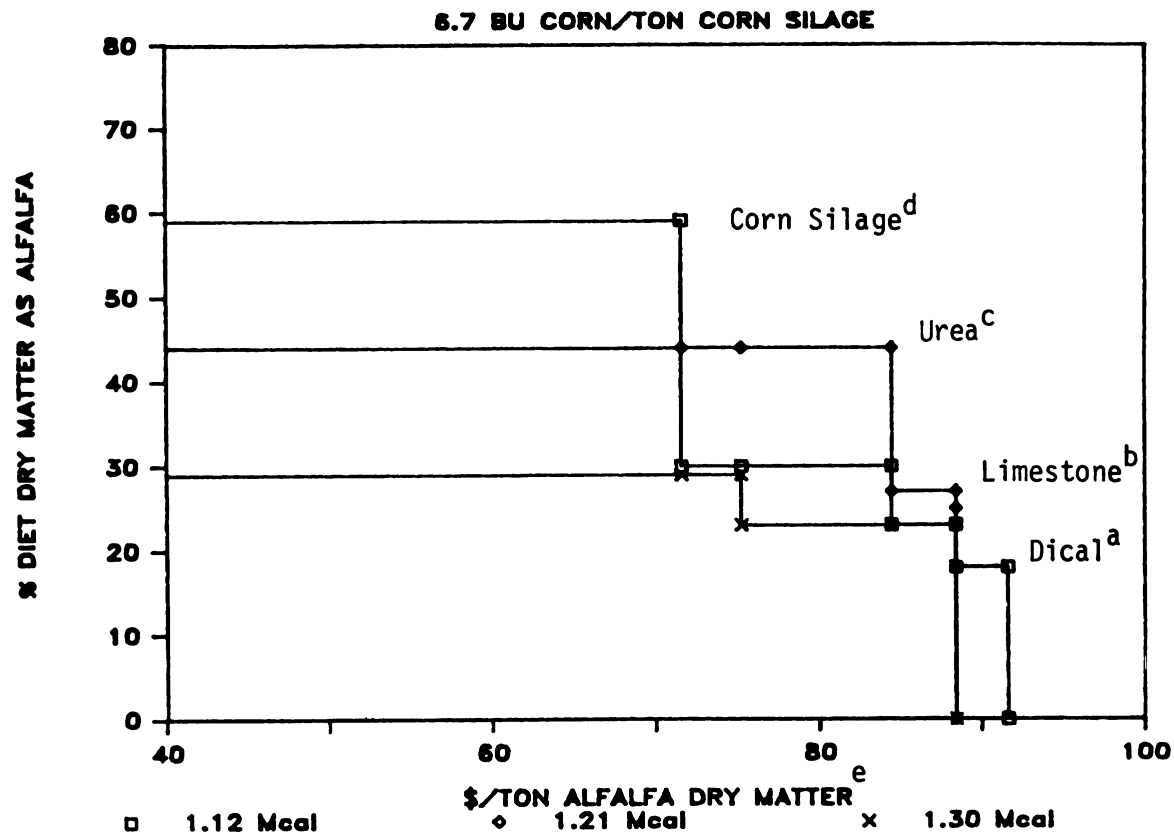

Figure 9. Price/Resource Map of the incorporation of alfalfa into a corn-corn silage diet, based on corn priced at $3 per bushel.

Low Energy Diet (1.12 Mcal of NEg/kg DM)

[a] Alfalfa ($88.40 - 90.60/ton DM) is added to the diet (18% of diet DM) replacing dicalcium phosphate as a phosphorus source.

[b] Alfalfa ($84.40 - 88.40/ton DM) is added to the diet (23% of diet DM) replacing limestone as a calcium source.

[c] Alfalfa ($71.60 - 84.40/ton DM) is added to the diet (30% of diet DM) replacing urea as a protein source.

[d] Alfalfa ($71.60/ton DM) is added to the diet (59% of diet DM) replacing corn silage.

[e] Specific prices for alfalfa as it is incorporated into diets containing three energy concentrations and five corn prices are reported in Table 16.

As alfalfa is incorporated in corn-corn silage diets, replacing more expensive nutrient supplements, corn silage is reduced accordingly to maintain a constant nutrient composition.

protein requirement can be met by the addition of alfalfa at the same relative price in which alfalfa was utilized for the low energy diet. The only difference is the level in which alfalfa is incorporated. Differences between calcium and protein replacement by alfalfa for this diet are only one or two percentage units apart (25 vs 26% and 25 vs 27% for the low and high energy corn silage diets respectively) therefore these dietary components could be substituted simultaneously.

For the high energy ration, alfalfa is incorporated into the diet only twice. Urea and limestone are replaced in the diet by the addition of alfalfa at 23% of the dietary dry matter. The next level in which alfalfa enters the diet, alfalfa completely replaces corn silage resulting in a diet of corn, alfalfa haylage.

In summary, alfalfa is utilized in a basic corn-corn silage diet by replacing more expensive protein and mineral supplements. Prices at which alfalfa is substituted for calcium and urea are constant for the low and moderate energy diets. For the high energy diet, as alfalfa is incorporated in place of the limestone portion of the diet the supplemental protein requirement is met, thereby eliminating the need for urea.

Several factors other than actual feeding value and animal performance must also be considered in determining the value of alfalfa for feedlot diets. If alfalfa were grown on the farm, production cost for alfalfa, production costs for corn silage, and the price at which alfalfa can be purchased must be considered. Alfalfa production costs are typically higher when compared to corn silage, depending on the length of the alfalfa stand in number of years.

Labor is another important factor which must be considered. Typically alfalfa is harvested for haylage at the first or fourth cutting due to the lack of favorable weather conditions for making hay. This usually occurs during the months of May, June or October when most of the available labor is utilized in planting or harvesting corn.

Another consideration is the added benefit from alfalfa in terms of soil restoration. Nitrogen is added to the soil by leguminous plants thereby reducing fertilizer costs. Also the use of corn and alfalfa in a crop rotation system has been shown to increase corn yields up to 20% of first year corn following three years of alfalfa.

The most important decision that should be made in determining advantages or disadvantages of alfalfa haylage to the feedlot operator when compared to corn silage should be which of these types of forages best suits the overall management cycle of an individual farm in terms of production and harvesting capabilities, forage storage and handling facilities.

Conclusions

Comparing research results from this trial and data collected from the literature review, several conclusions can be made concerning corn silage and alfalfa haylage as roughage sources for feedlot diets.

Due to the practice of two phase feeding systems in the feedlot industry, the effect of animal performance, diet digestibility and economic parameters must be separated for each phase. Typically growing diets contain grain to forage ratios of 1:1, while grain to forage ratios for finishing diets are approximately 3:1 or higher.

Berger et al. (1983) reported that in rations conducive to a growing type diet, high quality alfalfa continually out performed corn silage in daily gain, feed efficiency, and nutrient digestibility. Although economic analyses for these types of diets were not conducted, animals in the growing phase consuming a more expensive soybean meal supplement, alfalfa could economically be incorporated into these diets and provide an excellent source of protein and calcium.

Roughage sources for higher energy finishing diets indicate similar utilization of the total diet by animals and nutrient digestibility by cattle in the fattening phase. Rust and Owens (1981) compared six types of roughage sources ranging from low digestible sources such as cottonseed hulls and prairie hay to high digestible sources such as alfalfa hay and corn silage. Results indicate that the lower digestible roughage sources seem to improve dietary starch digestion. Typically the amount of energy provided by the roughage component of high concentrate diets are so diluted that any nutritional benefits other than a source of fiber are negligable.

Availability, palatability, and cost of the roughage should be the primary concern to consider when selecting a roughage source for these types of diets.

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APPENDIX

APPENDIX

A. 1. Partition of variance: Feedlot trial (3 x 3 factorial).

	degrees of freedom		
	DMI	ADG	F/G
Source (Silage)	2	2	2
Energy (mcals NEg/kg DM)	2	2	2
Source * Energy	4	4	4
Error	9	117	9
Total	17	125	17

A. 2. Partition of variance: Carcass Data (3 x 3 factorial).

	df
Source (Silage)	2
Energy (mcals NEg/kg DM)	2
Source * Energy	4
Error	27
Total	35

A. 3. Partition of variance: Digestibility Trial (4 x 4 latin square design.

	df
Row (Animals)	3
Column (Periods)	3
Treatment (Diets)	3
Error	6
Total	15