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EFFECT OF DRY MATTER LEVEL OF ALFALFA HAYLAGE
ON FEEDLOT PERFORMANCE AND CARCASS
CHARACTERISTICS OF FINISHING STEERS

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By

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THESIS

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ABSTRACT

EFFECT OF DRY MATTER LEVEL OF ALFALFA HAYLAGE ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING STEERS

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Alfalfa haylage (30% DM or 60% DM) was fed to 112 Angus steers during a 106 day finishing trial. The rations were: 1) 70% high moisture corn (HMC) + 30% untreated corn silage (UCS); 2) 70% HMC + 30% treated corn silage (TCS 11%); 3) 70% HMC + 30% treated corn silage (TCS 13%); 4) 85% HMC + 15% high moisture haylage (HMH); 5) 85% HMC + 15% low moisture haylage (LMH); 6) 80% HMC + 10% UCS + 10% HMH; 7) 80% HMC + 10% UCS + 10% LMH. Rations were calculated to be isonitrogenous and isocaloric. Average daily gain in Kg and feed/gain ratio were: 1.35 and 7.58; 1.45 and 6.67; 1.42 and 6.75; 1.40 and 7.38; 1.46 and 7.06; 1.41 and 7.12; 1.48 and 6.87, for the respective treatments. Carcass parameters showed no significant differences. Nitrogen balance and dry matter digestibility were obtained for each alfalfa haylage.

To my parents

Miguel Nahara and Nelida Cura de Nahara

and to

Mariana B. Ladmann

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INTRODUCTION

Alfalfa is a widely grown forage in the North Central area of the United States. In 1969, almost 20 million acres of alfalfa were grown in this area (Fed. Ext. Serv., 1970). Alfalfa follows corn in acreage in Michigan, where approximately 1,020,000 acres are grown for hay (Mich. Ag. Statistics, 1981).

The practice of ensiling the last cut of alfalfa is increasing due to the absence of optimum weather conditions for making hay at that time of the year. Research has been done in order to determine what would be the appropriate dry matter level at which alfalfa should be ensiled.

In a beef cattle feedlot operation alfalfa haylage can be used as an inexpensive protein source, replacing, up to a certain point, more expensive protein supplements such as soybean meal.

Increasing dry matter content of alfalfa by wilting in the field results in higher intake by sheep, dairy and beef cattle (Hawkins, 1969; and El Serafy *et al.*, 1974). Despite the higher intake of drier haylage, results on daily gain and feed efficiency are inconclusive. The same can be stated when alfalfa haylage was compared against corn silage. Also, there is little data reported on carcass traits of steers fed alfalfa haylage.

Thus, the objectives of this study were to gain further information on:

1. Effect of treating corn silage with urea at ensiling on feedlot cattle performance and carcass traits.

2. Effect of replacing corn silage with alfalfa haylage on feedlot cattle performance and carcass traits.

3. Effect of level of dry matter of alfalfa haylage on feedlot cattle performance and carcass traits.

LITERATURE REVIEW

Several research studies have been conducted in the last forty years evaluating alfalfa haylage at different dry matter (DM) levels. The majority of those studies tried to establish the most appropriate moisture content at which alfalfa silage should be ensiled. This review will cover the most important aspects affected by the DM level of the silage such as: silage characteristics, animal performance, nutrient digestibility and DM losses. Use of additives and type of silo are also included.

Several of these studies used silages made of other species than alfalfa (legumes, grasses, or a combination of both). Table A.1 lists all the species and DM levels used by the respective authors cited in this review.

Silage Characteristics

Thomas *et al*. (1980) in a review paper, cited that the main fermentation products in the silage-making process are lactate and acetate which reduce the pH in the silo to about 4 units, inhibiting further fermentation and preserving the crop. The action of saccharolytic and proteolytic clostridial bacteria, which ferment sugars and lactate to butyrate and raise the pH in the silo, is discouraged through a combination of the correct moisture conditions and pH in the silo. They reported that wilting reduces clostridial activity especially when the DM content of the crop is above 28%. This effect is achieved by a drop in the pH of the ensiled forage which encourages lactic acid bacteria activity resulting in a silage of good quality. The rate of fall in pH following ensilage depends on the buffering capacity of the grass, the establishment and maintenance of anaerobiosis in the silo and the availability of sugars for fermentation. These factors are influenced by the crop and the ensilage technique.

The same authors reported that for well preserved wilted formic acid silages non-protein nitrogen can often account for 60-65% of the total nitrogen.

Waldo _et al_. (1973) made a comparison between the characteristics of alfalfa haylage and the correspondent original forage. Silage oven dried matter contained less hemicellulose and sugars, but more energy, cellulose, lignin and nitrogen than fresh forage. Nitrogen in silage contained smaller how water insoluble and larger ammoniacal fractions than that in forage. The pH was lower in haylage than in fresh forage.

Effect of Wilting on Silage Characteristics

It is important at this point to establish the difference between direct-cut silage, high-moisutre haylage, low-moisture haylage and hay.

Direct-cut silage is forage ensiled right after being cut with a very high moisture level (usually 20 to 25% DM for alfalfa). When the forage is allowed to wilt in the field for a period of time and then ensiled, this will result in high-moisture haylage or low-moisture haylage, depending on the wilting period. Dry matter level of the high-moisture haylage is about 30 to 35% and for low-moisture haylage is approximately 50 to 60%. Finally, hay is the result of wilting the forage up to 85-90% DM to preserve it for a long time without being ensiled.

Hawkins (1969), working with alfalfa haylage of four different DM levels, found an extensive fermentation in the three lower DM haylages with a trend of decreased fermentation as DM increased. The highest DM haylage showed a very low organic acids content. This is in accordance with other studies (Gordon et al., 1965; Gordon et al., 1967; Jackson and Forbes, 1970; Forbes and Jackson, 1981; and Hinks et al., 1976) which showed an inhibition in fermentation as DM increased.

Gordon et al. (1961) reported that acetic acid was predominant in direct-cut silage, while lactic was the predominant acid in haylage. Gordon et al. (1965) cited that the drop in acetic acid is critical after 30% DM level. For lactic acid this limit was about 40% DM. The excess of lactic over acetic acid was most pronounced in the 40-50% DM range.

Several studies also reported a decreased organic acids content when DM level was increased (Murdoch, 1960; Roffler et al., 1967; Hawkins, 1969; Jackson and Forbes, 1970; Sutton and Vetter, 1971; and McGuffey and Owens, 1979). Forbes and Jackson (1971) observed a greater drop in organic acids when going from 18.7 to 35.2% DM than from 35.2 to 51.0%. Roffler _et al_. (1967) cited that butyric acid accounted for a much greater portion of the total acid present in wilted alfalfa-brome haylage than in low-moisture haylage.

Dry matter content of the ensiled forage has a negative correlation with the amount of ammonia nitrogen (Gordon _et al_., 1961; Roffler _et al_., 1967; Gordon _et al_. 1967; Wilkins _et al_., 1971; Hinks _et al_., 1976; and Rogers _et al_., 1979). Roffler _et al_., (1967) found that ammoniacal nitrogen constituted a much greater proportion of the total nitrogen in wilted haylage than in low-moisture haylage. This indicates that a more extensive breakdown occurs during the fermentation of wilted haylage compared to low-moisture haylage.

Hawkins (1969) also reported that the water soluble non-protein nitrogen and ammonia nitrogen decreased as haylage DM increased. The steepest decline in ammoniacal nitrogen occurs below 50% DM, according to Gordon _et al_. (1965). Sutton and Vetter (1971) measured some nitrogen parameters in low-moisture, wilted and high-moisture haylages and observed that wilted alfalfa contained the least soluble and non-protein nitrogen followed by low-moisture and high-moisture haylages respectively.

McGuffey and Owens (1979) ensiled alfalfa with 34 and 43% DM and observed greater total nitrogen in 43% DM haylage. Non-protein nitrogen and ammonia nitrogen were greater in 34% DM haylage. Finally, acid detergent insoluble nitrogen expressed as % of total nitrogen was greater in 34% DM haylage than in 43% DM haylage.

Hammes, et al., (1964) found that low-moisture haylage was higher in crude protein and nitrogen free extract, and lower in crude fiber and ether extract than high-moisture haylage. Also, the nitrogen free extract digestibility was higher for the low-moisture haylage than for high-moisture haylage but there were no significant differences in average TDN content for both types of forages.

Forbes and Jackson (1971) also reported a higher nitrogen free extract value as the DM of the haylage increased from 18.7 to 35.2%. In the same study, they obtained higher soluble carbohydrates figures going from 18.7 up to 51% DM. This is in accordance with data presented by Gordon et al., (1961), Gordon et al., (1965), and Rogers et al., (1979). The explanation for these higher sugar contents in high DM haylages (above 40% DM) can be found in the low fermentation occuring in these haylages and the consequent low sugar utilization by the fermentative bacteria.

Again Gordon et al., (1961 and 1965) reported a loss in carotene content in the low moisture haylage, but this lower level is still quite adequate from the standpoint of meeting nutritional requirements. This is also substantiated by Roffler et al., (1967).

Temperature Effects

McGuffey and Owens (1979) studied the effect of covering and DM at ensiling on preservation of alfalfa in bunker silos. They found that covering markedly reduced temperature of silage but they could not find any difference in temperature in alfalfa ensiled at either 34 or 43% DM.

Thomas et al., (1972) found a positive correlation (r = +.92) between extent of heating measured as degree-days above 35C, and acid detergent insoluble nitrogen (unavailable nitrogen) expressed as percent of total nitrogen.

Yu Yu and Veira (1977) studied the effect of artificial heating (88C for 24 or 48 hours) of alfalfa haylage and found that proximate analysis constituents were not affected by heating. Also, acid detergent fiber was increased by heating and hemicellulose was lowered. Both acid detergent insoluble nitrogen and acid detergent insoluble nitrogen as a percent of total nitrogen were increased by heat treatment.

Pierson et al., (1971) also studying the effect of heating on alfalfa haylage prepared two silages. One was ensiled using proper ensiling techniques and the other was ensiled so that it would heat during ensiling (forage mass was not packed and oxygen was not evacuated). Results of a digestion trial with lambs showed that the digestible protein content of the heated haylage was significantly less than in the haylage ensiled so that heating was prevented 8.0 vs. 13.5% digestible protein). Practices oriented towards a good quality haylage production are: fine chopping, packing, and ensiling at proper DM contents (not above 55% DM).

Animal Performance as Affected by the DM Level of the Haylage

Daily dry matter intake has a significant influence on animal performance. Intake of haylages has been correlated with haylage pH and with haylage concentration of ammonia (% in total nitrogen), lactic acid, acetic acid, and total acids (% in DM) suggesting that the haylage fermentation products are involved in appetite regulation (Thomas *et al.*, 1980).

It has been seen in the previous section of this review, how an increase in DM of the ensiled forage produced a decrease in fermentation resulting in lower concentrations of ammonia and organic acids. It is reasonable to say that an increase in DM will give an increase in feed intake.

Wilkins *et al.*, (1971) measured intake by sheep of seventy silages made of legumes and/or grasses. They found that voluntary intake was positively correlated with the content of DM, nitrogen and lactic acid as a percentage of total acids. Also, voluntary intake was negatively correlated with acetic acid and ammonia content as a percentage of total nitrogen.

Thomas *et al.*, (1961) also obtained higher intake in dairy heifers with higher levels of DM (r = +.79). However, this was shown to be a secondary relationship since changing the DM content of haylage or hay (watering the hay or drying the haylage at time of feeding) did not alter the rate of consumption. It was concluded that the DM content of the forage when ensiled and the resulting fermentation process, are very important factors in determining the rate of consumption of the resulting haylage.

Several studies also established the trend of higher DM consumption with higher DM level of the forage at the time of ensiling, and also reported higher weight gains (either with dairy heifers or beef cattle) of the animals eating the drier haylage (Voelker et al., 1960; Thomas et al., 1961; Yoelao et al., 1970; Jackson and Forbes, 1970; Forbes and Jackson, 1971; El Serafy et al., 1974; Hammes, et al., 1974; Hinks et al., 1976; and McGuffey and Owens, 1979).

Nevertheless, there were some works which were not in agreement with this general trend. Thomas et al., (1969) working with alfalfa haylage and hay in dairy heifers, obtained higher intakes for hay but they were not able to demonstrate a consistent difference in weight gains. Gordon et al., (1963) working with heifers, observed that they consumed similar amounts of low-moisture alfalfa haylage and hay DM per day, and also that the animals made similar gains. However, they did not use high-moisture haylage which would have provided a greater contrast in consumption and performance than low-moisture haylage when compared with hay.

Brown (1964) found that 24.3% DM haylage resulted in greater intakes and similar live weight gains than 17.5% DM haylage when fed to beef cattle.

Alder et al., (1969) ensiled wilted and unwilted grass-clover herbage for three consecutive years. Live-weight gains were higher with the wilted in the first two years but not in the last one.

Morgan et al., (1980) worked with fresh and wilted ryegrass silage. The voluntary intakes of DM for fresh and wilted silages were not significantly different. They concluded that the high intake of the fresh silage is noteworthy, as it casts grave doubt on the widely held view that fermentation acids, particularly lactate, are pre-eminent in governing the voluntary intake of silages.

Several researchers reported neither significant increase in milk yield nor any variation in milk composition when the DM of the consumed haylage was increased (Voelker et al., 1960; Gordon et al., 1961; Neidermeir et al., 1961; Byers, 1965; and Gordon et al., 1965). Nevertheless, Rogers et al., (1979) working with Jersey cross-bred dairy cows demonstrated relative increases in yields of milk and its components by increasing the DM at ensiling.

Roffler et al., (1967) compared milk production and milk fat from cows fed alfalfa-brome forage stored as wilted haylage, low-moisture haylage and hay. Low-moisture haylage ranked first in supporting 4% fat corrected milk production, wilted haylage ranked second and hay last. Fat test of cows fed wilted haylage was higher than that of cows fed low-moisture haylage and this, higher than cows fed hay.

Haylage-Corn Silage Diets

Henderson and Newland (1966) showed higher DM intakes in beef cattle with low-moisture haylage compared with high-moisture haylage. Despite this, cattle fed the wetter forage gained more weight during the trial with superior feed efficiencies. When they tested a constant vs. a varying level of concentrate, little or no difference existed in average daily gain and daily DM intake.

In further experiments, the same researchers (Newland and Henderson, 1966; and Henderson and Newland, 1967), used a similar design to compare alfalfa hay, haylage and corn silage. In 1966, cattle fed alfalfa hay gained non-significantly faster than those fed haylage, and consumed more feed daily as a percentage of their body weight. This was not true for 1967 since cattle fed hay gained significantly ($P<.01$) faster than the haylage fed group. In the same year, a corn silage fed group with 1% of body weight fed daily in shelled corn significantly outgained the haylage group and slightly outgained the hay fed group, although the hay and haylage fed groups received 1.5% of body weight daily in shelled corn. When they tested for constant vs. varying level of added shelled corn, they found no significant effect of these two variables on daily gain and daily DM intake.

A similar trend of superior performance with corn silage compared with alfalfa haylage was reported by Chase et al., (1971), and Tolman and Guyer (1974).

Some other researchers working with diets equalized for protein, calcium, salt and vitamin A reported no significant differences in gain and feed efficiency between corn silage and alfalfa haylage (Haarer et al., 1963; Perry and Beeson, 1966; Windels et al., 1966; and Goodrich and Meiske, 1967).

A third group of studies reported superior performances for alfalfa haylage than corn silage. Zimmerman et al., (1964) reported the superiority of a ration containing alfalfa haylage and corn over another containing corn silage, corn and soybean meal when fed to steer calves. Steers fed haylage outgained those fed corn silage by 19.5% in the lots receiving corn in a full-fed basis. When fed in a limited corn grain basis, haylage fed steers gained 17.1% faster than the corn silage fed group. Limiting the corn intake to a constant level equal to about one-half of a full-fed of corn was a slightly superior system of limiting the corn than increasing the level of corn as the feeding period progressed. The steers on the constant corn level were about 4% more efficient than the steers fed the increasing level of corn.

Zimmerman et al., (1965) working with steer calves found that in the first 112 days of the feeding period of their trial, haylage fed steers had a slight advantage in the rate of gain. During the remainder of the trial the haylage fed steers maintained their rate of gain, while those fed corn silage tended to decline. When results for the entire experiment were analyzed, they showed that the hayalge fed cattle had gained significantly faster than the corn silage fed cattle. The corn silage fed steers has lower liver vitamin A levels than the haylage fed steers at the conclusion of the trial. However, no response in gain was observed when part of the steers in each lot were injected with 1,000,000 IU of vitamin A near the end of the trial.

Berger and Fahey, Jr. (1981) conducted a trial feeding (1) direct-cut alfalfa ensiled with ground corn, (2) field wilted alfalfa haylage with ground corn added at feeding, (3) chopped baled alfalfa with ground corn added at feeding, and (4) corn silage plus a soybean meal supplement. Steers fed the alfalfa diets gained on the average 0.27 kg. more per day and required 5.12% less fed per kg. of gain then those fed the corn silage diet. The fastest and most efficient gains were made by steers fed the direct-cut alfalaf diet, followed by those fed the haylage and hay diets.

Krause and Britton (1981) evaluated alfalfa as a protein source. Growing cattle that require more bypass protein than is supplied by urea-supplemented corn silage rations gained more and were more efficient when fed high-moisture alfalfa haylage as a protein source than when fed alfalfa hay or low-moisture haylage. When additional bypass protein was not needed, no difference was observed in gain or efficiency of steers fed alfalfa hay or haylage.

Digestibility of Nutrients as Affected by DM Content of the Haylage

Results of studies comparing the digestibility of low-moisture haylage with high-moisture haylage have been inconsistent. Some reports have shown the DM of the low-moisture haylage to be less digestible than that of high-moisture haylage (Gordon et al., 1961; Brown, 1964; Roffler et al., 1967; Jackson and Forbes, 1970; Sutton and Vetter, 1971; El Serafy et al., 1974; Donaldson and Edwards, 1976; Rogers et al., 1979; and Morgan et al., 1980).

The decrease in digestibility of low-moisture haylage may result from excessive spontaneous heating during fermentation (Sutton and Vetter, 1971). This is specially true for nitrogen digestibility and availability. Apparent digestibility of DM, nitrogen, nitrogen free extract and acid detergent fiber is reduced by heating. With similar nitrogen intakes, sheep fed heated haylage will excrete more nitrogen in feces, less nitrogen in urine, and will retain less nitrogen than sheep fed unheated haylage (Yu Yu and Veira, 1977).

Other researchers have observed no differences in DM digestibility between low-moisture haylage and high-moisture haylage (Hammes, et al. 1964; Byers, 1965; Gordon et al., 1965; Campling, 1966; Hawkins, 1969; Forbes and Jackson, 1971; Hinks et al., 1976; Clancy et al., 1977; and McGuffey and Owens, 1979.)

A third group includes those which stated a higher digestibility value for low-moisture haylage compared with high-moisture haylage (Dodsworth, 1955; Roffler et al., 1967; Alder et al., 1969; and Yoelao et al., 1970).

El Serafy et al., (1974) found that steers fed low-moisture haylage consumed significantly more gross energy than those fed either high-moisture haylage or hay. Forage treatment had no significant effect on digestible energy or metabolizable energy intakes or on energy gain. They also found that steers consuming high-moisture haylage had the lowest ruminal pH value. Low-moisture haylage provided an intermediate value and hay value was the highest. Ruminal acetate: propionate ratios were 5.6:1 for steers fed hay, 5.2:1 for steers fed low-moisture haylage, and 4.5:1 for those fed high-moisture haylage.

Sutton and Vetter (1971) reported that cellulose digestibility was lowest for hay-fed lambs, intermediate for lambs fed low-moisture haylage, and highest for lambs fed high-moisture haylage. Nitrogen balance was highest for hay-fed lambs. For lambs fed high-moisture haylage, nitrogen balance was above the value of those fed low-moisture haylage. Rumen ammonia and blood urea nitrogen levels in hay-fed lambs were significantly higher than those in lambs fed fermented forages. No significant difference was found between the two fermented forages.

Hawkins (1969) working with sheep fed alfalfa haylage (from 22 to 80% DM) reported no significant differences in mean fluid retention time in rumen. The fluid was retained the longest in the rumen for the sheep fed 80% DM forage. Also these sheep showed the highest rumen fluid volume. The sheep fed the 80% DM forage may have compensated for the increased DM consumption by increasing fluid volume and by retaining the material in the rumen for a more extended fermentation period. Yoelao et al., (1970) however, reported no significant differences in retantion time when using alfalfa silage (20 and 50% DM)fed to dairy heifers.

Nitrogen retention increased as haylage DM increased (r = +.75) (Hawkins, 1969). This was also demonstrated by Roffler et al., (1967), Forbes and Jackson (1971), and MuGuffey and Owens (1979). However, studies conducted by Hinks et al., (1976) and Robers et al., (1979) did not show higher retention of nitrogen for the higher DM haylages.

Hawkins (1969) showed that the rumen ammonia levels for sheet fed 22% DM haylage were significantly lower at feeding time than for sheep fed 45% and 80% DM haylages but were higher at 6 hr. post-feeding than for sheep fed 45 and 80% DM haylages. At all sampling times, the total volatile fatty acids concentrations of sheep fed 22% DM haylage were lower than for other treatments. Markedly lower concentrations of the branched and longer chain volatile fatty (isobutyrate, isovalerate, 2-methyl-butyrate and valerate) occurred in the higher DM haylage treatments. Roffler et al., (1967) also found higher total volatile fatty acids concentration and butyrate in the lowest DM haylage level of their experiment.

Effect of DM of Haylage on Carcass Parameters

El Serafy *et al.*, (1974) found that carcasses from steers fed high-moisture haylage were fatter than those from steers fed hay or low-moisture haylage. However, Henderson and Newland (1966) reported little or no difference in any of the carcass traits of steers fed either low-moisture haylage or high-moisture haylage. Both haylages produced carcasses of desirable quality (middle choice) and minimum fat cover.

When Henderson and Newland (1966) tested a constant vs. a varying level of concentrate, differences which approached significance ($P<.10$) did exist in carcass grade and marbling and in both cases favored a constant level of grain feeding. The constant level of grain feeding group graded one-third of a grade higher (middle choice vs. low choice) and scored a point higher on marbling (modest vs. modest plus). They also tested the influence of protein addition and demonstrated that the added protein group averaged .23 cm greater external fat cover and dressing percent was increased by .9%. Both of these values proved to be significant. The added protein group also had a slightly higher marbling score but the difference did not prove to be significant. Combining all the carcass traits it appeared that the added protein group possessed a slightly higher degree of finish.

Comparisons between hay, haylage, and corn silage, showed small but non-significant differenced in carcass traits (Newland and Henderson, 1966; and Henderson and Newland, 1967). When constant vs. varying level of added shelled corn were included in these diets, rib eye area and dressing percent were significantly greater for the constant grain feeding system.

Shoemaker et al., (1964) measured carcass traits of steers fed alfalfa haylage and corn vs. a second group consuming corn silage, corn and soybean meal. They also studied the effect of a full-fed corn system vs. a limited corn grain system. Comparison of the full-fed lots showed statistically significant differences in carcass grade favoring haylage fed steers. No other differences were significant, and the two treatments produced carcasses that were very similar. Fat thickness and total fat trim were greater for full-fed lots than for the limited-fed lots. There were no significant differences in any of the measurements between silage fed steers and haylage fed steers. However, in another study (Zimmerman et al., 1965) silage fed steers produced carcasses that were significantly higher in both carcass quality grade and overall carcass grade compared with haylage fed steers.

Use of Additives in the Preparation of Alfalfa Haylage

Although no additives were used in the silage preparation of this research, it was considered important to briefly review this topic due to its importance in the preparation and utilization of alfalfa haylage.

Several researchers reported that organic acids (such as propionic and formic) or formaldehyde, inhibited fermentation when added to silage. The resulting material had higher levels of water-soluble carbohydrates, lower concentrations of volatile nitrogen and lower organic acid contents than untreated silages (Waldo et al., 1971; Binnie and Barry, 1976; Donaldson and Edwards, 1976; Hinks et al., 1976; Lancaster et al., 1977; Lancaster and Brunswick, 1977; Barry et al., 1978; Lu et al., 1979; Rogers et al., 1979; and Stallings et al., 1979).

Better responses in DM intake and liveweight gain by beef steers, dairy heifers or sheep were reported when using treated silages compared with untreated silages (Waldo et al., 1971; Binnie and Barry, 1976; Donaldson and Edwards, 1976; Clancy et al., 1977; Lancaster et al., 1977; Lancaster and Brunswick, 1977; Barry et al., 1978a; and Stallings et al., 1979).

However, Hinks et al., (1976) reported no advantage in DM intake and liveweight gain in beef steers by the addition of formic acid to the forage. Lu et al., (1979) found no difference in milk production and daily intake of DM in dairy cows fed pressed alfalfa forage treated with formic acid, compared with low moisture alfalfa haylage.

Reports of values for digestibility of nutrients and nitrogen balance were inconclusive. Some experiments showed superior digestibilities and imporved nitrogen balance for the acid treated silages compared with the untreated silages (Waldo et al., 1971; Wing et al., 1976; Lancaster et al., 1977; Barry et al., 1978a; and Stallings et al., 1979). Nevertheless, Hinks et al., (1976) showed no significant differences in digestibility, nitrogen retention or metabolizable energy concentration when adding formic adic. Negative results in digestibility of protein were reported by Barry et al., (1978a) and in nitrogen balance by Clancy et al., (1977).

Other additives have been used in the treatment of alfalfa haylage such as whey or lactose (Dash et al., 1974a; and Dash et al., 1974b) and ammonium isobutyrate (Yu Yu and Thomas, 1975). In their two studies, Dash et al. (1974a-1974b) reported superior fermentation conditions, intakes and digestibility coefficients for the treated silages compared with the untreated silages. Ammonium isobutyrate treatment produced no significant differences in DM intake. DM digestibility was slightly improved and retention of absorbed nitrogen was significantly improved (Yu Yu and Thomas, 1975).

Waldo et al., (1973) compared dairy heifer response from unwilted formic and wilted untreated haylage instead of using the unwilted and untreated type as the control. They reported slightly higher daily gains, intakes and energy digestibilities for the wilted haylage compared with the formic acid treated haylage.

Barry et al., (1978b) demonstrated that alfalfa haylages treated with formic acid and formaldehyde showed lower losses in amino acids and minimum increases in alanine and alpha and gamma amino-butyric acids.

Dry Matter Losses and Type of Silo

In 1955, Dodsworth reported no significant differences in amount of losses between concrete tower silos and surface silos (almost 40% of the ensiled DM was lost in both types). The DM remaining in the silage still had a starch value between 60 and 70.

Thomas et al., (1969) compared seepage of direct-cut and wilted haylage. All direct-cut silages had considerable seepage from the silo. Wilted haylage had practically no seepage. Seepage from the late-cut haylage was less than that for early-cut haylage. Addition of formic acid to direct-cut silage did not noticeably influence silo losses. Brown (1964) reported lower losses from trench silos compared to clamp silos. Wilting the forage decreased the losses specially in trench silos.

Other authors also found a negative correlation between DM and level of losses (Murdoch, 1960; Gordon et al., 1961; El Serafy et al., 1974; and McGuffey and Owens, 1979).

However considering DM losses during harvesting rather than during storage, El Serafy et al., (1971) reported that DM losses for alfalfa-brome hay (87.1% DM), haylage (48.2%), and silage (40.3%), were determined to be

25.4%, 14.6%, and 12.4%, respectively. Losses of other nutrients were of similar magnitude.

Nevens and Kuhlman (1936) described the importance of chopping in order to obtain a good quality silage. The whole (unchopped) alfalfa, did not keep quite as well as the chopped alfalfa. This was attributed to the difficulty experienced in packing the whole alfalfa close to the corrugated sides of the silo.

Marsh (1978) cited that chopping and/or lacerating herbage before ensiling has been found to reduce total DM losses from the silo by 7-15% of the DM ensiled compared with long cut (mown and buck-racked) material.

Addition of formic acid to unwilted alfalfa silage tended to improve DM and energy recovery compared to untreated silage (Waldo et al., 1971). When comparing recoveries of wilted haylages with unwilted but formic acid treated silages, Waldo et al., (1973) found higher values for the wilted haylages (35% DM). Increasing the degree of wilting up to 47% DM resulted in lower recoveries for the wilted silages compared with the formic acid unwilted silages.

Gordon et al., (1967) compared gas-tight and bunker silos for the storage of low-moisture orchardgrass. In a first experiment they had undesirable weather conditions and an extended harvesting period (8 days). The DM recovery from the bunker was as low as 72%. In a second experiment with desirable weather and a 4 day harvesting period, DM recoveries were 91 and 93% for the bunker and gas-tight silo, respectively.

In 1972, Thomas et al., reported that the amount of unavailable nitrogen in samples of 34 haylages from Michigan was similar for air-tight, cement staves, sealed concrete and bunker silos.

Goodrich et al., (1966) found little, if any, difference in the nutritional value of alfalfa-brome haylage stored in air-tight or concrete stave silos. Spoilage and fermentation losses were greatest in the concrete stave silo. Haylage DM losses of 1 to 3% can be expected in air-tight silos while such losses in concrete stave silos may be from 5 to 8%. When properly sealed at time of ensiling, haylage from an open top silo had a similar feeding value to that from air-tight storage (Perry and Beeson, 1966).

Embry et al., (1967) reconstituted haylage from hay by adding water to the hay decreasing its DM content to 54%. Dry matter storage losses of the reconstituted haylage stored in air-tight silo and concrete stave silo were 4.6% and 6.7%, respectively.

Summary

In summary, some important aspects need to be pointed out:

A. The combination of the correct moisture conditions and pH in the silo will discourage the action of saccharolytic and proteolytic clostridial bacteria, avoiding the formation of undesirable products such as ammonia and butyric acid.

B. Wilting the forage reduces clostridial activity, especially over 28% DM level.

C. Fine chopping and compaction should also be provided in order to obtain a good quality haylage.

D. Silage organic acids level and ammonia nitrogen are negatively correlated with the DM content of the silage.

E. Heated haylages may have a lower feeding value due to their higher acid detergent insoluble nitrogen (unavailable nitrogen) compared with nonheated haylages.

F. Daily dry matter intake tends to have a possitive correlation with DM content of the silage and negative correlation with the level of ammonia nitrogen.

G. Data relating DM level and digestibility of nutrients are inconsistent.

H. There appears to be no difference in feed-lot performance and carcass traits between cattle fed corn silage and cattle fed alfalfa haylage.

I. Treating alfalfa haylage with organic acids will improve haylage quality and animal performance.

J. There is a consistent trend to have less DM loss with higher DM silages. Type of silo is not likely to be an important factor for DM recovery.

MATERIALS AND METHODS

Forage Preparation

Alfalfa-orchardgrass (80% alfalfa, 20% orchardgrass) was harvested during the third week of June (6-13-80 to 6-18-80) at the early-bloom stage.

The forage was mowed, crimped and windrowed in one operation using a New Holland mower-conditioner model 49. Alternative windrows were selected for high and low-moisture haylage. Forage used for high-moisture haylage was allowed to wilt in the windrow until it reached approximately 30% DM. The same procedure was followed for the low-moisture haylage but the wilting period was lengthened to provide approximately 60% DM material. The forage was harvested using a New Holland (model 392) forage harvester and the material was chopped into approximately .65 to .97 cm pieces. Both herbages were ensiled in concrete stave silos (15.24 m x 3.66 m).

After five months of storage, crude protein values were 20.2% and 16.9% for the high-moisture and low-moisture haylage, respectively. This difference is probably due to a higher leaf loss during the chopping and filling process for the drier material. Average DM levels were 29.2% and 62.1% for the high and low-moisture haylage, respectively.

Feeding Trial

One hundred and twelve Aberdeen Angus steers were used. Within 12 hours of arrival at M.S.U. Beef Cattle Research Center, all steers were tattooed, ear-tagged and vaccinated for Pasteurella, IBR, BVD, and PI3. All cattle were injected with two million I.U. of vitamin A. Animals were adapted to a haylage-corn silage and high-moisture corn ration over a three week period. The steers averaged 364.1 Kg. at the beginning of the trial, and at which time they were implanted with Ralgro.

The cattle were randomly alloted to the treatment combinations shown in Table 1 on December 2, 1980. Steers were grouped in pens of eight animals per pen and two pens per treatment. The rations were calculated to be isocaloric (NEg in Mcal/Kg of DM). All rations were formulated to 11.5% CP by urea addition in the respective supplements. The average dry matter and crude protein for the ration ingredients are shown in Table 2. The composition of the respective supplements are found in Table 3.

Management Procedures

Ration ingredients were mixed prior to feeding in a horizontal batch mixer. Complete rations were fed once daily. Feed sheets were updated daily with the intake for each pen. Increases or reductions of feed were made as the animals cleaned up or left feed in the feed-bunks. Sufficient feed was furnished so that bunks were nearly clean

Table 1.--Feedlot Trial Experimental Design[a]

Trt.	Concentrate Source	Roughage Source					Calculated	
No.	%HMC[b]	%UCS[c]	%TCS11[d]	%TCS13[e]	%HMH[f]	%LMH[g]	NEg[h]	%CP
1	70	30	-	-	-	-	1.33	11.5
2	70	-	30	-	-	-	1.33	11.5
3	70	-	-	30	-	-	1.33	11.5
4	85	-	-	-	15	-	1.32	11.5
5	85	-	-	-	-	15	1.32	11.5
6	80	10	-	-	10	-	1.33	11.5
7	80	10	-	-	-	10	1.33	11.5

[a] Rations were formulated on a dry matter basis. Supplements replaced some of the high moisture corn in the respective diets.
[b] High moisture corn.
[c] Untreated corn silage.
[d] Corn silage treated with urea at ensiling to approximately 11% crude protein (CP).
[e] Corn silage treated with urea at ensiling to approximately 13% CP.
[f] High-moisture haylage (approximately 30% DM).
[g] Low-moisture haylage (approximately 60% DM).
[h] In Mcal/Kg of DM. Assumed values from N.R.C., 1976.

Table 2.--Dry Matter and Crude Protein Analyses for the Feedlot Trial

Ingredient	% Dry Matter	%Crude Protein
High Moisture Corn	71.4	9.90
Untreated corn silage	31.2	8.24
Corn silage treated to 11% CP	36.8	11.20
Corn silage treated to 13% CP	37.2	14.44
High-moisture haylage	28.8	19.51
Low-moisture haylage	62.0	16.80
Supplement No. 1081	91.0	35.33
Supplement No. 1181	90.8	26.50
Supplement No. 1281	90.3	7.93
Supplement No. 1381	89.3	8.40
Supplement No. 1481	90.0	14.73
Supplement No. 1581	89.9	18.90

Table 3.--Composition of the Supplements[1]

Supplement No.	1081	1181	1281	1381	1481	1581
Treatment No.	1	2	3	4	5	6
Ground Shelled Corn	713.0	762.0	828.0	865.0	832.0	814.0
Limestone	134.0	133.0	131.0	94.0	103.0	105.0
Urea (45% N)	93.0	54.0	--	--	38.0	38.0
Trace Mineral Salt	38.0	38.0	38.0	38.0	21.0	33.0
Calcium Sulfate	19.0	11.0	--	--	4.0	7.0
Vitamin A Premix	1.5	1.5	1.5	1.5	1.0	1.5
Vitamin D Premix	1.5	1.5	1.5	1.5	1.0	1.5
Total	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

[1] In kilograms.

before each feeding. Dry matter and crude protein analyses of the ingredients of the rations were made every fifteen days.

The duration of the feeding trial was 106 days divided in three periods of 28 days followed by one of 22 days. Cattle were individually weighed at the beginning of the trial and at the end of each period. Initial and final weights were taken after 16 hours without feed and water. Intermediate weights were taken after a 16-hour withdrawal from water only.

All cattle were group-fed and housed in partially covered concrete lots (4.27 m x 11.89 m) which were bedded with straw. Approximately one-half of the floor space of each pen was covered by a roof. Cattle in each pen had access to an automatic waterer.

Carcass Evaluation Procedure

At the termination of the feeding trial, on March 17, 1981, two animals per pen were randomly selected for carcass evaluation. These 28 animals were trucked to ADA Beef Co. at Ada, Michigan, 112 km. from M.S.U. Beef Cattle Research Center.

These cattle had an average final shrunk weight of 520.8 Kg. Hot carcass weights were obtained. After the carcasses had been chilled for a minimum of 24 hours, the other carcass parameters were determined by a U.S.D.A. grader. The 9-10-11 rib cut from the left side of each carcass (Hankins and Howe, 1946) was saved in order to estimate carcass composition. Rib eye area and fat thickness were measured at the 12th rib, and kidney, heart, and pelvic fat (KPH) was also determined.

At the M.S.U. Meat Laboratory, the soft tissue portion of the 9-10-11 rib cut was ground first coarsely and then three more times through a .47 cm screen, thoroughly mixed, and a subsample (500 g) frozen (-20C) for further analyses on fat, protein (N x 6.25), and moisture. Before these analyses, meat subsamples were left in a cooler (4C) for thawing, and then, moisture content was determined by drying 2 to 3 g in a 60C oven for 48 hours. Total nitrogen was determined on a wet portion of subsample weighing 1.00 to 1.10 g by the Technicon Block Digestion Auto-Kjeldahl System using HgO as a digestion catalyst. Ether extractable fat was determined on the oven dried sample by the Goldfisch procedure.

The following equations derived by Hankins and Howe (1946) were used to estimate carcass composition from the rib cut composition:

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

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

In order to calculate daily protein gain and daily fat gain, initial carcass data are required. Data from eight steers of similar breed, type, size, and weight (Lomas, 1979) were averaged for shrunk weight, hot carcass weight, percent protein, and percent fat. These values were considered representative of the steers in this study at the beginning of the feeding trail.

Nitrogen Balance Trial

Trial Design

A metabolism study was designed to evaluate the effect of dry matter level of alfalfa haylage on the nitrogen status of four crossbred steers (average weight 415 kg). Two steers were initially assigned to the low-moisture haylage diet and the other two received the high-moisture haylage diet. The diets were switched after the first experimental period. Each experimental period had an adaption period of 14 days followed by a 7 day period of feed, feces and urine collection.

During the adaptation period steers were placed in individual pens (182 x 224 cm) inside the M.S.U. Beet Cattle Research Center Metabolism Room. At this time, they were *ad libitum* fed the assigned haylage along with 45g of trace mineral salt. Protein, calcium, and phosphorus requirements (N.R.C., 1976) were met by this ration. Vitamin requirements were met by a 2 ml injection of vitamin A, D, and E complex at the start of the trial. Weighbacks were recorded in order to have a clear idea of their intake. Free access to water was provided.

During the collection period, the same diet was fed at 90% *ad libitum* intake level. Steers were fed twice daily at approximately 12-hour intervals.

Sample Collection and Preparation

During the collection period, the animals were confined to individual stalls (91 x 244 cm) and were elevated approximately 30 cm above the floor on wooden platforms (85 x 180 cm). Wooden boxes (90 x 84 x 58 cm) were placed behind the platforms in order to collect the fecal output. The boxes were tall enough to avoid fecal losses. Platforms were designed to make fecal collection possible without animal interference and a coarse mesh area in the center of the platform facilitated the collection of urine in a pan placed underneath.

Total fecal output was weighed daily and a 5% subsample was secured after thoroughly mixing the feces. Subsamples were kept in a cooler (4C) during the collection period and composited for each steer at the end of each collection period. At this time subsamples were correctly mixed and a 10% of the composite was frozen for later analyses.

Urine was collected daily in plastic bottles that had a capacity of approximately 30 liters. The bottles were connected to the pans by a hose. Prior to placing these bottles in the collection place, 250 ml of 50% sulfuric acid were poured into the bottles in order to avoid nitrogen losses from the collected urine. Collection pans were covered with wire screening to prevent contamination of the urine with foreign material. After measuring and recording urine volume, a 5% subsample was saved and cooled until the end of the collection period when composites were prepared from the subsamples and a 5% aliquot of those composites was frozen for later analyses.

Feed subsamples were taken daily during the collection period and at the end of this period, subsamples were thoroughly mixed and 1 kg of composite was frozen for later analyses.

Nitrogen and Dry Matter Determination

Total nitrogen content of feed, feces, and urine samples were determined on the wet samples by the Technicon Block Digestion Auto-Kjeldahl System.

Feed and feces DM was determined by drying in a 60C oven for 48 hours.

Nitrogen balance was expressed as total nitrogen intake - (fecal N + urinary N).

Digestible Energy Study

An energy study was conducted in order to evaluate the levels of digestible energy as affected by DM content of the haylage. Dried samples of feed and feces were ground through a Thomas mill (1 mm screen). After this, pellets of both feed and feces were prepared and burned in a Parr Adiabatic Calorimeter. Digestible energy of both haylages was expressed as 100 x (Mcal from feed - Mcal. from feces divided by Mcal. from feed).

Acid Detergent Fiber Evaluation

Dried and milled feed samples were also used for acid detergent fiber analyses (Van Soest, 1963). Acid detergent fiber fraction was expressed as a percentage of the DM of the sample.

Statistical Analysis

Analysis of variance (Snedecor and Cochran, 1967) was used to examine main effects and interactions for feedlot and carcass traits as well as nitrogen and digestibility studies. When appropriate, specific contrasts (Snedecor and Cochran, 1967) were designed for comparing selected treatment combinations of primary interest. If $P<.20$, the level of statistical significance was reported.

RESULTS AND DISCUSSION

Overall Feedlot Performance

A summary of the performance obtained from each diet is reported in Table 4. Since all diets consisted of 70% or more of the dry matter from high moisture corn, the primary area of interest was the roughage source in each diet. Four specific contrasts were constructed for the treatment combinations of primary interest to determine whether differences in animal performance were statistically significant. The comparison of diet roughage source were: 1. Untreated corn silage vs. urea treated corn silage, 2. Corn silage vs. corn silage and alfalfa haylage, 3. 30% DM alfalfa haylage vs. 60% DM alfalfa haylage, and 4. 10% alfalfa haylage vs. 15% alfalfa haylage in the ration.

Carcass Parameters

Carcass data obtained from each treatment are listed in Tables 5 and 6. The same contrasts as for the feeding trial, were tested and reported for carcass traits.

Table 4.--Effect of Treatments on Feedlot Performance[a]

Item	30%UCS 70%HMC	30%TCS11 70%HMC	30%TCS13 70%HMC	15%HMH 85%HMC	15%LMH 85%HMC	10%UCS+ 10%HMH+ 80%HMC	10%UCS+ 10%LMH 80%HMC	Overall Mean	S.E.
Treatment No.	1	2	3	4	5	6	7		
Initial Wt, Kg[b]	365	362	360	367	366	364	365	364	
Final Wt, Kg[b]	507	516	511	515	521	513	522	515	
Average Daily Gain, Kg	1.34	1.45	1.42	1.40	1.46	1.41	1.48	1.42	.14
Average Daily DM Intake, Kg	10.16	9.69	9.61	10.30	10.33	10.01	10.17	10.03	.18
Feed/Gain	7.58	6.67	6.75	7.38	7.06	7.12	6.87	7.06	.14

[a] There were two pens per treatment and eight steers per pen fed for 106 days.

[b] Initial and final weights were taken after 16 hours without feed and water.

Table 5.--Effect of Treatments on Carcass Traits[a]

Item	30%UCS 70%HMC	30%TCS11 70%HMC	30%TCS13 70%HMC	15%HMH 85%HMC	15%LMH 85%HMC	10%UCS +10%HMH 80%HMC	10%UCS +10%LMH 80%HMC	Overall Mean	S.E.
Treatment No.	1	2	3	4	5	6	7		
Hot Carcass Weight, Kg	319	312	313	334	320	324	330	332	15.08
Fat Thickness, cm	1.60	1.49	1.62	1.81	1.58	1.59	1.59	1.61	.20
Rib Eye Area, cm^2	76.62	80.81	85.33	83.07	79.52	79.84	82.91	81.16	3.06
KPH Fat, %	3.5	3.7	3.6	3.4	3.5	3.6	3.7	3.6	.25
Yield Grade	3.6	3.3	3.2	3.6	3.6	3.5	3.4	3.5	.27
Quality Grade[b]	10.5	10.5	9.7	11.5	12.2	10.0	10.2	10.7	.62
Marbling Score[c]	12.0	12.7	10.7	15.0	13.7	11.0	11.5	12.4	1.85

[a] There were two pens per treatment. A subsample of two steers (out of 8) per pen were taken for this study.

[b] Quality Grade: Good - = 8; Good + = 9; Choice - = 10; Choice 0 = 11; Choice + = 12; Prime - = 13; Prime 0 = 14; Prime + = 15.

[c] Marbling Score: slight - = 7; slight + = 9; small - = 10; small + = 12; modest - = 13; modest + = 15; moderate - = 16; moderate + = 18; slightly abundant - = 19; slightly abundant + = 21.

Table 6.--Effect of Treatments on Carcass Composition

Item	30%UCS 70%HMC	30%TCS11 70%HMC	30%TCS13 70%HMC	15%HMH 85%HMC	15%LMH 85%HMC	10%UCS +10%HMH 80%HMC	10%UCS +10%LMH 80%HMC	Overall Mean	S.E.
Carcass Protein, %	14.30	14.48	14.96	14.67	14.73	14.96	15.07	14.74	.22
Carcass Fat, %	31.85	34.17	29.80	34.72	33.29	32.30	32.76	32.70	1.23
Daily Protein Gain, Kg	.082	.077	.091	.112	.091	.108	.120	.097	.017
Daily Fat Gain, Kg	.510	.558	.439	.650	.557	.544	.573	.549	.080

Comparison No. 1: High Moisture Corn Plus Untreated Corn Silage Ration vs. High Moisture Corn Plus Urea-Treated Corn Silage Rations

Feedlot Performance

Feedlot performance of steers fed high moisture corn plus untreated corn silage vs. those fed high moisture corn plus urea-treated corn silage can be found in Table 7. Corn silage was treated with urea up to 11 and 13% CP. These two treatments were pooled and compared against treatment 1. Cattle fed urea treated corn silage gained 7.5% faster than those fed untreated corn silage as the roughage source but this difference did not prove to be significant ($P<.20$). This is in accordance with the experiment conducted by Combs et al. (1978) who found a 9.4% faster gain in growing steer calves (275 Kg. initial weight) fed either urea-treated corn silage plus corn grain, or corn silage plus corn grain treated with urea at feeding time. The difference was also non-significant for this study. Average daily dry matter intake was 5.3% higher for the untreated silage supplemented with urea at time of feeding, and this difference approached significance ($P<.10$). Kilograms of feed per each kilogram of gain was 16.4% lower ($P<.005$) for the urea-treated silage group. Combs et al. (1978) also found a lower feed per gain ratio for the urea-treated silage fed cattle.

Carcass Parameters:

Results of the carcass parameters of steers fed untreated corn silage compared with steers fed urea-treated corn

Table 7.--Feedlot Performance of Steers Fed High Moisture Corn Plus Untreated Corn Silage vs. Steers Fed High Moisture Corn Plus Urea-Treated Corn Silage

Item	30% UCS 70% HMC	30% TCS 70% HMC	Significance
Treatment No.	1	2,3	
Number of Steers	16	32	
Initial Weight, Kg	365	361	
Final Weight, Kg	507	513	
Average Daily Gain, Kg	1.34	1.44	NS
Average Daily DM Intake, Kg	10.16	9.65	<.10
Feed/Gain	7.58	6.51	<.005

silage as the roughage source are reported on Table 8. There were no significant differences between groups. Rib eye area was 8.4% larger for the urea-treated corn silage group and carcass protein was 2.9% higher for this group too. These differences approached significance (P<.15).

Comparison No. 2: High Moisture Corn Plus Corn Silage Rations vs. High Moisture Corn Plus Corn Silage and/or Alfalfa Haylage

Feedlot Performance

Table 9 shows the performance of steers fed high-moisture corn + corn silage vs. high moisture corn + corn silage and/or alfalfa haylage. Non-significant differences in average daily gain and feed efficiency were found between both groups. Average daily dry matter intake was 3.9% higher for the alfalfa haylage groups (P<.10). Similar results with finishing steers were reported in earlier studies by Goodrich et al. (1967) when alfalfa haylage and corn silage diets were supplemented to equalize protein, calcium, salt and vitamin A. Corn grain was present in both diets. This is also supported by studies done by Windels et al. (1966), Perry and Beeson (1966), and Haarer et al. (1963). However, other studies reported the superiority of corn silage over alfalfa haylage (Tolman and Guyer, 1974; and Chase et al. 1971) or vice-versa (Zimmerman et al. 1965). Henderson and Newland (1967) reported that Hereford finishing steers fed corn silage with 1% of body weight in shelled corn significantly (P<.01)

Table 8.--Carcass Parameters of Steers Fed High Moisture Corn Plus Untreated Corn Silage vs. Steers Fed High Moisture Corn Plus Urea-Treated Corn Silage

Item	30% UCS 70% HMC	30% TCS 70% HMC	Significance
Treatment No.	1	2,3	
Number of Steers	16	32	
Hot Carcass Weight, Kg	319.0	312.5	NS
Fat Thickness, cm	1.600	1.555	NS
Rib Eye Area, cm^2	76.62	83.07	<.15
KPH Fat, %	3.50	3.65	NS
Yield Grade	3.60	3.25	NS
Quality Grade	10.5	10.1	NS
Marbling Score	12.0	11.7	NS
Carcass Protein %	14.30	14.72	<.15
Carcass Fat %	31.850	31.985	NS
Daily Protein Gain, Kg	.082	.084	NS
Daily Fat Gain, Kg	.510	.498	NS

Table 9.--Feedlot Performance of Steers Fed High Moisture Corn + Corn Silage vs. Steers Fed High Moisture Corn + Corn Silage and/or Alfalfa Haylage

Item	Grain + Corn Silage	Grain + Corn Silage and/or Haylage	Significance
Treatment No.	1,2,3	4,5,6,7	
Number of Animals	48	64	
Initial Weight, Kg	362.3	365.5	
Final Weight, Kg	511.3	517.7	
Average Daily Gain, Kg	1.40	1.44	NS
Av. Daily DM Intake, Kg	9.82	10.20	<.10
Feed/Gain	7.00	7.11	NS

outgained 35% DM and 55% DM haylage groups although these groups received 1.5% of body weight daily in shelled corn. These results with yearling steers are not consistent with the results of a previous experiment (Henderson and Newland, 1965) where steer calves full fed haylage and 1.5% of body weight daily in shelled corn gained equal to steer calves receiving a full feed of corn silage and 1% of body weight daily in shelled corn. In 1967 cattle fed corn silage had a 68% higher NEg intake while in 1965 the corn silage fed group had a 63% higher NEg intake.

Carcass Parameters:

The carcass characteristics of steers fed high moisture corn + corn silage vs. steers fed high moisture corn + corn silage and/or alfalfa haylage are shown in Table 10. There were no significant differences in carcass traits. Alfalfa haylage showed slightly higher quality grades ($P<.20$). This is in agreement with experiments conducted by Henderson and Newland (1967) and Windels et al. (1966). Shoemaker et al. (1964) also reported no differences in carcass traits from steer calves finished on alfalfa haylage or corn silage. In that study, the only important difference was found in quality grade ($P<.05$) favoring the haylage group. The same was true for this study but the difference was not high ($P<.20$). Steers consuming alfalfa haylage showed higher percent protein in the carcass ($P<.20$) and higher daily protein gains ($P<.14$).

Table 10.--Carcass Parameters of Steers Fed High Moisture Corn + Corn Silage vs. Steers Fed High Moisture Corn + Corn Silage and/or Alfalfa Haylage

Item	Grain + Corn Silage	Grain + Corn Silage and/or Haylage	Significance
Treatment Number	1,2,3	4,5,6,7	
Number of Steers	48	64	
Hot Carcass Wt, Kg	314.6	327.0	NS
Fat Thickness, cm	1.57	1.64	NS
Rib Eye Area, cm^2	80.92	81.33	NS
KPH Fat, %	3.60	3.55	NS
Yield Grade	3.37	3.52	NS
Quality Grade	10.23	12.80	<.20
Marbling Score	11.80	12.80	NS
Carcass Protein, %	14.58	14.86	<.20
Carcass Fat, %	31.94	33.27	NS
Daily Protein Gain, Kg	.083	.108	<.14
Daily Fat Gain, Kg	.502	.581	NS

Comparison No. 3: High Moisture Corn Plus 30% DM Alfalfa Haylage vs. High Moisture Corn Plus 60% DM Alfalfa Haylage

Feedlot Performance

Feedlot performance of steers fed high moisture corn and 30% DM or 60% DM alfalfa haylage are presented in Table 11. Average daily gain and average daily dry matter intake did not differ when 30% DM haylage was compared with 60% DM haylage. Feed efficiency was 4.2% higher ($P<.10$) for the 60% DM haylage ration. Several researchers have shown higher intakes and gains for low-moisture haylage compared with high-moisture haylage when haylage was the major component of the ration (Jackson and Forbes, 1970; Forbes and Jackson, 1971; Hinks *et al.*, 1976; and McGuffey and Owens, 1979). In the present trial, haylage was fed at 10% or 15% of the total ration, and the other feed stuffs could decrease the effect of the DM level of the haylage on feed intake and average daily gain. In two experiments where differing dry matter levels of alfalfa haylage were fed with corn grain, Henderson and Newland (1966 and 1967) reported no difference in daily gain, feed intake, and feed efficiency between high-moisture haylage (30% DM) and low-moisture haylage (60% DM).

Carcass Parameters

Table 12 shows the effect of 30% DM haylage and 60% DM haylage on carcass parameters. There was no significant effect of dry matter level on any carcass trait. The

Table 11.--Feedlot Performance of Steers Fed High Moisture Corn Plus 30% DM Alfalfa Haylage vs. Steers Fed High Moisture Corn Plus 60% DM Alfalfa Haylage

Item	High Moisture Corn Plus 30% DM Haylage	High Moisture Corn Plus 60% DM Haylage	Significance
Treatment Number	4,6	5,7	
Number of Steers	32	32	
Initial Weight, Kg	365.5	365.5	
Final Weight, Kg	514.0	521.5	
Average Daily Gain, Kg	1.41	1.47	NS
Average Daily DM Intake, KG	10.15	10.25	NS
Feed/Gain	7.25	6.96	<.10

Table 12.--Carcass Parameters of Steers Fed High Moisture Corn Plus 30% DM Alfalfa Haylage vs. Steers Fed High Moisture Corn Plus 60% DM Alfalfa Haylage

Item	High Moisture Corn Plus 30% DM Haylage	High Moisture Corn Plus 60% DM Haylage	Significance
Treatment Number	4,6	5,7	
Number of Steers	32	32	
Hot Carcass Weight, Kg	329	325	NS
Fat Thickness, cm	1.70	1.58	NS
Rib Eye Area, cm^2	81.45	81.21	NS
KPH Fat, %	3.50	3.60	NS
Yield Grade	3.55	3.50	NS
Quality Grade	10.75	11.20	NS
Marbling Score	13.00	12.60	NS
Carcass Protein, %	14.81	14.90	NS
Carcass Fat, %	33.51	33.02	NS
Daily Protein Gain, Kg	.110	.105	NS
Daily Fat Gain, Kg	.597	.566	NS

same results were obtained by Henderson and Newland (1965) and Henderson and Newland (1966).

Comparison No. 4: High Moisture Corn Plus 10% Corn Silage Plus 10% Alfalfa Haylage vs. High Moisture Corn Plus 15% Alfalfa Haylage

Feedlot Performance:

Feedlot performance of steers fed high moisture corn plus 10% corn silage plus 10% alfalfa haylage vs. those fed high moisture corn plus 15% alfalfa haylage rations are shown in Table 13. Increasing the haylage level in the ration from 10 to 15% produced no significant changes ($P>.20$) in average daily gain, average gaily dry matter intake, and feed gain.

Carcass Parameters

Table 14 shows no significant differences in any of the carcass characteristics from steers fed 10% haylage or 15% haylage. Steers fed 15% haylage in the diet presented 17.3% higher quality grade ($P<.10$), 27.5% higher marbling score ($P<.20$) and 2.1% less carcass protein ($P<.20$).

Nitrogen Balance Trial

The nitrogen balance trial was conducted in April, May, and June 1981 after the feedlot trial had been completed. At this time, the haylage being fed was that in the lowest 2 m of each silo. The dry matter content of the low-moisture haylage decreased dramatically during the nitrogen balance study from 62.3% on April 1, 1981 to 36.9% on June 1, 1981.

Table 13.--Feedlot Performance of Steers Fed High Moisture Corn Plus 10% Corn Silage + 10% Alfalfa Haylage vs. Steers Fed High Moisture Corn Plus 15% Alfalfa Haylage in the Ration

Item	High Moisture Corn +10% Haylage +10% Corn Silage	High Moisture Corn +15% Haylage	Significance
Treatment Number	4,5	6,7	
Number of Steers	32	32	
Initial Weight, Kg	364.5	366.5	
Final Weight, Kg	517.5	518.0	
Average Daily Gain, Kg	1.45	1.43	NS
Average Daily DM Intake, Kg	10.09	10.31	NS
Feed/Gain	6.99	7.22	NS

Table 14.--Carcass Parameters of Steers Fed High Moisture Corn Plus 10% Corn Silage Plus 10% Alfalfa Haylage vs. Steers Fed High Moisture Corn Plus 15% Alfalfa Haylage in the Ration

Item	High Moisture Corn +10% Haylage +10% Corn Silage	High Moisture Corn +15% Haylage	Significance
Treatment Number	4,5	6,7	
Number of Steers	32	32	
Hot Carcass Weight, Kg	327	327	NS
Fat Thickness, cm	1.59	1.69	NS
Rib Eye Area, cm^2	81.37	81.29	NS
KPH Fat %	3.65	3.55	NS
Yield Grade	3.45	3.60	NS
Quality Grade	10.10	11.85	<.10
Marbling Score	11.25	14.35	<.20
Carcass Protein, %	15.01	14.70	<.20
Carcass Fat, %	32.53	34.00	NS
Daily Protein Gain, Kg	.114	.102	NS
Daily Fat Gain, Kg	.558	.604	NS

This could be partially explained by the fact that the first material ensiled was the last to be fed out. The weather conditions during the first day of harvest for the low-moisture haylage were not ideal for wilting. A second possibility would be the accumulation of sepage from higher levels in the silo.

Nitrogen balance data are presented in Table 15 for cattle fed both levels of haylage dry matter. Although it is reasonable to expect no differences in nitrogen retention between the 34.3% DM haylage and the 37.0% DM haylage, nitrogen retained was three times higher for the 34.3% DM haylage ($P<.10$). One of the reasons for this difference was the higher nitrogen intake of the animals fed the 34.3% DM haylage. Nitrogen retained was a function of nitrogen intake. In addition 37% DM haylage came from a 60% DM original material which may have produced excessive heating inside the silo apparently resulting in a haylage of low nitrogen availability. This silage had a brownish color and carmelization must have occurred to some extent.

Sutton and Vetter (1971) working with lambs reported lower nitrogen balance with low-moisture haylage (60% DM) than with high-moisture haylage (28% DM). Lambs fed the low-moisture haylage retained 0.4 g/day and those fed the high-moisture haylage retained 1.6g/day. However, Hawkins (1969) also working with sheep and four DM levels (22, 40, 45 and 80% DM) reported that nitrogen balance increased as silage DM increased ($r = .75$).

Table 15.--Effect of Alfalfa Haylage Harvested at Different Dry Matter Levels on Nitrogen Utilization

Item	Expected Dry Matter Level at Harvest / Observed Dry Matter Level of Feeding	30% DM / 34.3% DM	60% DM / 37.0% DM	S.E.	Significance
Nitrogen Intake (g/day)		205.6	138.5	4.86	<.01
Fecal Nitrogen (g/day)		72.6	52.0	1.18	<.05
Absorbed Nitrogen (g/day)		133.0	86.5	1.12	<.001
Urinary Nitrogen (g/day)		96.4	74.3	9.05	<.20
Excreted Nitrogen (g/day)		169.0	126.3	9.67	<.05
Retained Nitrogen (g/day)		36.6	12.2	7.77	<.10
Fecal N as % of N Intake		35.3	37.5	.59	<.10
Urinary N as % of N Intake		46.9	53.6	5.64	NS
Retained N as % of N Intake		17.8	8.8	6.68	NS
Retained N as % of N Absorbed		27.5	14.1	8.08	<.20
Apparent N Digestibility, %		64.7	62.4	.59	<.10

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In the later study, experimental silos were used and the drying process of the forage was closely observed. All silages were of excellent quality. When it is not possible to achieve good oxygen exclusion, excessive heating is likely to occur degrading protein and nitrogen compounds to less efficent undigestible forms due to aerobic fermentation.

Retained nitrogen as a percentage of nitrogen absorbed was 95% (P<.20) higher for the 34.3% DM haylage. This indicates that in the 37% DM haylage, the nitrogen absorbed from the small intestine and rumen had a lower quality (biological value) compared with the 34.3% DM haylage. The lower nitrogen value of the 37% DM haylage showed a lower utilization (retention) of nitrogen by the steers fed that silage.

Apparent nitrogen digestibility was 3.7% higher for the 34.3% DM haylage. This difference approached significance (P<.10). A reason for this difference could be the lower quality of the 37% DM haylage. Sutton and Vetter (1971) reported values of 72.8% and 63.0% in nitrogen digestibility for 28% and 60% DM haylages, respectively.

Acid Detergent Fiber and Digestibility of Dry Matter and Energy

Results on the effect of alfalfa haylage DM level on acid detergent fiber (ADF), DM digestibility, and energy digestibility are reported in Table 16.

Table 16.--Effect of Alfalfa Haylage Harvested at Different Dry Matter Levels on Acid Detergent Fiber Fraction and Digestibility of Dry Matter and Energy

Item				
Expected Dry Matter Level at Harvest	30% DM	60% DM	S.E.	Significance
Observed Dry Matter Level of Feeding	34.3% DM	37.0% DM		
Dry Matter Intake, (Kg/da)	7.08	5.85	.064	<.005
Fecal Dry Matter, (Kg/da)	2.92	2.61	.040	<.05
Dry Matter Digestibility, %	58.8	55.4	.45	<.05
Acid Detergent Fiber, %	39.2	39.1		
Gross Energy in Feed (Mcal/g)	4.46	4.62		
Gross Energy in Feces (Mcal/g)	1.80	1.85	.039	NS
Gross Energy Digestibility, %	59.6	60.0	.85	NS

Values for ADF were almost equal. This is in accordance with Thomas *et al*. (1969) who showed no differences in ADF when direct-cut silage was compared with wilted silage. Other researchers also showed no effect of dry matter level on the ADF content of the ensiled material (El Serafy *et al*., 1974; and Clancy *et al*., 1977). No statistical analysis is provided because the figures reported are means of the samples taken from each silo (one silo/haylage).

Dry matter digestibility was 6.1% higher for the 34.3% DM haylage than for the 37% DM haylage ($P<.05$). As was earlier stated, the lower DM digestibility of the 37% DM haylage could be due to its low-quality. Also, to a certain extent, the higher DM digestibility for the 34.3% DM haylage could be attributed to its higher DM intake during the digestibility trial. El Serafy *et al*. (1974) ensiled alfalfa at 42% and 51% DM and obtained dry matter digestibilities of 54.9% and 52.7%, respectively.

Gross energy in the feed was 3.6% higher for the 37% DM haylage. This was probably due to the lower fermentation taking place in the low-moisture silage (37% DM) at that time of the experiment. Again, it was not possible to report statistical results because the values are means of samples taken from each silo. Gross energy digestibility did not differ between silages. The values reported in this study are very close to those reported by Waldo *et al*.

(1971). Other experiments also showed similar digestible energy figures with different levels of DM (Hinks *et al.*, 1976; and Morgan *et al.*, 1980).

CONCLUSIONS

Reviewing the results of this experiment, the following conclusions can be made:

1. Feedlot performance on the high moisture corn-corn silage rations was superior when treating corn silage with urea at ensiling time, rather than feeding untreated corn silage supplemented with urea at feeding time.

2. Alfalfa haylage can successfully replace corn silage in a 85% HMC, 15% CS feedlot diet without affecting feedlot performance. This could save some protein supplementation.

3. There was no difference in performance of steers fed high moisture corn plus 30% DM haylage or 60% DM haylage.

4. Animal response was similar with 10% or 15% haylage level in the ration.

5. There were no significant effects in any of the carcass parameters by any treatment combination.

6. In the nitrogen balance study, nitrogen retained appeared to be a function of nitrogen intake.

7. There was no difference in ADF fractions of high-moisture or low-moisture silage.

8. Gross energy digestibility was not affected by DM level of alfalfa at time of ensiling.

APPENDIX

Table A.1.--Type of Forages Ensiled and Level of Dry Matter

References	Forage	DM Level (%)
Alder *et al*. (1969)	Perennial Ryegrass Meadow Fescue, Timothy	17, 29.
Barry *et al*. (1978a)	Alfalfa	20.
Barry *et al*. (1978b)	Alfalfa	*
Berger and Fahey, Jr. (1981)	Alfalfa	26, 46.
Binnie and Barry (1976)	Ryegrass and White Clover	23.
Brown (1964)	Grass	17, 25.
Byers (1965)	Alfalfa	34, 50.
Campling (1966)	Timothy, Meadow Fescue White Clover	21.
Chase *et al*. (1971)	Alfalfa	33.
Clancy *et al*. (1977)	Alfalfa	25, 50.
Dash *et al*. (1974a)	Alfalfa	60.
Dash *et al*. (1974b)	Alfalfa	60.
Dodsworth (1955)	Grass and Legume Pasture	17.
Donaldson and Edwards (1976)	Perennial Ryegrass	19, 32.
El Serafy *et al*. (1971)	Alfalfa	40, 48.
El Serafy *et al*. (1974)	Alfalfa, Bromegrass	42, 51.
Embry *et al*. (1967)	Alfalfa	54.
Forbes and Jackson (1971)	Timothy, Meadow Fescue	19, 35, 51.

Table A.1.--Continued

References	Forage	DM Level (%)
Goodrich et al. (1966)	Alfalfa, Bromegrass	50.
Goodrich et al. (1967)	Alfalfa, Bromegrass	42.
Gordon et al. (1961)	Alfalfa	25, 47.
Gordon et al. (1963)	Alfalfa	42.
Gordon et al. (1965)	Alfalfa	39, 65.
Gordon et al. (1967)	Orchardgrass	52.
Haarer et al. (1963)	Alfalfa	42.
Hammes, Jr., et al. (1964)	Alfalfa, Orchardgrass	23, 43.
Hawkins (1969)	Alfalfa	22, 40, 45, 80
Henderson and Newland (1966)	Alfalfa	30, 60.
Henderson and Newland (1967)	Alfalfa	35, 55.
Hinks et al. (1976)	Italian Ryegrass	17, 32.
Jackson and Forbes (1970)	Timothy, Meadow Fescue	19, 27, 32, 43.
Krause and Britton (1981)	Alfalfa	30, 60.
Lancaster et al. (1977)	Alfalfa	24.
Lancaster and Brunswick (1977)	Alfalfa	23.
Lu et al. (1979)	Alfalfa	23, 46.
Marsh (1978)	**	**
Morgan et al. (1980)	Italian Ryegrass Perennial Ryegrass Meadow Grass	16, 36.

Table A.1.--Continued

References	Forage	DM Level (%)
Murdoch (1960)	Alfalfa	20, 23, 27, 33, 35, 40
McGuffet and Owens (1979)	Alfalfa	34, 43.
Nevens and Kuhlman (1936)	Alfalfa	29.
Newland and Henderson (1966)	Alfalfa	54.
Niedermeier et al. (1961)	Alfalfa, Bromegrass	43, 68.
Perry and Beeson (1966)	Alfalfa	60.
Pierson et al. (1971)	Alfalfa	50.
Roeffler et al. (1967)	Alfalfa, Bromegrass	33, 49.
Rogers et al. (1979)	Perennial Ryegrass White Clover	22, 57.
Shoemacker et al. (1964)	Alfalfa, Red Clover Orchardgrass	60.
Stallings et al. (1979)	Alfalfa	50.
Sutton and Vetter (1971)	Alfalfa	28, 60.
Thomas et al. (1961)	Alfalfa	18, 54.
Thomas et al. (1969)	Alfalfa	20, 35
Thomas et al. (1972)	Alfalfa	47.
Thomas et al. (1980)	**	**
Tolman and Guyer (1974)	Alfalfa	*
Voelker et al. (1960)	Alfalfa	46.
Waldo et al. (1971)	Alfalfa, Sundan-Sorghum	23.

Table A.1.--Continued

References	Forage	DM Level (%)
Waldo et al. (1973)	Alfalfa, Orchardgrass	23, 36.
Wilkins et al. (1971)	Legume and Grass Pasture	28.
Windels et al. (1966)	Alfalfa	65.
Wing et al. (1976)	Alfalfa	56.
Yoelao et al. (1970)	Alfalfa	26, 47.
Yu Yu and Thomas (1975)	Alfalfa	50.
Yu Yu and Veira (1977)	Alfalfa	47.
Zimmerman et al. (1964)	Alfalfa, Red Clover Orchardgrass	60.
Zimmerman et al. (1965)	Grass Legume Mixture	69.

*Unavailable Information **Review Article

Note: DM level has been taken as an average when more than one level were reported in the same study.

Table A.2--Effect of Treatments on Feed lot Performance of Each Pen[a]

Item	30% UCS 70% HMC		30% TCS11 70% HMC		30% TCS13 70% HMC		15% HMH 85% HMC		15% LMH 85% HMC		10%UCS + 10%HMH + 80%HMC		10%UCS + 10%LMH + 80%HMC	
Trt. No.	1	1	2	2	3	3	4	4	5	5	6	6	7	7
Pen No.	42	43	10	11	12	13	47	48	14	15	45	46	16	44
In. Wt, Kg[b]	357	372	369	356	356	364	360	374	366	365	374	355	368	362
Fin. Wt, Kg[b]	494	519	517	514	503	519	501	529	526	516	520	506	532	512
ADG, Kg	1.29	1.38	1.40	1.50	1.39	1.46	1.33	1.46	1.51	1.42	1.38	1.42	1.55	1.41
ADDM, Kg	9.92	10.40	9.49	9.89	9.62	9.60	10.18	10.41	10.45	10.21	10.04	9.98	10.46	9.88
F/G	7.68	7.52	6.78	6.59	6.91	6.56	7.63	7.15	6.93	7.16	7.28	7.01	6.77	7.03

[a]There were two pens per treatment and eight steers per pen fed for 106 days.

[b]Initial and final weights were taken after 16 hours without feed and water.

Table A.3--Initial Carcass Data[a]

	Shrunk Weight, Kg	Hot Carcass Weight (Kg)	% Protein	% Fat
	376.5	231.3	16.19	26.62
	369.7	216.4	17.13	22.63
	365.1	220.9	17.48	21.17
	378.7	223.2	17.98	19.04
	371.9	213.2	17.93	19.26
	360.6	217.7	16.36	25,92
	356.1	197.3	17.06	22.95
	353.8	202.8	17.81	19.75
	351.5	211.8	16.70	24.47
	362.9	211.8	17.78	19.89
$\overline{X}$	364.6	214.6	17.24	22.17

[a]From Lomas (1979).

Table A.4--Effect of Treatments on Carcass Traits

Pen No.	Steer No.	Trt. No.	Hot Carcass Wt, Kg	Fat Thickness cm	Rib Eye Area, cm^2	KPH %	Yield[a] Grade	Quality Grade	Marbling[b] Score	Carcass Protein %	Carcass Fat %	Daily Protein Gain Kg	Daily Fat Gain Kg
42	322	1	332	1.65	69.04	3.5	4.2	11	14	13.71	34.47	.0804	.6308
42	361	1	278	1.40	74.20	3.5	3.2	10	10	14.44	33.27	.0297	.4237
43	350	1	316	1.52	83.23	4.0	3.3	10	11	14.53	28.45	.0841	.3993
43	353	1	351	1.78	80.00	2.5	3.7	11	13	14.54	31.22	.1324	.5850
10	301	2	331	1.52	83.23	4.0	3.4	13	21	14.29	35.08	.0972	.6466
10	330	2	294	1.65	76.13	4.0	3.6	10	10	14.32	35.90	.0481	.5469
11	392	2	330	1.40	83.88	3.5	3.2	10	12	14.79	33.88	.1114	.6059
11	410	2	293	1.40	80.00	3.5	3.1	9	8	14.54	31.83	.0529	.4310
12	305	3	309	1.29	81.29	3.5	3.0	10	11	14.72	29.74	.0801	.4181
12	331	3	302	2.16	83.88	4.0	3.8	11	14	15.40	26.83	.0897	.3156
13	379	3	357	1.90	84.52	3.5	3.9	10	11	14.01	35.37	.1228	.7424
13	426	3	283	1.14	91.62	3.5	2.2	8	7	15.71	27.26	.0704	.2790
47	389	4	300	1.27	77.42	3.5	3.1	10	11	15.21	31.22	.0814	.4347
47	421	4	329	1.90	87.10	3.0	3.4	13	19	14.66	35.27	.1060	.6459
48	360	4	375	2.67	90.33	4.0	4.6	11	14	13.99	37.98	.1459	.8948
48	393	4	331	1.40	77.42	3.0	3.4	12	16	14.82	34.42	.1137	.6260
14	307	5	333	1.65	70.33	3.5	4.1	10	10	14.97	32.07	.1213	.5586
14	319	5	319	1.52	86.46	3.5	3.1	13	19	15.00	32.43	.1024	.5271

Table A.4--Continued

Pen No.	Steer No.	Trt. No.	Hot Carcass Wt, Kg	Fat Thickness cm	Rib Eye Area, cm^2	KPH %	Yield[a] Grade	Quality Grade	Marbling[b] Score	Carcass Protein %	Carcass Fat %	Daily Protein Gain Kg	Daily Fat Gain Kg
15	320	5	341	1.27	82.58	4.0	3.3	11	13	14.35	34.96	.1126	.6758
15	335	5	288	1.90	78.71	4.5	3.8	11	13	14.61	33.70	.0479	.4668
45	371	6	357	2.03	85.17	4.0	4.1	10	11	14.75	34.02	.1477	.6969
45	405	6	295	1.40	72.26	2.5	3.3	9	8	15.15	27.72	.0726	.3226
46	365	6	326	1.65	83.23	4.0	3.5	10	11	15.03	33.10	.1132	.5691
46	406	6	319	1.27	78.71	4.0	3.3	11	14	14.90	34.38	.0994	.5858
16	321	7	307	1.65	83.88	4.0	3.3	11	14	15.47	30.63	.0990	.4383
16	401	7	340	1.65	82.58	4.5	3.8	10	11	15.29	31.46	.1414	.5603
44	324	7	360	1.65	89.04	3.0	3.3	9	8	14.98	35.86	.1597	.7690
44	370	7	312	1.40	76.13	3.5	3.4	11	13	14.53	33.09	.0787	.5251

[a]Quality Grade: Good - = 8; Good + = 9; Choice - = 10; Choice 0 = 11; Choice + = 12; Prime - = 13; Prime 0 = 14; Prime + = 15.

[b]Marbling Score: Slight - = 7; Slight + = 9; Small - = 10; Small + = 12; Modest - = 13; Modest + = 15; Moderate - = 16; Moderate + = 18; Slightly Abundant - = 19; Slightly Abundant + = 21.

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