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To the Graduate Council:

I am submitting herewith a thesis written by Benjamin B. Wilson, Jr. entitled "The Nutritional Value of Control and Antibiotic-treated Corn and Alfalfa Silages as Determined by Feeding Trials, Digestion Trials, and In Vitro Techniques." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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THE NUTRITIONAL VALUE OF CONTROL AND ANTIBIOTIC-TREATED CORN
AND ALFALFA SILAGES AS DETERMINED BY FEEDING TRIALS,
DIGESTION TRIALS, AND IN VITRO TECHNIQUES

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Benjamin B. Wilson, Jr.

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CHAPTER I

INTRODUCTION

Agriculture in Tennessee has been undergoing a tremendous change during the last decade, with an increasing conversion from a cash and row crop system to a grassland system of farming. The ultimate goal of grassland farming is to get more milk, meat, wool, and other products per acre at less cash cost than under the conventional method of farming. Because of the climatic conditions and topography of the land, Tennessee is very adaptable to this system of farming. Grassland farming is very important to the beef producer, because this system of farming will allow for the production of high-quality feeds as forages; thus, it has a diminishing effect on the narrow margin of profit in the beef cattle enterprise.

The preservation of quality in forages used for the wintering of cattle is very important to the success of a grassland system of farming, and the most economical method of insuring the keeping quality of forages in East Tennessee is to produce high-quality silages. The quality of a silage is dependent upon many factors, namely: variety of the forage, stage of maturity, moisture content at ensiling time, ensiling techniques, and preservative used on those forages of low sugar content.

The preservative used to insure desirable fermentation is very important in legume silage making, and many different types of preservatives have been used successfully. Antibiotics are known to control

natural fermentation. Therefore, it has been postulated that forage quality might be improved by the addition of an antibiotic which would beneficially alter fermentation.

Quality in forages is very important because it effects animal performance, and for years researchers and others have used such descriptive terms as low, medium, and high quality for indicating the suitability of forages to provide feed nutrients for animal production. The most common and oldest method used by man for the evaluation of a particular feed has been feedlot performance. Because of the expense and facilities involved in conducting feedlot studies, the development of a short-term laboratory method for the assessment of the nutritive value of forages has long been a goal of animal nutritionists.

Various workers have attempted to circumvent the more laborious methods of evaluation by proposing the use of regression equations for predicting the value of a forage from its chemical composition. These methods have not been entirely satisfactory, because the equations are based on single feed constituents and do not account for all the modifying effects encountered when dealing with animal investigations. For a realistic approach to the nutritive evaluation of a forage, the stated level and stage of animal production should be known. A forage may be evaluated as adequate when it is supplied in the correct quantity, possesses palatability, and its per-unit concentration of usable nutrients is high enough to permit the animal to meet its nutritional requirements. A study which would measure feedlot performance, digestion coefficients, and microbial activity would be very useful for evaluating a forage on this basis.

The major objective of this research problem was to compare and evaluate corn and alfalfa silages preserved with zinc bacitracin, as determined by the three methods of investigation mentioned above. The specific objectives of this investigation were as follows.

1. To determine the feeding value of control and antibiotic-treated corn and alfalfa silages when fed to steer calves ad libitum with a low level of protein supplement.
2. To determine the feeding value of control and antibiotic-treated corn and alfalfa silage when fed to heifer calves ad libitum with a medium level of concentrates.
3. To determine the digestibility of control and antibiotic-treated corn and alfalfa silages when fed with cottonseed meal or a concentrate mixture.
4. To determine the amount of microbial activity supported by the control and antibiotic-treated corn and alfalfa silages by measuring cellulose digestion in vitro.
5. To study the relationship that exists between feedlot performance, digestion coefficients, and in vitro cellulose digestion.

CHAPTER II

REVIEW OF LITERATURE

I. CORN VS. LEGUME SILAGE FOR WINTERING CATTLE

Snapp and Neumann (1960) reviewed many feeding trials with corn silage in comparison to other roughages, and found corn silage to be superior to all other types of roughages for wintering cattle. Most feeders consider corn silage the standard to which all other silages are compared, while alfalfa hay is considered the standard to which all hays are compared, as stated by Baird (1958). Many feeding trials have been conducted to compare high-moisture alfalfa silage to corn silage, and most results of these trials indicate the superiority of corn silage.

Dyer et al. (1954) found that alfalfa silage was inferior to corn, atlas sorghum, and barley silages for wintering beef calves when no supplement was added to the ration. On the contrary, Livesay and Cunningham (1953) conducted a five-year comparative feeding trial, and found that legume-grass and corn silages are nearly equal on a dry basis for wintering breeding cows. Cows on corn silage gained slightly more, but had lighter calves at weaning time. Benson et al. (1961) wintered steer calves on alfalfa silage and corn silage, both supplemented with 3 pounds of corn-cob meal and 4 pounds of alfalfa hay, and the average daily gains were 0.97 and 1.23 pounds, respectively. Branaman and Davis (1940) compared legume silage with corn silage, and found that one pound of grain

per day per hundred pounds of steer weight must be added to legume silage preserved with molasses to produce gain and finish equivalent to that obtained when steers are fed well-eared corn silage and hay balanced for protein with cottonseed meal.

Hall and Felts (1963) compared corn silage and orchardgrass-clover silage supplemented with limited amounts of concentrates, and observed no significant difference in the performance of beef heifers over a three-year period. Another study conducted over two years, in which orchardgrass-clover silage and alfalfa silage supplemented with limited amounts of concentrate were compared, showed that average daily gains of beef heifers fed alfalfa silage were significantly higher than average daily gains of heifers fed orchardgrass-clover silage. The literature reviewed indicates that alfalfa silage, when supplemented with a limited amount of concentrates, produces daily gains comparable to those obtained from corn silage.

II. DIGESTIBILITY OF ALFALFA AND CORN SILAGE

Garrigus (1951) concluded that alfalfa silage ranks high in overall feeding value because of its high content of digestible crude protein, but it ranks low in total digestible nutrients, as compared with corn silage. Average coefficients of digestibility for alfalfa silage were 59.2 per cent for dry matter in comparison to 67.27 per cent for corn silage, 68.9 and 58.9 per cent for crude protein, 49.5 and 58.8 per cent for crude fiber, 66.6 and 74.4 per cent for nitrogen-free extract, and 58.4 and 64.7 per cent for energy, respectively. Hall and Felts (1963)

reported no significant differences between alfalfa, orchardgrass-clover, and oat silage rations in digestibility of dry matter, crude protein, and nitrogen-free extract, but the digestibility of crude fiber in the alfalfa silage ration was significantly lower ($P < .05$) than for the other silages. They concluded that digestibility coefficients were of no help in explaining why calves fed the alfalfa silage ration gained faster and more efficiently than the calves fed the other silage rations. Morrison (1956) reported digestion coefficients similar to those reported by Garrigus et al. (1951) and Hall and Felts (1963).

III. USE OF ANTIBIOTICS FOR PRESERVING FORAGE QUALITY

Quality of a forage, which is very important to its feeding value, is dependent upon many factors. Quality of a silage is assured by control of undesirable fermentation, which is accomplished by prevention of undesirable anaerobic respiration and resultant putrefaction, butyric acid formation, and other undesirable fermentations. In order to prevent these undesirable fermentations, pH of the silage must be lowered to within 3.5 to 4.2. For high quality silage, the soluble carbohydrates must be converted to lactic acid and other desirable organic acids, and butyric acid must be kept at a minimum. Washko (1958) reported that if sufficient carbohydrates are present in crops ensiled the addition of soluble carbohydrates is not necessary. However, silages which are low in carbohydrates require the addition of a preservative to insure the keeping quality of the silage. Corn silage has approximately 20 per cent soluble carbohydrates and does not need a preservative, but legume silage

is low in soluble carbohydrates and must be preserved to maintain the quality.

Many preservatives, such as molasses, mineral acids, chemicals, corn-cob meal, and--recently--zinc bacitracin, have been used successfully for the preservation of silages. Zinc bacitracin is now available in large quantities, but few experiments have been conducted to compare it to other more commonly used preservatives.

Andrews and Stob (1958) ensiled alfalfa at the full bloom stage of maturity in small plastic bags, and found that 4 grams of zinc bacitracin per ton did not affect the pH at either 14 or 42 days after ensiling. At either 40 or 400 grams of bacitracin per ton, the pH was higher for both periods of fermentation. When ground corn and molasses were added individually, with and without bacitracin, the pH was lowered materially. Molasses and bacitracin together lowered the pH more than ground corn and bacitracin, but at the 400 gram level, bacitracin definitely inhibited acid formation.

Dexter (1957) used five antibiotics individually, mixed, and at varying concentrations as preservatives in making alfalfa silage in glass jars, which were opened successively on the 3rd, 7th, and 21st days after ensiling. There appeared to be a great difference between treated and non-treated silages. Forages treated with antibiotics were green and similar to fresh chopped alfalfa, while untreated samples had the brownish-green color characteristic of legume silage. When the jars were opened, the treated silages smelled fresh and grassy, while the untreated silages were fermented, as would be expected.

Rusoff et al. (1959a) used 10 grams of zinc bacitracin per ton as a preservative for white clover silage in comparison with molasses (80 pounds per ton), metabisulfite (8 pounds per ton) and an untreated control. The effect of the silages on milk production was determined with 12 milking cows in a 63-day reversed trial. Average values were determined for each silage for pH, dry matter intake, F. C. M. production, and total dry matter consumed per pound of F. C. M. produced. The only significant difference ($P < .05$) was in silage consumption. Amounts eaten were 67 pounds, bacitracin-treated silage; 73.9 pounds, molasses-treated silage; 63.3 pounds, metabisulfite-treated silage; and 86.2 pounds, untreated silage. Pounds of milk produced per pound of total dry matter intake were 1.05 for bacitracin-treated silage and 0.97 for each of the other three treatments.

Rusoff (1959b) determined the lactic acid and volatile fatty acid content of the four silages previously mentioned, and found that bacitracin-treated silages contained a higher concentration of lactic acid, propionic acid, and acetic acid, and a lower butyric acid concentration than did the other silages. The pH of the bacitracin-treated silages was comparable to that of the metabisulfite-treated silage. The nitrogen-free extract content of the four silages indicated that during the fermentation process bacitracin maintained the nitrogen-free extract content of the silage while lowering the pH. Zinc bacitracin, like molasses and metabisulfite, reduced protein decomposition and resulting ammonia formation.

Ramsey et al. (1959) fed young cattle Johnsongrass silages preserved with molasses, metabisulfite, and zinc bacitracin. Digestion trials showed coefficients of dry matter digestibility to be 60.95 per cent for the molasses-treated silage, 54.42 per cent for the metabisulfite-treated silage, 56.04 for the bacitracin-treated silage, and 55.73 for the untreated silage.

Pratt and Conrad (1961) conducted a series of experiments to determine the effects of metabisulfite and zinc bacitracin on chemical composition and feeding value of low-dry-matter alfalfa silage. Their results indicated that metabisulfite decreased the formation of volatile fatty acids, while zinc bacitracin did not. Milk production was lower while dry-matter intake was greater for cows fed metabisulfite-treated silage ($P < .05$) in comparison to those fed untreated or bacitracin-treated silage. A digestion trial showed no marked differences in digestibility of dry matter from untreated and bacitracin-treated silages, but it did show marked differences in nitrogen balance, reflected by the level of milk production.

IV. RELATIONSHIP OF FEEDLOT DATA, DIGESTIBILITY DATA, AND IN VITRO DATA

Harris et al. (1964) conducted a study on the relationship that exists between silage digestibility and live weight gains of stocker cattle. Corn and sorghum silage were fed ad libitum to yearling beef steers as the major source of energy, supplemented with 2 pounds of ground snapped corn and 1.5 pounds of cottonseed meal per head daily. Seven digestion trials were conducted with sorghum silage and five digestion

trials were conducted with corn silage. Digestibility of the dry matter ranged from 49.63 per cent to 70.35 per cent, and was not significantly correlated with daily gains, initial body weight, or per cent of dry matter in silage. Gay et al. (1960) found no relationship between dry matter digestibility, daily feed intake, and body weight. Likewise, no relationship was shown between dry matter digestibility, daily feed intake, and body weight, by simple regression. However, the regression coefficient for daily feed intake on body weight was highly significant. Gay et al. (1960) postulated that gains and digestibility of ration supplements are not strictly related.

Baker et al. (1951) studied the relationship of feed efficiency to digestion rates in beef cattle. This investigation indicated an inverse relationship between feed efficiency and rate of gain, and, under the conditions of this trial, feed efficiency appeared to be inversely related to digestion of crude fiber. Cattle using the least feed per pound of gain seem to do the best job of digesting crude fiber. Since it was demonstrated that feed efficiency is significantly correlated with rate of gain, and since feed efficiency is also significantly correlated with digestible crude fiber, it seems that the animal making the best gains does the best job of digesting crude fiber. From this they postulated that the great differences existing between animals, as far as their ability to gain is concerned, are due to utilization of their food after it is absorbed, rather than to a difference in the animal's ability to digest and absorb nutrients.

Crampton et al. (1960) concluded that the usefulness of quantitative digestion data is limited when trying to evaluate a forage because neither TDN nor the digestibility of energy consistently describes the effective feeding value of forages as measured by performance of animals subsisting on the forages. They indicate one reason for this might be that measurements of the extent of digestibility do not depend on or include consideration of the total intake of feed, an important factor when considering the relative feeding value of forages. There are factors, which appear to be characteristic of specific roughages, that limit voluntary consumption, and this is common knowledge among feeders.

Burroughs et al. (1950b) supports use of the artificial rumen technique for measuring the feeding value of a forage. Results indicated rather strongly that certain cereal grains and protein-rich feeds influence the microbiological digestion of cellulose. There is evidence that these influences are brought about through the nutrients which these feeds supply to cellulose splitting microorganisms. The artificial rumen can serve best as a screening device for developing a concept whose actual application can then be tested with animal experiments.

Burroughs et al. (1950b) reported that rumen microorganisms have nutritional requirements which must be fulfilled if they are to digest roughages efficiently in the symbiotic role with cattle and other ruminants, and that these nutrients are found in ample quantities in good quality roughages and in inadequate quantities in poor quality roughages. Generally, rumen microorganisms need three types of nutrients:

(1) those related to energy required for the rumen bacteria to attack and digest cellulose, (2) those related to protein or nitrogen compounds which are synthesized into protein material, and (3) those of inorganic nature which are integral constituents of enzymes and vitamins. The eventual specific use of nutrients required by these microorganisms, along with the amounts of such nutrients furnished by different roughages and other feeds, is of considerable importance when feeding cattle.

Burroughs et al. (1950a) found that cellulose in good quality roughages was digested efficiently without supplementation, and no difference in cellulose digestion was observed when supplements were added to good quality roughages. Inversely, poor quality roughages were not digested efficiently without supplementation.

Various workers have found a very close relationship between in vivo and in vitro data. Pigden et al. (1955) found that when the artificial rumen procedure was used in conjunction with regression equations, estimates of TDN and DCP for 21 forages were in close agreement to those established conventionally with sheep. Barnett (1957) found that in vitro cellulose digestion by whole rumen liquor had a high correlation to in vivo crude fiber digestion by sheep. Hershberger et al. (1959) investigated the relationship between cellulose digestibility in vitro and digestible energy, and obtained a highly significant relationship ($r = +0.92$). Baumgardt et al. (1964) reported a close relationship between estimated digestible dry matter determined from in vitro cellulose digestion and digestible dry matter obtained from in vivo steer and goat trials. The literature cited above indicates that in vitro cellulose

digestion is closely related to various digestibility coefficients determined by in vivo experiments.

Hall et al. (1962) reported that in vitro cellulose digestion and gas production may give an indirect indication of feedlot performance of cattle. They reported that steers fed alfalfa hay in conjunction with a full feed of concentrates gained significantly faster than steers fed orchardgrass hay and a full feed of concentrates. Similarly, in vitro cellulose digestion and total gas production, used as indicators of microbial activity, were significantly higher for alfalfa hay than for orchardgrass hay. A significant feature of these laboratory results is that a roughage which supported more microbial activity under laboratory conditions also contributed to faster and more efficient gains in the feedlot. This work indicates that in vitro studies can be used as a research tool for determining subsequent animal performance in the feedlot.

V. RELATIONSHIP OF DIGESTIBILITY DATA OBTAINED FROM TWO SPECIES OF RUMINANTS

Alexander et al. (1962) conducted a series of digestion trials with wethers, steers, and cows maintained in the same environment and fed 17 different rations, including two oat silage rations, four corn silage rations, and 11 coastal Bermudagrass hay rations. There were highly significant correlations between cattle and sheep digestion coefficients for dry matter, 0.86; protein, 0.77; crude fiber, 0.95; NFE, 0.87; ether extract, 0.83; energy, 0.85; and TDN, 0.89, when all 17 rations were averaged. Swift and Bratzler (1959) compared digestion coefficients of

various forages, obtained from cattle and sheep, and found that differences between averages for each of the values lacked significance at the 5 per cent level of probability.

After reviewing literature pertinent to the problem involved, the initiation of a study utilizing a complete method of forage evaluation would be of utmost importance toward understanding the feeding value of forages. The use of feedlot trials, digestion trials, and in vitro trials will allow for a more comprehensive evaluation of preservatives used with the silages, and will perhaps give a better understanding of results obtained in the feedlot.

CHAPTER III

EXPERIMENTAL PROCEDURE

This experiment, which was conducted for three consecutive years from 1961 to 1964, was designed to evaluate corn and alfalfa silages preserved with the antibiotic, zinc bacitracin, by utilizing three methods of investigation. The three methods used were feedlot performance, digestion trials, and in vitro trials. Feedlot performance of both beef steer and heifer calves was measured by daily gain, feed efficiency, average daily consumption, and change in condition grade. Coefficients of digestibility by both steers and sheep were determined for dry matter, crude protein, crude fiber, ash, ether extract, nitrogen-free extract, and energy. Microbial activity supported by silages was measured by in vitro cellulose digestion.

I. DESCRIPTION OF SILAGES

Alfalfa Silage

Alfalfa silage (Buffalo) used for the three-year study was from first and second cuttings averaging 5 to 7 tons per acre. Alfalfa fed during the first year was composed of approximately 70 per cent alfalfa and 30 per cent ryegrass, while that fed during the second and third years was of relatively pure stands. The alfalfa was harvested at the one-tenth bloom stage of maturity, and it was "direct cut" with a conventional-type forage harvester. Preservatives were spread across each

wagon load of forage before it was blown into the silo. Each silage fed in this experiment was stored in a 10' x 40' concrete stave silo having a capacity of approximately 75 tons. Five pounds of Silotracin (equivalent of 5 grams of zinc bacitracin) were applied to each ton of forage for the antibiotic-treated silages and 5 pounds of Kylage (sodium nitrite-calcium formate) was applied to each ton of forage for the control alfalfa silage. Alternate wagon loads of forage were blown into each silo to insure uniformity of the silages in each silo, and a man was stationed in each silo to insure uniform packing of the silage.

Physical appearance of the alfalfa silage fed during the first year was quite similar for both treatments, even though the pH of the chemically-treated alfalfa silage was lower than the pH of the antibiotic-treated alfalfa silage; 4.65 and 5.70, respectively. Both silages were dark brown in color and had an objectionable odor. Top spoilage amounted to approximately 6 feet in both silos, and could probably be attributed to poor ensiling techniques.

Physical appearance of the alfalfa silages fed during the second and third years was somewhat different for the treatments. Chemically-treated alfalfa silage was brownish-green in color, while antibiotic-treated alfalfa silage was lighter green in color. There was an objectionable odor associated with the antibiotic-treated alfalfa silage, but the pH of both alfalfa silages was very nearly the same on a within-year basis. Approximately two feet of top spoilage was present for both silages ensiled during the second and third years.

Chemical composition of silages fed during the three years varied considerably from year to year, as shown in Table I. Dry matter content of the silages varied from 17.0 per cent to 24.9 per cent for the chemically-treated alfalfa silage and from 18.0 per cent to 24.3 per cent for the antibiotic-treated alfalfa silage between years, but there was no significant difference between silages within each year. Differences in percentage of crude protein, nitrogen-free extract, and caloric value were also not significant ($P < .10$) for the chemical and antibiotic-treated silages, when compared within each year.

Corn Silage

Corn silage (Dixie 29) fed during the three-year study was harvested at the late-dent stage of maturity, the second and third years, and at the early-dent stage of maturity the first year. When harvested, the corn was very green and succulent, yielding 16 to 18 tons per acre. The antibiotic preservative was spread over each wagon load of forage before it was blown into the silo. Antibiotic-treated corn silage was preserved with 5 pounds of Silotracin per ton and, in order to insure the uniformity of fill and packing, the same procedures for filling the silos as described for the alfalfa silages were used. No preservative was used with the control corn silage.

Some differences were noted in the physical appearance of the control and antibiotic-treated corn silages. The control corn silage had a bright green color, while the antibiotic-treated corn silage was discolored. The antibiotic-treated corn silage had a much sweeter aroma,

TABLE I
CHEMICAL COMPOSITION OF FEEDS
(FRESH BASIS)

Feed	Year	Dry Matter	Crude Protein	Crude Fiber	N.F.E.	Ether Extract	Ash	K-cal. gm. (air-dry)	pH
Alfalfa silage (kylage)	1961	24.90	3.08	9.18	9.82	0.68	2.14	4.15	4.65
	1962	22.86	4.02	7.18	8.28	0.96	2.43	4.38	5.40
	1963	17.93	2.52	7.06	4.84	0.54	2.10	4.49	5.45
Alfalfa silage (zinc bacitracin)	1961	24.30	2.86	9.31	9.40	0.56	2.17	4.17	5.70
	1962	23.00	4.11	7.36	8.21	1.00	2.32	4.43	5.38
	1963	18.02	2.60	7.04	5.94	0.60	1.82	4.56	5.80
Corn silage (control)	1961	23.20	2.19	6.52	12.97	0.58	0.94	4.17	3.92
	1962	25.25	2.28	6.10	15.16	0.73	0.99	4.20	4.10
	1963	22.58	2.12	6.03	12.87	0.55	1.00	4.22	3.65
Corn silage (zinc bacitracin)	1961	23.72	2.24	6.74	13.22	0.58	0.94	4.17	4.02
	1962	25.18	2.32	6.15	15.01	0.71	0.99	4.20	4.06
Cottonseed meal	1961	94.34	41.37	14.38	29.19	3.40	6.00	4.58	--
	1962	89.86	30.80	14.78	39.44	2.92	5.04	4.31	--
	1963	92.20	39.90	11.75	31.10	4.06	5.39	4.58	--
Concentrate mixture	1961	87.68	14.42	3.56	64.39	3.11	2.20	4.11	--
	1962	89.52	15.07	4.09	63.44	3.50	3.42	3.98	--
	1963	87.94	17.58	3.46	60.82	3.76	2.32	4.22	--
Hay	1963	89.16	14.36	31.64	34.95	1.66	6.16	--	--

as compared to the control corn silage, and after being thrown down for feeding, the control corn silage tended to heat and spoil much faster than the antibiotic-treated corn silage. The pH of the two silages was very similar, averaging 4.0 for both years. Control corn silage fed the third year was similar to that fed the previous two years.

Chemical composition of the control and antibiotic-treated corn silages was very nearly the same within years, but it varied from year to year, as shown in Table I. Dry matter content varied from 23.2 to 25.2 per cent for the antibiotic-treated corn silage, but there were no significant differences in per cent crude protein, nitrogen-free extract, and gross energy for the control and antibiotic-treated corn silages ($P < .10$) on a within-year basis. Samples of all the silages and concentrates fed each year were taken at periodic intervals throughout the feeding period for chemical analyses, and were analyzed according to A. O. A. C. (1960) methods.

II. FEEDING TRIALS

Description of Cattle

Steers. Hereford and Angus steer calves purchased at local feeder calf sales in the East Tennessee area were used on the low supplementation regime. Calves used on the first and third years weighed an average of 525 pounds and graded Good, while calves used the second year graded Choice and averaged 550 pounds. Both Herefords and Angus were used the first and second years, but only Herefords were used the third year.

Heifers. Hereford and Angus heifer calves purchased at local feeder calf sales in the East Tennessee area were used as the experimental animals in this phase of the study. Calves used during the first and third years had an average initial weight of approximately 385 pounds, and graded Good, while those used for the second year had an average initial weight of 420 pounds and graded Medium. Both breeds were represented on each treatment the first year, but only the Angus breed was represented the second and third years of the study.

Pre-experiment Treatment

Immediately after purchase, the calves were taken by truck to the main experiment station, at which time they were tagged and tattooed for identification, weighed, and received preventative medication against hemorrhagic septicemia. Two different preventative measures were used during the course of the three-year experiment. On the first and third years the calves were treated orally with 500 mg. capsules of aureomycin (Aureofac-10) and injected with 0.8 mg. of tranquilizer (Diquil) per pound of body weight. During the first three days of the pre-treatment period each calf consumed approximately 300 mg. of Aureofac-10 per day, and 75 mg. per day thereafter in the pre-test ration. The preventative measures used for the second year included the injection of 10 cc. of penicillin, followed one week later with 80 cc. per head of hemorrhagic septicemia serum.

The calves were placed in two-acre lots (approximately 50 head per lot) and fed ad libitum a high roughage ration consisting of 70 per cent

ground alfalfa-orchardgrass hay, 18 per cent cracked corn, 8 per cent cottonseed meal, 3 per cent molasses, 0.5 per cent salt, and 0.5 per cent dicalcium phosphate. After one week the ground alfalfa-orchardgrass hay was reduced 10 per cent and the cracked corn was increased 10 per cent for the remainder of the pre-test period. The third year pre-test treatment was somewhat similar, with the exception that the calves were fed corn silage ad libitum for the last two weeks of the pre-test period. Two weeks prior to the beginning of the experiment the calves were hip-branded for identification purposes. The calves gained approximately 1.75 pounds per head daily while on the pre-test treatment, some of which could be accounted for by fill.

Experimental Treatment

The calves were divided into comparable lots of five head per lot on the basis of weight and grade. An average of two weights taken on consecutive days was used as the beginning and ending experimental weights, and the calves were also weighed at 28-day intervals throughout the experimental period. All calves were graded for condition and type by at least two qualified graders, of the Animal Husbandry-Veterinary Science Department at the University of Tennessee, at the beginning and end of the experiment. Two lots of calves--one lot from each breed when two breeds were represented--were selected at random and assigned to each treatment. The allotment procedure described above was used for both heifers and steers.

Calves were started on the experiment about November 1 each year and remained on the experiment for 112 to 140 days, depending upon the

amount of silage available. Steer calves were fed twice daily all the silage they would consume, plus 1 pound of cottonseed meal and approximately 2 pounds of fair quality alfalfa-orchardgrass hay per head daily. Heifer calves were fed twice daily all the silage they would consume, plus 4 pounds of cracked shelled corn, 1 pound of cottonseed meal (1.5 pounds of cottonseed meal the third year), and approximately 2 pounds of fair quality alfalfa-orchardgrass hay per head daily. Weigh-backs were taken once a day to insure freshness of the silage. Water, salt, and a mineral mixture (two parts dicalcium phosphate and one part salt) were accessible at all times. The calves were housed in an open pole barn with 13' x 36' lots, allowing approximately 93 square feet per head.

At the termination of the wintering experiment, steer calves were placed on summer pasture experiments, and heifer calves were placed on a finishing ration by gradually decreasing the silage and increasing the concentrate level. This transition took place over a three-week period, and heifer calves were finished out for market in approximately 60 days. Feed prices used to compute cost of gain during the wintering period are shown in Table II.

III. METABOLISM STUDIES

Cattle

Allotting and feeding methods. Twelve beef steer calves of similar breeding, age, type, and condition were used as experimental animals in the cattle metabolism studies. Steer calves used for the metabolism studies were handled in a manner similar to the used for steer

TABLE II
FEED PRICES USED TO COMPUTE COSTS OF GAINS

Ingredient	Price/Unit
Corn silage	\$ 8.00/ton
Alfalfa silage	6.00/ton
Cottonseed meal	70.00/ton
Ground shelled corn	1.37/bushel
Alfalfa-orchardgrass hay	34.00/ton
Dicalcium phosphate	80.00/ton
Salt	31.00/ton

calves on the feedlot studies at the farm, with the exception that the calves were halter-broke two weeks prior to the metabolism studies. Before being placed in the metabolism stalls, the calves were weighed and allotted to three weight groups--heavy, medium, and light--and were then randomly assigned by weight groups to each treatment, utilizing a randomized block design.

Each digestion trial consisted of a ten-day preliminary period, which allowed for an adjustment to the ration and stress conditions imposed on the steers in the metabolism stalls, and a seven-day collection period. The steers were fed twice daily, at 7:30 a.m. and 4:30 p.m., all of the silage they would consume, plus the calculated concentrate level. The concentrate level was adjusted on an air-dry basis so that the ratio of silage to concentrate level fed during the digestion trial was similar to the ratio fed during the feedlot studies. During the preliminary period, silage intake was regulated to yield a constant daily intake for each steer three to four days prior to and throughout the collection period. Weigh-backs were taken once a day, to insure the freshness of the silage, and were subtracted directly from the amount of silage fed. Water was offered the steers before the morning and evening feedings. Silage fed during the course of each trial was brought from the farm each day in 30 gallon galvanized cans to insure similar freshness and uniformity of the silage fed to the feedlot cattle.

Equipment. The metabolism stalls and urine collection apparatus used for the cattle digestion studies were similar to those described by

Hobbs et al. (1950), with the exception that in the third year grates were used instead of the rubber conduits. Beam scales, accurate to 0.5 pound, were used to weigh both the silage and fecal excretion. Fecal aliquots were weighed on triple-beam balances, accurate to within 5 grams. Plastic sacks were used to hold the silage samples and wide-mouth glass jars were used for the fecal aliquots. During the collection period, feed samples and fecal aliquots were preserved in a refrigerator maintained at 35°F.

Weighing and sampling procedures. In order to maintain a definite collection interval, each fecal pan was weighed, sampled, and cleaned once every 24 hours. The difference in weight of each pan when empty and when loaded represented the day's output of feces. After weighing, the feces was mixed thoroughly with a shovel, and a 3 per cent aliquot was placed in a labeled wide-mouth jar, sealed, and refrigerated at 35°F. Collections were made on seven consecutive days, and the total amount of fecal excretion for the seven-day period was used for calculating digestion coefficients.

Preparation and analysis of samples. When a collection period had been completed, the seven-day composite sample for each steer was mixed thoroughly. Two 500 gram samples were taken from this composite and each was placed in a weighed aluminum cake pan. These samples were then placed in a drying oven maintained at a temperature of approximately 70°C. After 72 hours of drying, the samples were removed from the oven and allowed to come to an approximate moisture equilibrium with the air before weighing

to determine air-dry matter. The air-dry samples were ground in a Wiley Mill to pass through a 20 mesh screen, mixed well, and a composite sample was placed in an 8 ounce glass bottle until chemically analyzed. A sample of approximately 500 grams of fresh silage was obtained from each day's supply during the last three days of the preliminary period and the first four days of the collection period. This procedure was followed because of the demonstrated three-day lag between the time a feed is eaten and the time its waste products are defecated, Dukas (1955). Samples were placed in plastic bags and maintained at 35°F. until the end of the collection period. The contents of each sample bag was then mixed thoroughly and two 500 gram samples were placed in aluminum cake pans and dried at 70°C. for 72 hours. The samples were allowed to come to an approximate moisture equilibrium with the air before weighing, and were then ground in a Wiley Mill to pass through a 20 mesh screen. A composite sample was then taken from the two samples and placed in air-tight jars until chemically analyzed.

All chemical analysis of the silage and fecal samples were made in accordance with A. O. A. C. (1960) methods with the exception of nitrogen which was determined by the Kjeldahl method with slight modifications. The gross energy determinations were made with a Parr Adiabatic Type Oxygen Bomb Calorimeter.

Two digestion trials which were conducted with steer calves during the 1961-1962 studies compared the two silages supplemented with cottonseed meal. During the 1962-1963 studies, one digestion trial was conducted with steer calves fed the silages supplemented with cottonseed

meal, and one trial was conducted to compare silages with a concentrate mixture similar to that fed to the heifers in the feedlot. The 1963-1964 digestion trials were similar to those described for 1962-1963.

Sheep

Allotting and feeding methods. Twelve wether sheep of similar breeding, type, and condition were used as experimental animals in the metabolism studies the second and third years. The wethers were weighed, branded, and allotted into three weight groups--heavy, medium, and light. One sheep from each weight group was then randomly assigned to the treatments, giving a randomized block design.

Each digestion trial consisted of a 10-day preliminary period for adjustment to the ration and a seven-day collection period. The sheep were fed twice daily, at 8:00 a.m. and 4:00 p.m., all the silage they would consume and the calculated amount of concentrate. Concentrates fed to the sheep were also adjusted to the proportion of silage to concentrate, on an air-dry basis, fed in the feedlot. During the preliminary period, silage intake was regulated to yield a constant daily intake for all wethers three to four days prior to and throughout the collection period. Weigh-backs were taken before each feeding and subtracted directly from the amount of silage fed. Silage used for the sheep trials was from the same source as that used for the cattle digestion trials. Water was available before each feeding.

Equipment. Metabolism stalls used for the sheep digestion studies were similar to those described by Briggs and Gallup (1949). A triple-beam

balance (accurate to 1 gram) was used to weigh the feed and fecal collections. Paper bags were used to collect daily samples and each day's collection was placed in heavy plastic bags and refrigerated at 35°F.

Weighing and sampling procedures. In order to maintain a definite collection interval, the contents of each fecal pan were weighed and sampled once every 24 hours. The entire fecal excretions for each 24-hour period were placed in paper bags and weighed, and these bags were then placed in heavy plastic bags for refrigeration. Collections were made for seven consecutive days, and the total amount of fecal excreta was used to calculate the digestion coefficients.

Preparation and analysis of samples. When a collection period was completed, the seven-day collections were mixed thoroughly and two 500 gram composite samples were taken for each animal. Feed samples were taken, prepared, and analyzed in a manner similar to that described for the cattle digestion trials.

Summary of trials. During the 1962-1963 studies, wethers represented in the first digestion trial were fed silage supplemented with cottonseed meal, and those represented on the other trial were fed silage supplemented with the concentrate mixture similar to that fed to the heifers in the feedlot. The 1963-1964 digestion trials were similar to those described for the 1962-1963 studies.

IV. IN VITRO STUDIES

General

The procedure adapted for in vitro cellulose digestibility studies was that of Cheng et al. (1955), Hall (1955), and Barth (1958), with minor modifications.

Description of Technique

Preparation of forage sample. Forage samples used for the in vitro studies were collected during the digestion and feedlot trials. The air-dry samples were passed through a 40 mesh screen to insure uniformity of particle size. Prior to the time of processing the rumen liquor, 0.4 gram samples of the forage were weighed into 75 milliliter erlenmeyer flasks, and each sample was duplicated in order to check the experimental technique. When a supplement was added to the digestion flasks, the level was regulated in proportion to the ratio of silage-dry matter fed to the cattle in the feedlot.

Approximately three hours prior to the inoculation of the forage sample with the bacterial culture, 15 milliliters of 0.8 per cent sodium bicarbonate were added to each flask and agitated on a magnetic stirrer for one minute, in order to suspend the forage in the buffer solution. Immediately after agitation, duplicate flasks were connected with a glass tubing train and placed in a water bath maintained at 39.5°C. A fine stream of carbon dioxide was bubbled through the flask contents to insure anaerobic conditions when the flasks were inoculated with the bacteria.

Collecting, processing, and washing of rumen microorganisms. Rumen contents, obtained from a 1500 pound fistulated steer maintained on good quality alfalfa hay and concentrates, were strained through eight layers of cheesecloth into a previously warmed (approximately 39°C.) thermos. Approximately 2200 milliliters of the whole rumen liquid were collected from the fistulated steer five hours after the morning feeding.

The whole rumen juice was centrifuged in an Ivan Servall angle centrifuge at 1000 rpm for one minute to sediment the protozoa, feed debris, and undigested feed particles not removed by straining. The supernatant (containing the cellulolytic bacteria) was then strained through eight layers of cheesecloth into a 1000 milliliter erlenmeyer flask which was placed in a warm water bath at 39.5°C. A few drops of the sediment remaining in the centrifuge tubes was also added to the supernatant and the remaining sediment was discarded. The supernatant was left in the water bath, with a fine stream of carbon dioxide bubbling through it for ten minutes.

The supernatant was centrifuged in a Sharples super centrifuge at the rate of 20,000 rpm, and the bacterial sediment was scraped into a Waring Blender bowl containing a small amount of previously warmed and carbonated 0.8 per cent sodium bicarbonate. The packed bacteria were then agitated for 12 seconds in order to resuspend them in the buffer solution and the volume of the suspension was increased to 800 milliliters by the addition of 0.8 per cent sodium bicarbonate (pH 6.9). This bacterial suspension was rewarmed and carbonated with a fine stream of carbon dioxide for 10 minutes, and again centrifuged in a Sharples

centrifuge at 20,000 rpm. The bacterial sediment was scraped into a Waring Blender bowl containing 100 milliliters of the 0.8 per cent sodium bicarbonate, and agitated for 12 seconds to resuspend the bacteria. The bacterial suspension was increased to 550 milliliters with previously warmed and carbonated 0.8 per cent sodium bicarbonate, and was then returned to the water bath and bubbled briskly with carbon dioxide for 15 minutes before being used to inoculate the digestion flasks.

Fifteen milliliters of the bacterial suspension were pipetted into the digestion flasks, being sure that sample particles were washed down the side of the flask into the solution. The carbon dioxide source was continued throughout the procedure, and, in order to keep the anaerobic conditions and temperature relatively constant, the flasks were disconnected two at a time, inoculated, and placed back in the 39.5°C. water bath. A fermentation period of 22 hours was used, and the flasks were agitated every few hours to keep the suspension mixed.

At the end of the fermentation period, the amount of cellulose was determined from the contents of each flask, using the procedure of Crampton and Maynard (1938), with slight modifications. The cellulose content was also determined on one gram samples of the silages using the same technique, and from this cellulose digestibility coefficients were calculated for each flask.

Summary of the In Vitro Trials Conducted Over the Three-Year Period

A total of 16 in vitro trials were conducted over the three-year period. Two trials were conducted during 1961-62, and each silage was

represented by two samples obtained during the digestion trials. The microbial activity supported by the silages with and without cottonseed meal supplementation, as indicated by the amount of cellulose digestion, was determined for each silage sample. During the 1962-63 trials each silage was represented by four samples. Samples one and four were obtained two weeks after the start and two weeks prior to the end of the feedlot trials, and samples two and three were obtained during the digestion trials. A total of eight trials were conducted in 1962-63; two with the silages alone, two with the silages supplemented with cottonseed meal, two with the silages supplemented with the concentrate mixture, and two with composite samples of each silage. The 1963-64 in vitro trials were conducted in a similar manner to those conducted during 1962-63 with the exception that only three silages were compared.

V. STATISTICAL ANALYSIS

Data obtained from the feedlot, digestion, and in vitro trials were analyzed by analysis of variance, Snedecor (1956), and by the multiple range test, Duncan (1955), where applicable. A covariance analysis was applied to the data from each of the three methods of investigation to determine if a significant relationship exists between the methods.

CHAPTER IV

RESULTS AND DISCUSSION

I. FEEDLOT PERFORMANCE

Steers

1961-1962. During the 113-day steer wintering experiment, the beef steers receiving corn silage free choice and 1.0 pound of cottonseed meal per head daily gained significantly faster ($P < .01$) than those steers receiving alfalfa silage free choice and 1.0 pound of cottonseed meal per head daily. As shown in Table III, actual rates of gain for the steers fed the four silage rations were 1.32 and 1.31 pounds per head daily for the control and antibiotic-treated corn silages, as compared to 0.79 and 0.48 pounds per head daily for the control and antibiotic-treated alfalfa silages, respectively. Difference in average daily gains for the steers fed the control and antibiotic-treated corn silages was negligible, but the difference in average daily gains of steers fed the control and antibiotic-treated alfalfa silages was significant at the 1 per cent level of probability. This difference in average daily gains was due to individual variation of animal performance within the Hereford steer calves rather than to the inhibitory effect of the antibiotic preservative.

Average daily silage consumption, on an air-dry basis, was significantly lower ($P < .05$) for those steers fed the antibiotic-treated alfalfa silage than for those steers fed the control corn silage, antibiotic-treated corn silage, and control alfalfa silage--6.88, 7.86,

TABLE III

WINTERING PERFORMANCE OF BEEF STEER CALVES FED CONTROL AND
ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES, 1961-62

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
No. of calves/lot	5	5	5	5
No. of calves/treatment	10	10	10	10
Av. wt. and gain/head, lb.				
Initial wt.	516	527	519	526
Final wt.	665	675	608	580
Total gain	149	148	89	54
Daily gain	1.32	1.31	0.79	0.48
Av. daily ration, lb.				
Silage				
Fresh basis	33.9	33.0	31.4	28.3
Air-dry basis	7.86	7.83	7.82	6.88
Cottonseed meal	1.0	1.0	1.0	1.0
Alfalfa-orchardgrass hay	1.8	1.8	1.9	1.9
Air-dry feed/cwt. gain, lb.				
Silage	618	619	1024	1514
Cottonseed meal	76	76	126	211
Alfalfa-orchardgrass hay	141	141	239	398
Total	835	836	1389	2123
Feed cost/head	\$23.11	\$22.69	\$20.32	\$19.01
Feed cost/lb. gain	15.5¢	15.3¢	22.7¢	35.5¢
Grades ^a				
Initial type	10.6	10.4	10.4	10.4
Initial condition	7.4	7.5	7.3	7.7
Final condition	6.4	7.3	5.8	5.8

^a10 = Ave. Good.

7 = Ave. Standard.

7.83, and 7.82 pounds, respectively. This difference was due to an individual variation of animal performance within the Hereford steer lot, as reflected in average daily gains, rather than to a difference in silages and preservatives within silages. Differences between silage treatments for air-dry feed required per unit of gain were not statistically significant ($P > .10$), even though the differences between treatments were large. This can probably be accounted for by an apparent breed-antibiotic interaction rather than differences in silages or the preservatives added to the silages.

The condition grade of steers fed the antibiotic-treated corn silage remained the same during the wintering experiment, but the condition grade of steers fed the control corn silage, control alfalfa silage, and antibiotic-treated alfalfa silage decreased during the wintering experiment. The final condition grade of steers fed the control and antibiotic-treated corn silages was significantly different ($P < .01$) from that of steers fed the control and antibiotic-treated alfalfa silages. Addition of the antibiotic preservative to the corn silage resulted in a significantly higher ($P < .10$) final condition grade, but there was no significant difference ($P > .10$) in final condition grades of those steers fed the control and antibiotic-treated alfalfa silages. Mean squares for average daily gain, average daily silage consumption, feed efficiency, and change in condition grade are shown in Table IV.

1962-1963. Results of the 112-day steer wintering experiment are summarized in Table V. The average daily gains of steers fed the control

TABLE IV
MEAN SQUARES FOR FEEDLOT PERFORMANCE OF
BEEF STEER CALVES, 1961-62

Source of Variation	df	Mean Squares			Change in Condition Grade
		Av. Daily Gain	Av. Daily Consumption	Feed/cwt. Gain	
Silage (C)	1	4.436**	0.461	246.87	11.00**
Preservative (A)	1	0.225	0.461	80.27	0.63
C x A	1	0.193	0.461	116.79	3.62 ⁺
Breed	1	0.930**	3.976*	60.72	2.02
Breed inter- action	3	0.448	0.332	49.28	1.01
Animal/breed/ C, A	32	2.670			0.92
Pooled	35	3.118			0.92

* $P < 0.05$.

** $P < 0.01$.

⁺ $P < 0.10$.

TABLE V

WINTERING PERFORMANCE OF BEEF STEER CALVES FED CONTROL AND
ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES, 1962-63

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
No. of calves/lot	5	5 (3)	5	5
No. of calves/treatment	10	8 ^a	10	10
Av. wt. and gain/head, lb.				
Initial wt.	546	554	551	552
Final wt.	688	680	672	667
Total gain	142	125	121	115
Daily gain	1.27	1.15	1.08	1.04
Av. daily ration, lb.				
Silage				
Fresh basis	34.0	30.8	37.0	35.9
Air-dry basis	8.58	7.76	8.46	8.26
Cottonseed meal	1.0	1.0	1.0	1.0
Alfalfa-orchardgrass hay	2.0	2.0	2.0	2.0
Air-dry feed/cwt. gain, lb.				
Silage	718	778	841	853
Cottonseed meal	79	93	92	97
Alfalfa-orchardgrass hay	157	185	183	192
Total	954	1056	1116	1142
Feed cost/head	\$22.97	\$22.33	\$22.24	\$21.84
Feed cost/lb. gain	16.2¢	17.9¢	18.4¢	18.9¢
Grades ^b				
Initial type	12.1	12.2	12.2	12.2
Initial condition	8.6	8.6	9.1	8.8
Final condition	8.1	7.7	8.1	8.2

^aTwo calves were removed because of digestive disorders.

^b13 = Ave. Choice.

10 = Ave. Good.

7 = Ave. Standard.

and antibiotic-treated corn silages free choice, supplemented with 1.0 pound of cottonseed meal per day, were 1.27 and 1.15 pounds, respectively; as compared to 1.08 and 1.04 pounds for those steers fed the control and antibiotic-treated alfalfa silage free choice, supplemented with 1.0 pound of cottonseed meal daily. Although difference in gains between steers fed the control corn silage and those fed the antibiotic-treated alfalfa silage was 0.23 pound, this difference was not statistically significant at the 10 per cent level of probability.

Steers fed the control corn and alfalfa silages consumed slightly more silage per day than did the steers fed the antibiotic-treated silages. The difference in the amount of feed required per hundred pounds of gain for those steers fed the control and antibiotic-treated silages was not significantly different ($P > .10$) even though those steers fed the antibiotic-treated corn silage required one pound more air-dry feed per pound of gain than the steers fed the control corn silage.

Final condition grades of all steers on the silage treatments were lower than the initial condition grades, but there were no significant differences ($P > .10$) in condition grades of steers on the various silage treatments. There was a significant breed x antibiotic interaction ($P < .10$), that can be attributed to variation between the breed condition grades of those steers fed the various silage treatments. Hereford steers tended to lose condition on all silage treatments with the exception of the antibiotic-treated corn silage treatment. Mean squares for average daily gains, average daily silage consumption, feed efficiency, and change in condition grades are shown in Table VI.

TABLE VI
MEAN SQUARES FOR FEEDLOT PERFORMANCE OF
BEEF STEER CALVES, 1962-63

Source of Variation	df	Mean Squares			Change in Condition Grade
		Av. Daily Gain	Av. Daily Consumption	Feed/cwt. Gain	
Silage (C)	1	0.183	0.004	2.02	0.73
Preservative (A)	1	0.108	0.228	1.34	0.01
C x A	1	0.009	0.008	0.11	0.16
Breed	1	0.182	0.633	1.00	2.20 ⁺
Breed inter-action	3	0.022	0.190	0.41	1.91 ⁺
Animals/breed/ C, A	32	0.092			0.80
Pooled	35	0.086			0.89

⁺P < 0.10.

1963-1964. The third year steer wintering experiment involving three treatments--corn silage with no preservative, control alfalfa silage, and antibiotic-treated alfalfa silage--was conducted for 141-days. Beef steer calves fed corn silage free choice with 1.0 pound of cottonseed meal per head daily gained significantly faster ($P < .01$) than steers fed the alfalfa silages free choice plus one pound of cottonseed meal per head daily. Actual rates of gain for the steers on the three silage treatments were 1.50, 0.87, and 0.87 pounds per head daily for the corn silage, control alfalfa silage, and antibiotic-treated alfalfa silage, respectively, as shown in Table VII.

Average daily silage consumption, on an air-dry basis, by the steers fed the corn silage ration was approximately 1.6 pounds greater than that of steers fed the control and antibiotic-treated alfalfa silage rations. Average daily silage consumption and feed required per hundred pounds of gain for steers fed the control and antibiotic-treated alfalfa silages were not significantly different, but steers fed the corn silage ration required significantly less ($P < .05$) air-dry feed per hundred pounds of gain than did the other groups.

Final condition grades were slightly lower than the initial condition grades. Change in condition grades for steers fed the control and antibiotic-treated alfalfa silage was significantly greater ($P < .01$) than that for steers fed the corn silage, but condition grades of steers fed the control and antibiotic-treated alfalfa silages were relatively the same at the end of the wintering experiment. Mean squares for average daily silage consumption, feed efficiency, and change in condition grade are shown in Table VIII.

TABLE VII

WINTERING PERFORMANCE OF BEEF STEER CALVES FED CONTROL CORN
AND ALFALFA SILAGE AND ANTIBIOTIC-TREATED
ALFALFA SILAGE, 1963-64

	Corn Silage	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
No. of calves/lot	5	5	5
No. of calves/treatment	10	10	10
Av. wt. and gain/head, lb.			
Initial wt.	530	526	527
Final wt.	740	648	648
Total gain	210	122	121
Daily gain	1.50	0.87	0.87
Av. daily ration, lb.			
Silage			
Fresh basis	32.8	32.0	31.2
Air-dry basis	7.38	5.74	5.62
Cottonseed meal	1.0	1.0	1.0
Alfalfa-orchardgrass hay	2.0	2.0	2.0
Air-dry feed/cwt. gain, lb.			
Silage	537	795	763
Cottonseed meal	67	116	116
Alfalfa-orchardgrass hay	132	299	230
Total	736	1140	1109
Feed cost/head	\$28.08	\$23.12	\$22.80
Feed cost/lb. gain	13.4¢	19.0¢	18.9¢
Grades ^a			
Initial type	10.6	11.1	11.2
Initial condition	8.1	8.1	7.9
Final condition	7.7	6.3	6.4

^a10 = Average Good.

7 = Average Standard.

TABLE VIII
MEAN SQUARES FOR FEEDLOT PERFORMANCE OF
BEEF STEER CALVES, 1963-64

Source of Variation	df	Mean Squares			Change in Condition Grade
		Av. Daily Gain	Av. Daily Consumption	Feed/cwt. Gain	
Treatments	2	1.323**	1.946**	6.978*	3.90**
Lots	3	0.096	0.093	0.551	1.21 ⁺
Animals	24	0.075			0.63
Pooled	27	0.075			0.70

* $P < 0.05$.

** $P < 0.01$.

⁺ $P < 0.25$.

Summary. Results of the three-year study indicated that steers fed corn silage free choice supplemented with 1 pound of cottonseed meal gained faster than the steers fed alfalfa silage free choice supplemented with 1 pound of cottonseed meal. Addition of the antibiotic preservative to either the corn or alfalfa silages failed to improve the feeding value of these silages for the steer calves.

Generally, the average daily silage consumption, on an air-dry basis, was higher for steers fed the corn silage than for steers fed the alfalfa silages, but there were no significant differences ($P > .10$) in average daily silage consumption of the control and antibiotic-treated silages. The first and second year studies indicated that the feed efficiency of steers fed the corn and alfalfa silages was not significantly different, while the third year study indicated that steers fed the alfalfa silages required significantly more feed per pound of gain ($P < .05$) than did steers fed the corn silage. During the three-year study there was no evidence that the antibiotic preservative increased feed efficiency of the steers.

At the termination of the wintering experiments, final condition grades were generally lower than initial condition grades. This change in condition grades was significantly less ($P < .01$) for steers fed the corn silages than for steers fed the alfalfa silages, with the exception of results obtained during the second year. Condition grades of steers fed the antibiotic-treated corn and alfalfa silages were similar to condition grades of steers fed the control silages.

Heifers

1961-1962. During the 113-day heifer wintering experiment, heifers fed corn silage free choice and 5.0 pounds of a concentrate mixture gained significantly faster ($P < .01$) than did heifers fed the alfalfa silage free choice and 5.0 pounds of a concentrate mixture. As shown in Table IX, actual rates of gain were 1.35 and 1.38 pounds per head daily for the control and antibiotic-treated corn silage rations, as compared to 1.12 and 1.04 pounds per head daily for the control and antibiotic-treated alfalfa silage rations, respectively. Average daily gains of heifers fed the antibiotic-treated corn and alfalfa silages were not significantly different ($P > .10$) from those of heifers fed the control corn and alfalfa silages.

Average daily silage consumption, on an air-dry basis, was slightly less for heifers fed the alfalfa silages, but the differences were not significant at the 10 per cent level of probability when comparing treatments. Angus heifers receiving the control corn, antibiotic-treated corn, and antibiotic-treated alfalfa silages consumed significantly more ($P < .10$) silage than did Hereford heifers on these same three treatments, but the difference in silage intake of Hereford and Angus heifers fed the control alfalfa silage was not statistically significant ($P > .10$). Heifers fed the control and antibiotic-treated corn silage rations required significantly less air-dry feed per pound of gain ($P < .05$) than those fed the control and antibiotic-treated alfalfa silage rations, but the differences in feed efficiency were not statistically significant ($P > .10$).

TABLE IX
WINTERING PERFORMANCE OF BEEF HEIFER CALVES FED
CONTROL AND ANTIBIOTIC-TREATED CORN
AND ALFALFA SILAGE, 1961-62

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
No. of calves/lot	5	5	5	5
No. of calves/treatment	10	10	10	10
Av. wt. and gain/head, lb.				
Initial wt.	506	510	508	518
Final wt.	659	666	634	635
Total gain	153	156	126	117
Daily gain	1.35	1.38	1.12	1.04
Av. daily ration, lb.				
Silage				
Fresh basis	24.0	23.7	21.4	22.5
Air-dry basis	5.76	5.83	5.04	5.47
Corn	4.0	4.0	4.0	4.0
Cottonseed meal	1.0	1.0	1.0	1.0
Alfalfa-orchardgrass hay	1.8	1.9	1.9	1.9
Air-dry feed/cwt. gain, lb.				
Silage	418	416	481	537
Corn	290	285	349	376
Cottonseed meal	73	71	87	94
Alfalfa-orchardgrass hay	128	134	166	180
Total	909	906	1083	1187
Feed cost/head	\$28.77	\$29.05	\$25.52	\$25.96
Feed cost/lb. gain	18.9¢	18.7¢	20.2¢	22.1¢
Grades ^a				
Initial type	11.8	12.0	12.1	11.8
Initial condition	8.0	8.2	8.0	8.0
Final condition	7.6	8.4	8.0	7.6

^a13 = Average Choice.

10 = Average Good.

7 = Average Standard.

The condition grades of the heifers fed the four silage treatments remained relatively constant during the wintering experiment. Mean squares for average daily gains, average daily silage consumption, feed efficiency, and change in condition grade are shown in Table X.

1962-1963. During the 112-day heifer wintering experiment, average daily gains of those heifers fed the control and antibiotic-treated corn silages free choice, supplemented with 5.0 pounds of a concentrate mixture, were 1.41 and 1.40 pounds, respectively, as compared to 1.44 and 1.29 pounds per day for heifers fed the control and antibiotic-treated alfalfa silages free choice, supplemented with 5.0 pounds of a concentrate mixture as shown in Table XI. The difference in average daily gain of heifers fed the control alfalfa silage rations, in comparison to the antibiotic-treated alfalfa silage ration, was 0.16 pounds per head daily, but this was not statistically significant ($P > .10$).

Average daily silage consumption, on an air-dry basis, was slightly higher, but not significantly different, for heifers fed the control corn and alfalfa silage rations, as compared to heifers fed the antibiotic-treated corn and alfalfa silage rations. The air-dry feed required per pound of gain was significantly lower ($P < .10$) for heifers fed the control corn and alfalfa silage rations, as compared to heifers fed the antibiotic-treated corn and alfalfa silage rations.

The change in condition grade during the 112-day experiment was not significant ($P > .10$) when comparing heifers fed the corn silage rations to those fed the alfalfa silage rations. However, there was a

TABLE X
MEAN SQUARES FOR FEEDLOT PERFORMANCE OF
BEEF HEIFER CALVES, 1961-62

Source of Variation	df	Mean Squares			Change in Condition Grade
		Av. Daily Gain	Av. Daily Consumption	Feed/cwt. Gain	
Silage (C)	1	0.801**	0.061	10.811*	3.30
Preservative (A)	1	0.008	0.026	0.405	0.30
C x A	1	0.028	0.003	0.470	0.06
Breed	1	0.004	0.661 ⁺	0.551	0.50
Breed interaction	3	0.077	0.098	0.769	0.34
Animals/breed/ C, A	32	0.052			0.59
Pooled	35	0.054			0.57

*P < 0.05.

**P < 0.01.

⁺P < 0.10.

TABLE XI

WINTERING PERFORMANCE OF BEEF HEIFER CALVES FED
CONTROL AND ANTIBIOTIC-TREATED CORN
AND ALFALFA SILAGE, 1962-63

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
No. of calves/lot	5	5	5	5
No. of calves/treatment	10	10	10	10
Av. wt. and gain/head, lb.				
Initial wt.	461	465	457	460
Final wt.	619	622	618	604
Total gain	158	157	161	144
Daily gain	1.41	1.40	1.44	1.29
Av. daily ration, lb.				
Silage				
Fresh basis	22.0	24.2	24.5	24.6
Air-dry basis	5.56	6.09	5.60	5.66
Corn	4.0	4.0	4.0	4.0
Cottonseed meal	1.0	1.0	1.0	1.0
Alfalfa-orchardgrass hay	2.0	2.0	2.0	2.0
Air-dry feed/cwt. gain, lb.				
Silage	418	469	419	472
Corn	283	284	276	312
Cottonseed meal	71	71	69	78
Alfalfa-orchardgrass hay	141	141	138	155
Total	913	965	902	1017
Feed cost/head	\$28.53	\$29.54	\$28.31	\$28.34
Feed cost/lb. gain	18.1¢	18.8¢	17.6¢	19.8¢
Grades ^a				
Initial type	11.0	11.2	11.2	11.2
Initial condition	8.2	8.1	8.0	8.0
Final condition	8.3	8.4	8.1	8.1

^a10 = Average Good.

7 = Average Standard.

significant difference ($P < .05$) in condition grade change of heifers fed the antibiotic-treated corn silage ration, as compared to those fed the antibiotic-treated alfalfa silage ration. Mean squares for average daily gains, average daily silage consumption, feed efficiency, and change in condition grade are shown in Table XII.

1963-1964. The three treatments involved in the 141-day wintering experiment conducted during the third year study were corn silage with no preservative, control alfalfa silage, and antibiotic-treated alfalfa silage. Heifers receiving the corn silage free choice, supplemented with 5.4 pounds of a concentrate mixture per day, gained significantly faster ($P < .01$) than heifers receiving the control and antibiotic-treated alfalfa silages free choice, supplemented with 5.4 pounds of a concentrate mixture, as summarized in Table XIII, but the difference in average daily gains of heifers fed the control and antibiotic-treated alfalfa silage rations was not statistically significant.

The average daily silage consumption, on an air-dry basis, of heifers fed the corn silage was significantly higher ($P < .01$) than the average daily consumption of heifers fed the control and antibiotic-treated alfalfa silages. Heifers fed the corn silage ration required less feed per hundred pounds of gain than those receiving the control and antibiotic-treated alfalfa silage rations, but this difference of 40 pounds was not statistically significant ($P > .10$). The antibiotic preservative did not have a significant effect on feed efficiency of the alfalfa silage rations.

TABLE XII
MEAN SQUARES FOR FEEDLOT PERFORMANCE OF
BEEF HEIFER CALVES, 1962-63

Source of Variation	df	Mean Squares			Change in Condition Grade
		Av. Daily Gain	Av. Daily Consumption	Feed/cwt. Gain	
Silage (C)	1	0.026	0.086	0.067	0.50
Preservative (A)	1	0.066	0.235	1.403 ⁺	0.05
C x A	1	0.060	0.256	0.189	1.87*
Lots/C, A	4	0.061	0.142	0.289	0.08
Animals/lots/ C, A	32	0.058			0.38
Pooled	36	0.058			0.35

*P < 0.05.

⁺P < 0.10.

TABLE XIII

WINTERING PERFORMANCE OF BEEF HEIFERS FED CONTROL CORN
SILAGE, CONTROL ALFALFA SILAGE AND ANTIBIOTIC-
TREATED ALFALFA SILAGE, 1963-64

	Corn Silage	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
No. of calves/lot	5	5	5
No. of calves/treatment	10	10	10
Av. wt. and gain/head, lb.			
Initial wt.	388	390	390
Final wt.	613	594	592
Total gain	225	204	202
Daily gain	1.61	1.45	1.44
Av. daily ration, lb.			
Silage			
Fresh basis	19.0	19.0	19.4
Air-dry basis	5.73 ? <i>limit</i>	4.68	4.76
Corn	4.0	4.0	4.0
Cottonseed meal	1.4	1.4	1.4
Alfalfa-orchardgrass hay	2.0	2.0	2.0
Air-dry feed/cwt. gain, lb.			
Silage	291	283	284
Corn	250	276	278
Cottonseed meal	88	98	98
Alfalfa-orchardgrass hay	122	136	138
Total	751	793	798
Feed cost/head	\$36.09	\$33.44	\$33.63
Feed cost/lb. gain	16.0¢	16.4¢	16.6¢
Grades ^a			
Initial type	10.5	10.5	10.3
Initial condition	7.4	7.6	7.4
Final condition	8.9	8.2	8.2

^a10 = Average Good.

7 = Average Standard.

All condition grades of the heifers increased during the wintering experiment, but heifers fed the corn silage ration had a significantly greater ($P < .05$) condition grade change than did heifers fed the control and antibiotic-treated alfalfa silage rations. Mean squares for average daily gain, average daily silage consumption, feed efficiency, and change in condition grade are shown in Table XIV.

Summary. Results of the three-year study indicate that feedlot traits of heifers fed the alfalfa silage rations varied from year to year. The first and third year studies indicated that corn silage fed free choice supplemented with about 5.0 pounds of a concentrate mixture was superior to similarly supplemented alfalfa silage fed free choice for wintering heifer calves. However, the second year study indicated that average daily gains of heifers fed the alfalfa silage rations were approximately equal to those of heifers fed the corn silage rations. Average daily gains of heifers fed the control silage rations were not significantly different ($P > .10$) from the gains of heifers fed the antibiotic-treated silage rations.

Average daily silage consumption, on an air-dry basis, for heifers during the first and second years was essentially the same for all silage treatments. However, the third year study indicated a significant difference ($P < .01$) in average daily silage consumption of heifers fed the corn silage, as compared to the alfalfa silages.

During the first year, heifers fed the corn silage rations required significantly less ($P < .05$) feed per pound of gain than did

TABLE XIV
MEAN SQUARES FOR FEEDLOT PERFORMANCE OF
BEEF HEIFER CALVES, 1963-64

Source of Variation	df	Mean Squares			Change in Condition Grade
		Av. Daily Gain	Av. Daily Consumption	Feed/cwt. Gain	
Treatments	2	0.083 ⁺	0.690**	0.053	2.06*
Lots	3	0.016	0.022	0.041	0.42
Animals	24	0.044			0.49
Pooled	27	0.041			0.48

*p < 0.05.

**p < 0.01.

⁺p < 0.10.

heifers fed the alfalfa silage rations, but the second and third year studies indicated no significant difference ($P > .10$) in feed efficiency between treatments. It should be mentioned, however, that during the second year heifers fed the control silage rations required significantly less ($P < .10$) feed per pound of gain than those fed the antibiotic-treated silage rations.

Condition grades of the heifers remained about the same during all three wintering periods. The first and second year studies showed no significant differences ($P > .10$) in condition grade change, while the third year study indicated that heifers fed the corn silage ration had a significantly greater ($P < .05$) condition grade change than heifers fed the alfalfa silage rations.

II. DIGESTION TRIALS

Steers

1961-1962. Chemical composition and digestion coefficients of silages fed to the steers during the first and second digestion trials are summarized in Tables XV and XVI, respectively. Chemical composition of the silages was more variable between trials than between silages within trials, but most digestion coefficients were similar between trials. Average daily dry matter intake of steers fed the corn silages supplemented with 1 pound of cottonseed meal was approximately 0.5 to 1 pound higher than that of those steers fed similarly supplemented alfalfa silages.

TABLE XV

PROXIMATE COMPOSITION AND DIGESTIBILITY BY STEERS OF CONTROL
AND ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES
SUPPLEMENTED WITH COTTONSEED MEAL, 1961-62

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a				
Dry matter	24.03	24.45	25.50	25.52
Crude protein	2.51	2.57	3.91	3.63
Crude fiber	6.60	6.68	9.25	9.80
Nitrogen-free extract	13.32	13.50	9.17	9.01
Ether extract	0.60	0.66	0.85	0.68
Ash	0.99	1.04	2.32	2.41
Kilocalories/gm.	4.34	4.32	4.35	4.37
No. of calves	3	3	3	3
Ave. wt. of calves, lbs.	535	528	533	538
Ave. daily silage consumption, lb.				
Fresh basis	24.76	23.24	19.16	18.42
Air-dry basis	6.17	5.94	5.08	4.93
Ave. daily CSM consumption, lb.	1.00	1.00	1.00	1.00
Digestibility of rations, %				
Dry matter	69.39	68.97	54.66	50.80
Crude protein	68.64	67.43	66.77	61.55
Crude fiber	63.96	64.17	45.89	42.19
Ether extract	83.76	81.47	68.87	62.96
Nitrogen-free extract	74.94	74.48	57.52	54.35
Energy	68.89	68.62	54.33	49.57
TDN, %				
Fresh basis	18.94	19.23	15.46	14.28
Air-dry basis	70.81	70.44	53.47	49.16
Caloric value of TDN (K-cal/lb.)	1926	1947	2044	2071

^aComposition of cottonseed meal, %: dry matter, 94.34; crude protein, 41.37; crude fiber, 14.38; nitrogen-free extract, 29.19; ether extract, 3.40; ash, 6.00; kilocalories/gm., 4.85.

TABLE XVI

PROXIMATE COMPOSITION AND DIGESTIBILITY BY STEERS OF CONTROL
AND ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES
SUPPLEMENTED WITH COTTONSEED MEAL, 1961-62

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a				
Dry matter	22.38	23.00	24.30	23.08
Crude protein	1.87	1.90	2.26	2.09
Crude fiber	6.43	6.81	9.11	8.83
Nitrogen-free extract	12.62	12.95	10.47	9.77
Ether extract	0.55	0.50	0.52	0.43
Ash	0.90	0.84	1.95	1.96
Kilocalories/gm.	4.29	4.35	4.26	4.30
No. of calves	3	3	3	3
Ave. wt. of calves, lbs.	530	521	518	512
Ave. daily silage consumption, lb.				
Fresh basis	23.02	22.86	19.95	19.86
Air-dry basis	5.15	5.26	4.85	4.58
Ave. daily CSM consumption, lb.	1.00	1.00	1.00	1.00
Digestibility of rations, %				
Dry matter	69.35	69.16	54.42	52.13
Crude protein	65.99	65.63	58.85	61.07
Ether extract	88.25	86.19	67.71	60.94
Nitrogen-free extract	74.27	73.67	59.79	56.92
Energy	68.86	68.80	53.78	52.81
TDN, %				
Fresh basis	18.04	18.96	14.85	13.69
Air-dry basis	71.16	70.36	53.73	51.73
Caloric value of TDN (K-cal/lb.)	1900	1965	1918	2036

^aComposition of cottonseed meal, %: dry matter, 94.34; crude protein, 41.37; crude fiber, 14.38; nitrogen-free extract, 29.19; ether extract, 3.40; ash, 6.00; kilocalories/gm., 4.85.

A comparison of the two trials conducted during 1961-62 indicates a significant difference in the amount of digestible crude protein ($P < .05$), crude fiber ($P < .10$), and total digestible nutrients ($P < .10$) of the silages, which could probably be attributed to extreme variation in the nutrient content of the same silage types at different locations in the silo. On a within trial basis, there was a highly significant difference ($P < .01$) in digestibility of the dry matter, crude protein, crude fiber, ether extract, nitrogen-free extract, and energy of corn silage rations as compared to the digestibility of these same constituents of alfalfa silage rations. With the exception of ether extract, digestion coefficients of the control and antibiotic-treated silage rations were similar ($P > .10$). There was an indication that ether extract of the silage rations was more digestible during the second trial than the first trial, but ether extract of the antibiotic-treated alfalfa silage ration was not as digestible as that of the antibiotic-treated corn silage ration. This variation might be attributed to fluctuation of the metabolic fat excretion.

Total digestible nutrient content of the corn silage rations was significantly greater ($P < .01$) than that of the alfalfa silage rations, but there was a significant interaction ($P < .10$) since the per cent of total digestible nutrients of the antibiotic-treated corn silage ration was higher than that of the control corn silage ration with an inverse relationship occurring for the alfalfa silage rations. Digestion coefficients were not affected by the different weight groups of steers used in both experiments. Mean squares for the digestion coefficients

of the silages supplemented with cottonseed meal are shown in Table XVII.

1962-1963. Chemical composition and digestibility of the silages fed during the first 1962-63 digestion trial are summarized in Table XVIII. Average daily dry matter intake of steers fed the corn silage supplemented with 1 pound of cottonseed meal was approximately 0.5 pound greater than that of steers fed the alfalfa silage rations. Digestibility of the dry matter, crude fiber, ether extract, nitrogen-free extract, and energy of the corn silage rations was significantly greater ($P < .01$) than digestibility of these constituents in the alfalfa silage rations. However, the differences in the crude protein digestibility were not statistically significant ($P > .10$).

The antibiotic preservative had little effect on digestibility of the nutrients in the silages, with the exception of nitrogen-free extract of the control silages which was digested to a greater extent ($P < .10$) than that of the antibiotic-treated silages. Per cent digestible energy and total digestible nutrients (air-dry basis) were similar on a within silage basis for this trial, as well as for the first year study, which illustrates the close relationship between digestible energy and total digestible nutrients. Digestion coefficients obtained for each silage from the three weight groups were not statistically significant ($P > .10$), as shown in Table XIX.

Chemical composition and digestibility of the silage rations fed during the second digestion trial are summarized in Table XX. Average daily dry matter intake of the steers was approximately the same for all

TABLE XVII

MEAN SQUARES FOR DIGESTIBILITY COEFFICIENTS OF SILAGES SUPPLEMENTED
WITH CSM, CATTLE DIGESTION TRIALS 1 AND 2, 1961-62

Source of Variation	df	Mean Square						
		DDM	DCP	DCF	DEE	DNFE	TDN DE	
Trials (T)	1	0.60	62.08*	64.68 ⁺	13.80	4.00	3.53 ⁺	2.28
Silages (G)	1	1577.88**	142.10**	2016.67**	2352.24**	1771.60**	101.68**	1548.83**
Preservative (A)	1	17.34	7.70	6.20	109.22**	18.73	1.04	12.33
Weight (W)	2	17.07	7.54	38.13	4.18	10.02	0.35	14.18
T x C	1	0.33	5.80	17.34	57.66**	15.05	0.24	1.60
T x A	1	1.21	26.04	3.38	0.17	0.01	0.01	5.04
T x W	2	9.69	0.10	24.54	6.28	6.08	0.36	7.15
C x A	1	10.94	0.82	12.33	26.04 ⁺	9.13	3.09 ⁺	9.62
C x W	2	5.80	3.00	5.62	5.52	5.50	0.47	4.18
A x W	2	13.17	4.60	12.50	12.76	11.86	0.87	10.35
Residual	9	14.81	12.26	21.11	5.04	8.28	0.62	13.21
Pooled	18	11.28	8.80	17.13		8.09	0.68	9.92

**Significant at P = 0.01.

*Significant at P = 0.05.

⁺Significant at P = 0.10.

TABLE XVIII

PROXIMATE COMPOSITION AND DIGESTIBILITY BY STEERS OF CONTROL
AND ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES
SUPPLEMENTED WITH COTTONSEED MEAL, 1962-63

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a				
Dry matter	26.31	25.64	22.81	23.09
Crude protein	2.36	2.49	3.73	3.82
Crude fiber	6.32	6.03	6.98	7.37
Nitrogen-free extract	15.97	15.25	8.78	8.64
Ether extract	0.72	0.73	0.93	0.91
Ash	0.94	1.14	2.39	2.36
Kilocalories/gm.	4.46	4.41	4.71	4.68
No. of calves	3	3	3	3
Ave. wt. of calves, lbs.	524	522	519	528
Ave. daily silage consumption, lb.				
Fresh basis	19.90	19.79	20.00	19.50
Air-dry basis	5.51	5.34	4.86	4.77
Ave. daily CSM consumption, lb.	1.00	1.00	1.00	1.00
Digestibility of rations, %				
Dry matter	71.07	68.40	59.00	56.99
Crude protein	59.69	64.91	64.39	62.98
Crude fiber	62.18	61.44	45.98	45.96
Ether extract	88.37	88.71	71.57	68.48
Nitrogen-free extract	77.22	74.01	65.16	62.96
Energy	69.78	68.43	60.14	57.34
TDN, %				
Fresh basis	20.73	20.17	14.84	14.61
Air-dry basis	70.57	70.22	57.06	55.48
Caloric value of TDN (K-cal/lb.)	2024	1976	2147	2140

^aComposition of cottonseed meal, %: dry matter, 89.86; crude protein, 30.80; crude fiber, 14.78; nitrogen-free extract, 39.44; ether extract, 2.92; ash, 5.04; kilocalories/gm., 4.80.

TABLE XIX
 MEAN SQUARES FOR DIGESTIBILITY COEFFICIENTS OF SILAGES SUPPLEMENTED
 WITH CSM, CATTLE DIGESTION TRIAL 1, 1962-63

Source of Variation	df	Mean Square					
		DDM	DCP	DCF	DEE	DNFE	TDN DE
Silage (C)	1	436.82**	6.02	753.67**	1028.60**	401.37**	84.27**
Preservative (A)	1	11.61	10.64	0.52	5.47	21.87*	3.63
Weight (W)	2	1.08	0.78	6.69	1.42	5.31	0.68
C x A	1	1.32	32.34	0.37	8.84	0.75	0.16
C x W	2	7.16	11.91	10.02	2.90	5.76	1.17
A x W	2	0.06	2.81	7.93	2.19	1.22	0.54
Residual	2	6.61	15.62	13.65	12.41	10.00	1.88
Pooled	7	4.14	13.29	9.08	6.26	4.96	1.05

**Significant at $P = 0.01$.

*Significant at $P = 0.10$.

TABLE XX

PROXIMATE COMPOSITION AND DIGESTIBILITY BY STEERS OF CONTROL AND
ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES SUPPLEMENTED
WITH THE CONCENTRATE MIXTURE, 1962-63

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a				
Dry matter	24.92	24.36	23.23	23.86
Crude protein	2.12	2.26	4.37	4.41
Crude fiber	6.09	6.14	7.26	7.83
Nitrogen-free extract	14.93	14.31	8.03	8.30
Ether extract	0.79	0.71	1.10	1.02
Ash	1.02	0.95	2.46	2.29
Kilocalories/gm.	4.60	4.62	4.84	4.90
No. of calves	3	3	3	3
Ave. wt. of calves, lbs.	554	551	563	524
Ave. daily silage consumption, lb.				
Fresh basis	19.51	19.90	20.00	19.56
Air-dry basis	5.27	5.25	5.15	5.12
Ave. daily conc. consumption, lb.	4.00	4.00	4.00	4.00
Digestibility of rations, %				
Dry matter	72.49	71.06	67.26	66.43
Crude protein	75.56	74.37	75.78	74.07
Crude fiber	60.71	59.33	45.49	47.98
Ether extract	86.53	84.74	75.03	70.86
Nitrogen-free extract	77.54	76.15	75.88	74.56
Energy	71.79	69.90	66.29	66.33
TDN, %				
Fresh basis	27.53	27.50	24.69	24.77
Air-dry basis	79.37	77.98	71.99	70.73
Caloric value of TDN (K-cal/lb.)	1859	1851	1951	2003

^aComposition of corn:cottonseed meal (4:1), %: dry matter, 89.52; crude protein, 15.07; crude fiber, 4.09; nitrogen-free extract, 63.44; ether extract, 3.50; ash, 3.42; kilocalories/gm., 4.45.

the silage rations, but steers fed the corn silage supplemented with 4.0 pounds of a concentrate mixture digested significantly more ($P < .01$) dry matter than those fed the similarly supplemented alfalfa silages. With the exception of crude protein, other components in the corn silage rations were significantly more digestible ($P < .05$) than those in the alfalfa silage rations. Addition of concentrates to these silages did not decrease the digestibility of the crude fiber as might have been expected. The corn silage rations contained a significantly greater ($P < .01$) amount of total digestible nutrients than did the alfalfa silage rations.

There were no significant differences ($P > .10$) for digestion coefficients obtained from the three weight groups represented within the silage treatments, but lighter calves digested significantly more dry matter ($P < .10$) and nitrogen-free extract ($P < .05$) than did heavier calves fed the corn silage rations, as compared to the same digestibility coefficients obtained from the light and heavy calves fed the alfalfa silage rations. Mean squares for digestion coefficients obtained during the second digestion trial are shown in Table XXI.

1963-1964. Chemical composition and digestibility of the silages fed to the steers during the first digestion trial are summarized in Table XXII. Average daily dry matter intake was similar for all silage rations, but steers fed the corn silage supplemented with 1 pound of cottonseed meal digested significantly more ($P < .05$) dry matter than did steers fed the similarly supplemented alfalfa silages. Crude protein of

TABLE XXI

MEAN SQUARES FOR DIGESTIBILITY COEFFICIENTS OF SILAGES SUPPLEMENTED
WITH CONCENTRATE MIXTURE, CATTLE DIGESTION TRIAL 2, 1962-63

Source of Variation	df	Mean Square						
		DDM	DCP	DCF	DEE	DNFE	TDN	DE
Silage (C)	1	72.52**	4.20	528.02**	482.60**	7.68*	32.67**	62.10*
Preservative (A)	1	3.97	0.24	0.97	26.70*	5.61*	0.66	2.71
Weight (W)	2	2.08	0.02	4.63	6.24	2.62	0.56	3.50
C x A	1	0.30	6.02	11.20	4.20	0.00	0.96	5.85
C x W	2	14.28*	7.66	8.58	1.26	13.87*	0.22	7.48
A x W	2	4.18	1.66	27.56	4.08	0.08	1.24	6.27
Residual	2	1.36	2.52	27.40	1.85	0.36	0.72	5.02
Pooled	7	5.71	4.24	19.76	2.68		0.76	6.20

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

+Significant at $P = 0.10$.

TABLE XXII

PROXIMATE COMPOSITION AND DIGESTIBILITY BY STEERS OF CORN SILAGE
AND CONTROL AND ANTIBIOTIC-TREATED ALFALFA SILAGE
SUPPLEMENTED WITH COTTONSEED MEAL, 1963-64

	Corn Silage (No Preservative)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition,% ^a			
Dry matter	21.43	20.07	19.55
Crude protein	2.12	2.82	2.75
Crude fiber	5.85	7.81	7.57
Nitrogen-free extract	11.91	4.71	6.55
Ether extract	0.55	0.59	0.68
Ash	1.00	2.38	1.99
Kilocalories/gm.	4.54	4.92	4.88
No. of calves	3	3	3
Ave. wt. of calves, lbs.	463	460	463
Ave. daily silage consumption, lb.			
Fresh basis	21.76	23.08	23.66
Air-dry basis	4.93	5.02	4.97
Ave. daily CSM consumption, lb.	1.00	1.00	1.00
Digestibility of rations, %			
Dry matter	62.29	52.96	56.11
Crude protein	60.66	61.55	64.36
Crude fiber	59.89	43.23	46.40
Ether extract	81.99	54.59	57.96
Nitrogen-free extract	66.04	57.55	60.75
Energy	61.63	53.67	56.02
TDN, %			
Fresh basis	16.09	11.33	11.93
Air-dry basis	65.64	49.16	53.02
Caloric value of TDN (K-cal/lb.)	1963	2443	2346

^aComposition of cottonseed meal, %: dry matter, 92.20; crude protein, 39.90; crude fiber, 11.75; nitrogen-free extract, 31.10; ether extract, 4.06; ash, 5.39; kilocalories/gm., 4.97.

the alfalfa silage rations was slightly more digestible than that of the corn silage ration, but these differences were not significant ($P > .10$). There was a highly significant difference in digestibility of crude fiber ($P < .01$), ether extract ($P < .01$), nitrogen-free extract ($P < .05$), and energy ($P < .05$) of the corn silage ration, as compared to digestibility of these same nutrients in the alfalfa silage rations. The per cent of total digestible nutrients of the corn silage ration was significantly greater ($P < .01$) than that of the alfalfa silage rations, as would be expected. Total digestible nutrients of the silage rations were somewhat lower than those reported in the previous year's work, which can probably be attributed to dry matter content of the forages at ensiling time. Mean squares for the digestion coefficients of the silage rations are shown in Table XXIII.

Chemical composition and digestion coefficients for the silage rations fed during the second digestion trial are summarized in Table XXIV. Dry matter content of the control and antibiotic-treated alfalfa silages were much lower than those reported during the first digestion trial, but dry matter content of the corn silage fed during the second trial was higher.

Average daily dry matter intake of steers fed the corn silage supplemented with 4 pounds of concentrate was approximately 1.5 pounds greater than that of those fed similarly supplemented alfalfa silages. Even though there were large differences in daily dry matter intake, digestible dry matter and energy were significantly greater for the corn silage ration. Crude protein of the corn silage ration was slightly more

TABLE XXIII
MEAN SQUARES FOR DIGESTION COEFFICIENTS OF SILAGES SUPPLEMENTED WITH
COTTONSEED MEAL AND WITH CONCENTRATES, ALL TRIALS, 1963-64

Source of Variation	df	Mean Square					
		DDM	DCP	DCF	DEE	DNFE	TDN
Cattle trial 1 Treatment	2	67.79*	11.39	235.02**	669.84**	55.29*	20.52**
Silage + CSM	6	6.78	7.76	15.32	12.62	6.07	0.43
Cattle trial 2 Treatment	2	76.06*	10.12 ⁺	550.05**	50.13	13.48	49.42**
Silage + conc. Animals/treatments	6	9.55	4.87	13.19	10.51	11.07	2.93
Sheep trial 1 Treatment	2	21.79	41.08**	26.94	631.78**	45.56 ⁺	9.16**
Silage + CSM	6	7.10	2.93	21.71	32.68	9.36	0.26
Sheep trial 2 Treatment	2	88.02**	4.48	798.87**	288.70**	5.20	68.20**
Silage + conc. Animals/treatments	6	5.94	3.54	24.08	4.52	3.57	1.36
							7.07

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

⁺Significant at $P = 0.10$.

TABLE XXIV

PROXIMATE COMPOSITION AND DIGESTIBILITY BY STEERS OF CORN SILAGE AND
CONTROL AND ANTIBIOTIC-TREATED ALFALFA SILAGE SUPPLEMENTED
WITH THE CONCENTRATE MIXTURE, 1963-64

	Corn Silage (No Preservative)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a			
Dry matter	23.73	15.79	16.48
Crude protein	2.13	2.21	2.46
Crude fiber	6.21	6.32	6.52
Nitrogen-free extract	13.83	4.96	5.33
Ether extract	0.55	0.48	0.51
Ash	1.00	1.82	1.66
Kilocalories/gm.	4.38	4.86	4.91
No. of calves	2	3	3
Ave. wt. of calves, lbs.	474	484	468
Ave. daily silage consumption, lb.			
Fresh basis	19.40	19.89	18.13
Air-dry basis	4.95	3.50	3.31
Ave. daily conc. consumption, lb.	4.00	4.00	4.00
Digestibility of rations, %			
Dry matter	77.07	66.04	68.79
Crude protein	71.52	67.45	69.73
Crude fiber	69.54	41.53	43.58
Ether extract	83.66	75.10	75.93
Nitrogen-free extract	81.28	76.60	79.16
Energy	76.22	66.15	68.24
TDN, %			
Fresh basis	27.24	18.36	20.20
Air-dry basis	78.49	65.84	68.98
Caloric value of TDN (K-cal/lb.)	2010	2201	2171

^aComposition of concentrate mixture, %: dry matter, 87.94; crude protein, 17.58; crude fiber, 3.46; nitrogen-free extract, 60.82; ether extract, 3.76; ash, 2.32; kilocalories/gm., 4.79.

digestible ($P < .10$) than that of the alfalfa silage rations, but digestibility of the nitrogen-free extract and ether extract was not significantly different ($P > .10$) for all three rations. Crude fiber digestibility of the alfalfa silage rations was significantly lower ($P < .01$) than that of the corn silage ration. However, when the high energy concentrate was added, the per cent digestible crude fiber in the corn silage ration fed during the second digestion trial was approximately 15 per cent lower than that for the first digestion trial, while digestible crude fiber of the alfalfa silage rations remained approximately the same after the addition of the high energy concentrate. The per cent total digestible nutrients of the corn silage ration was significantly greater than ($P < .01$) that of the alfalfa silage rations. Digestion coefficients of the antibiotic-treated alfalfa silage ration are slightly higher than those of the control alfalfa silage ration, but, as shown in Table XXIII, these differences were not significant ($P > .10$).

Summary. Average daily dry matter intake of steers fed the corn silage supplemented with 1 pound of cottonseed meal was considerably higher than that of steers fed similarly supplemented alfalfa silage, and dry matter digestibility of the corn silage rations was significantly higher ($P < .05$) than that of the alfalfa silage rations. Although the second and third year digestion trials indicated no significant difference in crude protein digestibility of the corn and alfalfa silage rations, the first year study indicated that crude protein of the corn silage rations was more digestible than that of the alfalfa silage rations which

could be attributed to the quality of the alfalfa silage used in the first year trial. All three years' studies indicated that crude fiber, ether extract, nitrogen-free extract, and energy were more digestible in the corn silage rations than those same components in the alfalfa silage rations, and, due to the higher digestion coefficients obtained for the corn silage rations, there was a significantly greater per cent of total digestible nutrients in the corn silage rations. The antibiotic preservative did not significantly increase or decrease digestibility of the nutrients in the corn and alfalfa silages.

As chemical composition of the silages supplemented with a concentrate mixture during the second and third year digestion trials were quite variable, a year to year comparison was less valid. Average daily dry matter intake was similar for all steers during the second year, but steers fed the corn silage ration during the third year consumed about 1.5 pounds more dry matter per day than steers fed the alfalfa silage rations. Dry matter, crude fiber, and energy of corn silage rations were more digestible than the same components of the alfalfa silage rations. Due to the differences in chemical composition of the silages fed during the second and third years, the digestibility of crude protein, ether extract, and nitrogen-free extract were quite variable from year to year, and a definite trend could not be established. Even though the energy content of the silage rations was increased with the addition of a concentrate mixture, total digestible nutrients of the corn silage rations were significantly higher ($P < .01$) than those of the alfalfa silage rations. The antibiotic preservative lowered the

digestibility of the ether extract and nitrogen-free extract of both the alfalfa and corn silage rations, but had no effect on digestibility of the other nutrients or the total digestible nutrients.

Sheep

1962-1963. As shown in Table XXV, chemical composition and digestion coefficients for the silages fed to the wethers were quite similar to those silages fed to the steers. Average daily dry matter intake of the wethers was approximately equal for all the silage treatments, but there was a significant difference ($P < .01$) in dry matter digestibility of the corn silage supplemented with cottonseed meal, as compared to the dry matter digestibility of similarly supplemented alfalfa silage. Crude protein of the alfalfa silage rations was digested to a greater extent than that of the corn silage rations, but crude fiber ($P < .05$), ether extract ($P < .01$), and nitrogen-free extract ($P < .01$) of the corn silage rations were more digestible than those same components of the alfalfa silage rations. Since most nutrients in the corn silage rations were more digestible than those in the alfalfa silage rations, the per cent total digestible nutrients and digestible energy was significantly higher ($P < .01$) in the corn silage rations. There were small differences in digestion coefficients for the nutrients in the control and antibiotic-treated silage rations, but these were not statistically significant ($P > .10$), as shown in Table XXVI.

Chemical composition and digestion coefficients for silage rations fed to the wethers during the second digestion trial are summarized in

TABLE XXV

PROXIMATE COMPOSITION AND DIGESTIBILITY BY WETHERS OF CONTROL AND
ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES SUPPLEMENTED
WITH COTTONSEED MEAL, 1962-63

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a				
Dry matter	25.46	25.37	24.05	23.88
Crude protein	2.27	2.09	4.25	4.47
Crude fiber	5.92	6.27	7.23	7.19
Nitrogen-free extract	15.56	15.45	9.10	8.74
Ether extract	0.70	0.66	1.06	1.14
Ash	1.00	0.90	2.40	2.34
Kilocalories/gm.	4.39	4.43	4.60	4.71
No. of wethers	3	3	3	3
Ave. wt. of wethers	76	77	79	76
Ave. daily silage consumption, lb.				
Fresh basis	5.08	4.78	5.79	5.34
Air-dry basis	1.37	1.29	1.47	1.36
Ave. daily CSM consumption, lb.	0.50	0.50	0.50	0.50
Digestibility of rations, %				
Dry matter	62.44	64.42	55.81	57.24
Crude protein	65.24	61.02	65.96	68.34
Crude fiber	47.12	53.89	40.08	42.58
Ether extract	83.99	84.44	68.54	66.98
Nitrogen-free extract	69.52	71.41	62.69	61.94
Energy	62.72	65.05	56.64	58.18
TDN, %				
Fresh basis	20.04	20.87	16.22	14.32
Air-dry basis	64.28	66.38	55.47	56.64
Caloric value of TDN (K-cal/lb.)	1992	2014	2153	2204

^aComposition of cottonseed meal, %: dry matter, 89.86; crude protein, 30.80; crude fiber, 14.78; nitrogen-free extract, 39.44; ether extract, 2.92; ash, 5.04; kilocalories/gm., 4.80.

TABLE XXVI
 MEAN SQUARES FOR DIGESTION COEFFICIENTS OF SILAGES SUPPLEMENTED
 WITH CSM, SHEEP DIGESTION TRIAL 1, 1962-63

Source of Variation	df	Mean Squares					
		DIM	DCP	DCF	DEE	DNEE	TDN
Silage (C)	1	142.83**	69.60*	252.17*	813.46**	198.45**	48.00**
Preservative (A)	1	8.67	0.07	65.42	0.97	0.96	1.47
Weight (W)	2	1.38	9.30	4.40	5.61	1.08	0.69
C x A	1	0.22	19.51	13.56	2.99	5.08	0.12
C x W	2	1.36	8.66	6.27	2.67	1.42	0.32
A x W	2	1.47	2.12	2.52	4.53	6.02	0.54
Residual	2	21.46	3.46	79.43	4.74	20.52	2.69
Pooled	7	6.97	6.86	27.14	3.84	8.72	1.03

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

Table XXVII. The average daily dry matter intake of wethers fed the control corn, control alfalfa, and antibiotic-treated alfalfa silages was approximately the same, but that of the antibiotic-treated corn silage ration was much lower due to animal variation. The amount of silage dry matter consumed decreased with the increase in concentrate level, but the total dry matter intake was very nearly the same for trials one and two.

Digestible dry matter ($P < .01$), ether extract ($P < .01$), and nitrogen-free extract ($P < .05$) of the corn silage rations were significantly higher than those of the alfalfa silage rations, but digestible crude protein of the alfalfa silage rations was significantly higher ($P < .05$) than that of the corn silage rations. This difference was also evident when the silages were supplemented with cottonseed meal. Although there were no significant differences ($P > .10$) in digestible crude fiber of the corn and alfalfa silage rations, the total digestible nutrients and digestible energy of the alfalfa silage rations were significantly lower ($P < .01$) than those of the corn silage rations. Digestible crude fiber of the antibiotic-treated silage rations was significantly higher ($P < .01$) than that of the control silage rations, and wethers of the light weight groups digested more crude fiber in the antibiotic-treated silage rations than did the heavier wethers. However, the ether extract portion of the antibiotic-treated silage rations was not digested as extensively as that of the control silage rations. Weight of the experimental animals also affected the amount of nitrogen-free extract digested, as lighter weight wethers digested significantly more

TABLE XXVII

PROXIMATE COMPOSITION AND DIGESTIBILITY BY WETHERS OF CONTROL AND
ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES SUPPLEMENTED
WITH THE CONCENTRATE MIXTURE, 1962-63

	Corn Silage (Control)	Corn Silage (Zinc Bacitracin)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a				
Dry matter	24.92	24.36	23.23	23.86
Crude protein	2.12	2.26	4.37	4.41
Crude fiber	6.09	6.14	7.26	7.83
Nitrogen-free extract	14.93	14.31	8.03	8.30
Ether extract	0.79	0.71	1.10	1.02
Ash	1.02	0.95	2.46	2.29
Kilocalories/gm.	4.60	4.62	4.84	4.90
No. of wethers	3	3	3	2
Ave. wt. of wethers	71	76	74	71
Ave. daily silage consumption, lb.				
Fresh basis	3.73	3.11	4.00	3.94
Air-dry basis	1.01	0.82	1.03	1.03
Ave. daily conc. consumption, lb.	0.80	0.80	0.80	0.80
Digestibility of rations, %				
Dry matter	72.19	74.26	68.73	69.01
Crude protein	64.14	64.91	70.23	68.84
Crude fiber	47.46	55.21	44.69	49.79
Ether extract	85.12	81.58	71.90	67.03
Nitrogen-free extract	80.61	82.13	79.70	79.54
Energy	71.67	73.58	68.06	67.84
TDN, %				
Fresh basis	26.98	28.92	23.62	22.89
Air-dry basis	74.07	76.40	68.69	65.37
Caloric value of TDN (K-cal/lb.)	1992	1978	2100	2211

^aComposition of corn:cottonseed meal (4:1), %: dry matter, 89.52; crude protein, 15.07; crude fiber, 4.09; nitrogen-free extract, 63.44; ether extract, 3.50; ash, 3.42; kilocalories/gm., 4.45.

($P < .10$) nitrogen-free extract than medium and heavy weight wethers, but digestive ability of the wethers was probably due to animal variation rather than to animal weight. Mean squares for digestion coefficients of the silages supplemented with the concentrate mixture are shown in Table XXVIII.

1963-1964. The three treatments involved in the third year study were corn silage with no preservative, control alfalfa silage, and antibiotic-treated alfalfa silage, and the chemical composition and digestion coefficients of these are shown in Table XXIX. Average daily dry matter intake, digestible dry matter, crude fiber, and energy of the corn and alfalfa silage rations were not significantly different ($P > .10$) when the silages were supplemented with cottonseed meal, but digestible crude protein of the antibiotic-treated alfalfa silage ration was significantly higher ($P < .01$) than that of the corn silage and control alfalfa silage rations. Digestible nitrogen-free extract and total digestible nutrients of the corn silage were significantly higher ($P < .01$) than those of the control and antibiotic-treated alfalfa silage rations. Digestion coefficients for nutrients in the antibiotic-treated alfalfa silage ration were slightly higher than those of the control alfalfa silage ration, but most differences were not significant, as shown in Table XXIII.

Chemical composition and digestion coefficients for silages supplemented with the concentrate mixture are summarized in Table XXX. Average daily dry matter intake of wethers fed the corn silage

TABLE XXVIII
 MEAN SQUARES FOR DIGESTION COEFFICIENTS OF SILAGES SUPPLEMENTED WITH
 CONCENTRATE MIXTURE, SHEEP DIGESTION TRIAL 2, 1962-63

Source of Variation	df	Mean Squares						
		DM	DCP	DCP	DCP	DEE	DNFE	TDN
Silage (C)	1	57.20**	81.64*	39.61	648.21**	11.80*	81.12**	64.40**
Preservative (A)	1	4.08	0.04	141.46**	75.00 ⁺	1.69	3.63	2.25
Weight (W)	2	6.94	5.82	7.43	29.77	7.50*	5.73	8.30
C x A	1	2.44	2.34	2.24	6.75	3.52	9.72	3.21
C x W	2	2.62	10.41	9.08	13.89	1.44	3.98	2.48
A x W	1	2.67	18.65	13.81 ⁺	1.80	1.14	3.16	3.46
Residual	2	1.36	3.36	4.49	23.97	0.32	1.36	1.66
Pooled	6	2.18	10.04	7.37	14.04	1.36	3.93	2.49

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

⁺Significant at $P = 0.10$.

TABLE XXIX

PROXIMATE COMPOSITION AND DIGESTIBILITY BY WETHERS OF CORN SILAGE
AND CONTROL AND ANTIBIOTIC-TREATED ALFALFA SILAGE
SUPPLEMENTED WITH COTTONSEED MEAL, 1963-64

	Corn Silage (No Preservative)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a			
Dry matter	21.43	20.07	19.55
Crude protein	2.12	2.82	2.75
Crude fiber	5.85	7.81	7.57
Nitrogen-free extract	11.91	4.71	6.55
Ether extract	0.55	0.59	0.68
Ash	1.00	2.38	1.99
Kilocalories/gm.	4.54	4.92	4.88
No. of wethers	3	3	3
Ave. wt. of wethers	100	99	105
Ave. daily silage consumption, lb.			
Fresh basis	8.73	8.93	8.94
Air-dry basis	1.98	1.94	1.88
Ave. daily CSM consumption, lb.	0.35	0.35	0.35
Digestibility of rations, %			
Dry matter	59.16	53.92	57.67
Crude protein	59.53	62.60	66.91
Crude fiber	50.23	45.21	50.53
Ether extract	74.23	45.68	64.58
Nitrogen-free extract	65.69	58.52	59.28
Energy	60.30	55.90	57.74
TDN, %			
Fresh basis	14.59	11.29	12.29
Air-dry basis	60.49	49.65	55.16
Caloric value of TDN (K-cal/lb.)	2064	2543	2321

^aComposition of cottonseed meal, %: dry matter, 92.20; crude protein, 39.90; crude fiber, 11.75; nitrogen-free extract, 31.10; ether extract, 4.06; ash, 5.39; kilocalories/gm., 4.97.

TABLE XXX

PROXIMATE COMPOSITION AND DIGESTIBILITY BY WETHERS OF CORN SILAGE
AND CONTROL AND ANTIBIOTIC-TREATED ALFALFA SILAGE
SUPPLEMENTED WITH CONCENTRATE MIXTURE, 1963-64

	Corn Silage (No Preservative)	Alfalfa Silage (Kylage)	Alfalfa Silage (Zinc Bacitracin)
Composition, % ^a			
Dry matter	23.73	15.79	16.48
Crude protein	2.13	2.21	2.46
Crude fiber	6.21	6.32	6.52
Nitrogen-free extract	13.83	4.96	5.33
Ether extract	0.55	0.48	0.51
Ash	1.00	1.82	1.66
Kilocalories/gm.	4.38	4.86	4.91
No. of wethers	3	3	3
Ave. wt. of wethers	109	100	105
Ave. daily silage consumption, lb.			
Fresh basis	5.51	5.73	5.73
Air-dry basis	1.41	1.01	1.05
Ave. daily conc. consumption, lb.	1.20	1.20	1.20
Digestibility of rations, %			
Dry matter	71.92	62.00	62.08
Crude protein	64.86	64.52	66.83
Crude fiber	54.00	26.89	24.69
Ether extract	86.80	71.43	68.52
Nitrogen-free extract	79.84	77.35	77.80
Energy	71.28	62.48	63.16
TDN, %			
Fresh basis	26.30	17.73	18.18
Air-dry basis	74.46	62.69	63.00
Caloric value of TDN (K-cal/lb.)	1984	2181	2207

^aComposition of corn:cottonseed meal (4:1.5), %: dry matter, 87.94; crude protein, 17.58; crude fiber, 3.46; nitrogen-free extract, 60.82; ether extract, 3.76; ash, 2.32; kilocalories/gm., 4.79.

supplemented with the concentrate mixture was 20 per cent higher than that of the wethers fed similarly supplemented alfalfa silages; dry matter, crude fiber, and ether extract of corn silage rations were more extensively digested than those of the alfalfa silage rations ($P < .05$). Addition of the concentrate, which made up about one-half of the ration dry matter, reduced crude fiber digestibility of the alfalfa silage rations to approximately 25 per cent, as compared to 50 per cent when the silages were supplemented with cottonseed meal. Per cent digestible crude protein and nitrogen-free extract of the three silage rations was not statistically different ($P > .10$), but the per cent digestible energy ($P < .05$) and total digestible nutrients ($P < .01$) of the corn silage ration was significantly greater than that of the alfalfa silage rations. Digestion coefficients obtained for the components of the antibiotic-treated alfalfa silage ration were not significantly different ($P > .10$) from those of the control alfalfa silage ration when the silages were supplemented with the concentrate mixture. Mean squares for the digestion coefficients of the silages supplemented with the concentrate mixture are shown in Table XXIII.

Summary. Chemical composition of the silages fed to the wethers was quite variable from year to year, with the dry matter content being much lower during the third year. This wide range in chemical composition, along with the difference in ratio of concentrate dry matter to silage dry matter helps explain the variation in digestion coefficients obtained from year to year.

Digestion coefficients for the corn silage rations obtained during the first wether digestion trial the second year were significantly different ($P < .05$) from those of the alfalfa silage rations, but digestible dry matter, crude fiber, and energy of the three silage rations fed during the first trial the third year were not significantly different ($P > .10$). The antibiotic preservative had no significant effect on digestibility of nutrients in the silages, with the exception of crude protein of the antibiotic-treated alfalfa silage ration fed during the third year which was significantly more digestible ($P < .01$) than that of the control alfalfa silage ration. Both years' studies indicated that corn silage supplemented with cottonseed meal contained significantly more ($P < .01$) total digestible nutrients than did similarly supplemented alfalfa silages.

When approximately 50 per cent of the dry matter in the ration was derived from the concentrate mixture, digestible dry matter, ether extract, and energy were significantly higher ($P < .05$) for the corn silage rations than for the alfalfa silage rations. Differences in digestible crude protein and nitrogen-free extract of the silage rations fed during the third year were not statistically significant ($P > .10$), but nitrogen-free extract of the corn silage rations fed during the second year was more digestible than that of the alfalfa silage rations. Differences in crude fiber digestibility of the corn and alfalfa silage rations fed during the second year were not significant ($P > .10$), but crude fiber of the corn silage fed during the third year was more digestible. These results illustrate the variation in "direct cut" alfalfa silage that is

encountered from year to year. The antibiotic preservative did tend to increase the digestibility of the crude fiber of the silage supplemented with a concentrate mixture, but had no effect on digestibility of the other nutrients in the silage rations. Both years' studies indicated that corn silage supplemented with a concentrate mixture contained significantly more ($P < .01$) total digestible nutrients than did similarly supplemented alfalfa silages.

III. IN VITRO INVESTIGATIONS

1961-1962

Two experiments were conducted to determine the rumen microbial utilization of the silages with and without protein supplementation, using digestibility of cellulose in the silages as an indicator of microbial activity. Cellulose content of the silages and the per cent of cellulose digested are summarized in Table XXXI. The alfalfa silage had a significantly higher cellulose content ($P < .01$) than did the corn silage, and the antibiotic-treated silages had significantly more cellulose ($P < .05$) than did the control silages. However, actual difference in cellulose content of the silages was very small, and there was a significant difference ($P < .01$) in cellulose content of the silage samples taken at different sampling periods, as shown in Table XXXII.

Alfalfa silages supported significantly more microbial activity ($P < .05$), as determined by the amount of cellulose digested, than did corn silages, but digestibility of cellulose in the antibiotic-treated silages was not significantly different ($P > .10$) from that of the

TABLE XXXI

RUMEN MICROBIAL ACTIVITY SUPPORTED BY CONTROL AND ANTIBIOTIC-
TREATED CORN AND ALFALFA SILAGES, 1961-62

Silage	Sample	Per cent Cellulose ^b	Cellulose Digested, % ^a	
			No Supplement	+ CSM
Corn (control)	1	26.15	69.46	72.08
	2	28.21	70.57	72.16
	Ave.	27.18	70.02	72.12
Corn (zinc bacitracin)	1	26.68	72.44	73.84
	2	28.54	67.06	69.30
	Ave.	27.61	69.72	71.57
Alfalfa (kylage)	1	30.43	73.77	74.97
	2	32.95	71.45	71.12
	Ave.	31.69	72.61	73.04
Alfalfa (zinc bacitracin)	1	31.51	72.47	73.98
	2	34.07	68.30	72.66
	Ave.	32.79	70.38	73.32
CSM		12.34	--	--

^aEach figure is an average of four observations.

^bAir-dry basis.

TABLE XXXII
MEAN SQUARES FOR CELLULOSE CONTENT OF SILAGES, 1961-62

Source of Variation	df	Mean Squares
Silage (C)	1	47.05**
Preservative (A)	1	1.13*
Samples (S)	1	10.13**
A x C	1	0.24
C x S	1	0.24
A x S	1	0.00
Residual	1	0.01
Pooled	4	0.12

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

control silages. Addition of the protein supplement increased cellulose digestion of both the corn and alfalfa silages. However, this addition did not decrease the margin of digestible cellulose that existed between the corn and alfalfa silages without protein supplementation. The difference in per cent cellulose digested in sample one and sample two for each silage was statistically significant ($P < .01$) as shown in Table XXXIII.

1962-1963

Eight experiments were conducted to determine microbial utilization of the silages: two using silage samples without supplementation; two using silage samples supplemented with cottonseed meal; two using silage samples supplemented with the concentrate mixture; and two using pooled silage samples without supplementation, with cottonseed meal and with the concentrate mixture. Cellulose content of the silages and per cent of cellulose digested in the individual samples are summarized in Table XXXIV.

Cellulose content of the control and antibiotic-treated alfalfa silages was 30.90 and 33.35, respectively, as compared to 26.39 and 26.74 for the control and antibiotic-treated corn silage. There was an apparent silage-antibiotic interaction, since alfalfa silage treated with the antibiotic preservative contained significantly more cellulose ($P < .05$) than did similarly treated corn silage, and, as shown in Table XXXV, there was a significant difference ($P < .10$) between samples within silages which illustrates the variation in composition of a silage at different locations in the silo.

TABLE XXXIII
 MEAN SQUARES FOR IN VITRO CELLULOSE
 DIGESTIBILITY DATA, 1961-62

Source of Variation	df	Mean Squares
Silages	1	17.41*
Preservatives	1	3.78
Samples	1	51.51**
Supplement	1	27.01**
Residual	27	3.10
Within	16	2.37
Lack of fit	11	4.15

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

TABLE XXXIV

RUMEN MICROBIAL ACTIVITY SUPPORTED BY CONTROL AND ANTIBIOTIC-
TREATED CORN AND ALFALFA SILAGES, 1962-63

Silage	Sample	Cellulose Content, % ^b	Cellulose Digested, % ^a		
			Without Supplement	With CSM	With Concentrate
Corn (control)	I	27.32	33.94	32.18	50.92
	II	26.71	33.66	29.35	48.50
	III	26.06	27.64	29.50	48.54
	IV	25.48	26.10	29.09	46.72
	Ave.	26.39	30.34	30.03	48.67
Corn (zinc bacitracin)	I	25.39	30.66	31.31	47.84
	II	26.84	28.72	27.20	48.83
	III	27.50	27.86	28.98	46.98
	IV	27.22	28.17	27.82	47.44
	Ave.	26.74	28.85	28.83	47.77
Alfalfa (kylage)	I	31.95	48.24	49.30	61.02
	II	32.30	53.10	53.17	64.14
	III	29.71	50.58	50.32	64.34
	IV	29.66	50.07	51.54	62.10
	Ave.	30.90	50.50	51.08	62.90
Alfalfa (zinc bacitracin)	I	33.34	50.94	52.86	61.73
	II	35.20	56.04	56.71	65.52
	III	32.60	52.44	52.96	63.94
	IV	32.25	47.09	53.44	63.45
	Ave.	33.35	51.78	53.99	63.66
CSM		18.82			
Concentrate mixture		6.08			

^aEach figure is an average of two trials.

^bAir-dry basis.

TABLE XXXV
MEAN SQUARES FOR CELLULOSE CONTENT OF SILAGES, 1962-63

Source of Variation	df	Mean Squares
Silage (C)	1	123.77**
Preservative (A)	1	7.43*
Samples (S)	3	1.95*
C x A	1	4.30*
C x S	3	1.67
A x S	3	1.32
Residual	3	0.31

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

When reviewing Table XXXIV, it is important to compare only those values appearing in each column because each column represents the results of separate experiments. Regardless of the level of supplementation or trial, alfalfa silages supported significantly more microbial activity ($P < .01$) than did the corn silages, as indicated by the amount of cellulose digested. Even though there was a significant difference ($P < .05$) in the per cent of cellulose for the control and antibiotic-treated silages, the control silages did not support significantly more microbial activity ($P > .10$) than the antibiotic-treated silages. Per cent of digestible cellulose in each set of silage samples was not significantly different ($P > .10$), even though there was a significant difference in cellulose content of the samples.

There appeared to be an additive effect on the per cent of cellulose digested in the silages, but this was due to a highly significant difference ($P < .01$) between trials, as shown in Table XXXVI. Addition of the protein supplement and the concentrate mixture did not significantly decrease ($P > .10$) the margin of per cent cellulose digested existing between the corn and alfalfa silages without supplementation.

Each sample within a silage was pooled into a composite sample for that silage, and two in vitro trials were conducted to determine the effect of the supplements on microbial utilization of the silages, as shown in Table XXXVII. Regardless of supplementation, the alfalfa silages supported significantly more microbial activity ($P < .01$) than did the corn silage. Digestibility of cellulose in the antibiotic-treated silages was significantly higher ($P < .05$) than in the control silages,

TABLE XXXVI
 MEAN SQUARES FOR IN VITRO CELLULOSE
 DIGESTIBILITY DATA, 1962-63

Source of Variation	df	Mean Squares
Silage	1	9502.25**
Preservative	1	1.24
Sample	3	28.73
Trials	2	2430.74**
Residual	88	31.96
Within	48	14.16
Lack of fit	40	14.97

**Significant at $P = 0.01$.

TABLE XXXVII

IN VITRO RUMEN MICROBIAL DIGESTIBILITY OF THE CELLULOSE
OF POOLED SILAGE SAMPLES, 1962-63

Silage	Trial	Cellulose Content, % ^b	Cellulose Digested, % ^a		
			No Supplement	+ CSM	+ Conc.
Corn (control)	I	--	71.17	70.59	67.80
	II	--	74.04	71.92	71.62
	Ave.	25.20	<u>72.60</u>	<u>71.25</u>	<u>69.71</u>
Corn (zinc bacitracin)	I	--	72.25	70.70	69.18
	II	--	72.93	72.88	70.74
	Ave.	25.82	<u>72.59</u>	<u>71.79</u>	<u>69.96</u>
Alfalfa (kylage)	I	--	80.54	78.77	77.40
	II	--	80.42	77.98	77.80
	Ave.	29.04	<u>80.48</u>	<u>78.38</u>	<u>77.60</u>
Alfalfa (zinc bacitracin)	I	--	82.17	79.96	77.57
	II	--	80.22	80.32	79.60
	Ave.	31.74	<u>81.20</u>	<u>80.14</u>	<u>78.58</u>

^aEach figure is an average of two trials.

^bAir-dry basis.

which was not shown in previous trials. There was a significant ($P < .01$) silage-trial interaction due to a higher per cent of cellulose digested in trial two, as compared to trial one. Addition of the protein supplement and the concentrate mixture did not significantly ($P > .10$) alter the digestibility of cellulose in the silages. Mean squares for per cent of cellulose digested in the pooled samples are shown in Table XXXVIII.

1963-1964

Eight experiments, similar to those described for the second year with the exception that three silages were used, were conducted to determine microbial utilization. Cellulose content and per cent cellulose digested are summarized in Table XXXIX. Cellulose content of the alfalfa silages was significantly higher ($P < .05$) than that of corn silage, but the difference in cellulose content of the control and antibiotic-treated alfalfa silages was not significant ($P > .10$), as shown in Table XXXX.

Only that data appearing in each column of Table XXXIX should be compared, because each column represents the results of separate experiments. Alfalfa silages supported significantly more ($P < .01$) microbial activity than did corn silage, as indicated by the amount of cellulose digested, but the difference in cellulose digestibility of the control and antibiotic-treated alfalfa silages was not significant ($P > .10$). Addition of the protein supplement and the concentrate mixture did not significantly alter the margin of per cent of cellulose digested existing between the corn and alfalfa silages without supplementation, and

TABLE XXXVIII
 MEAN SQUARES FOR IN VITRO CELLULOSE DIGESTIBILITY
 DATA FROM POOLED SAMPLES, 1962-63

Source of Variation	df	Mean Squares
Silage (C)	1	392.85**
Preservative (A)	1	3.01*
Trial (T)	1	30.00**
Supplement (L)	2	0.63
C x A	1	1.26
C x T	1	6.51**
C x L	2	0.18
A x T	1	0.30
A x L	2	0.33
T x L	2	1.34
Residual	9	0.52

**Significant at $P = 0.01$.

*Significant at $P = 0.05$.

TABLE XXXIX

RUMEN MICROBIAL ACTIVITY SUPPORTED BY CONTROL CORN AND ALFALFA
SILAGES AND ANTIBIOTIC-TREATED ALFALFA SILAGE, 1963-64

Silage	Sample	Cellulose Content, % ^b	Cellulose Digested, % ^a		
			No Supplement	+ CSM	+ Conc.
Corn (no preservative)	I	26.91	38.03	40.59	29.36
	II	28.43	34.60	40.79	36.18
	III	26.75	33.43	36.92	32.12
	IV	30.19	35.22	41.42	37.62
	Ave.	28.07	35.32	39.93	33.82
Alfalfa (kylage)	I	33.47	45.25	48.79	47.08
	II	33.25	48.88	50.72	44.60
	III	27.70	50.29	46.70	35.56
	IV	34.35	46.48	51.11	51.11
	Ave.	32.19	47.72	49.33	44.56
Alfalfa (zinc bacitracin)	I	33.42	46.76	45.72	45.64
	II	34.52	48.82	47.08	42.90
	III	32.62	53.64	53.01	33.11
	IV	35.34	47.51	47.82	59.10
	Ave.	33.98	49.18	48.41	45.19
Cottonseed meal		13.34			
Concentrate		6.23			

^aEach figure is the average of two trials.

^bAir-dry basis.

TABLE XXXX
MEAN SQUARES FOR CELLULOSE CONTENT OF SILAGES, 1963-64

Source of Variation	df	Mean Squares
Treatment	2	36.40*
Samples/treatments	9	4.41'

*Significant at $P = 0.05$.

differences existing between trials were not statistically significant ($P > .10$), due to variations within trials.

Each sample within a silage was pooled into a composite sample, and two trials were conducted to determine the effect of supplements on cellulose digestibility, as shown in Table XXXXI. Alfalfa silages supported significantly more ($P < .01$) microbial activity than did corn silage, and the antibiotic preservative did not significantly increase or decrease cellulose digestion. Addition of the protein supplement and the concentrate mixture did not significantly alter ($P > .10$) cellulose digestibility of the silages. Mean squares for cellulose digestion of the pooled silage samples with and without supplementation are shown in Table XXXXII.

Summary

Cellulose content of the alfalfa silages was significantly higher ($P < .05$) than that of the corn silages, and the antibiotic-treated silages contained significantly more ($P < .05$) cellulose than did the control silages, with the exception of silages analyzed the third year. There was a significant difference ($P < .10$) in cellulose content of samples represented within each silage, illustrating variations in chemical composition of a silage at different locations in the silo.

Results of all experiments indicated that alfalfa silages supported more microbial activity than did corn silages, and that the antibiotic preservative had no effect on digestibility of cellulose. During the first year, there was a significant difference ($P < .01$) in

TABLE XXXXI

IN VITRO RUMEN MICROBIAL DIGESTIBILITY OF THE CELLULOSE
OF POOLED SILAGE SAMPLES, 1963-64

Silages	Trial	Cellulose Content, % ^b	Cellulose Digested, % ^a		
			No Supplement	+ CSM	+ Conc. ^c
Corn (control)	I	--	39.40	45.06	40.08
	II	--	41.65	42.18	38.46
	Ave.	27.84	40.52	43.62	39.27
Alfalfa (kylage)	I	--	49.97	48.34	51.38
	II	--	54.42	53.07	50.92
	Ave.	33.07	52.20	50.70	51.15
Alfalfa (zinc bacitracin)	I	--	50.48	47.54	51.17
	II	--	54.76	51.10	50.87
	Ave.	33.92	52.62	49.32	51.02

^aEach figure is the average of two trials.

^bAir-dry basis.

^cConcentrate is composed of 4 parts corn and 1.5 parts CSM.

TABLE XXXXI
 MEAN SQUARES FOR IN VITRO CELLULOSE DIGESTION OF
 POOLED SILAGE SAMPLES, 1963-64

Source of Variation	df	Mean Squares	
		Individual Samples	Pooled Samples
Treatments	2	488.82**	200.52**
Trials/silages	6	27.21	8.87
Samples/trials	27(9) ^a	23.25	2.87

**Significant at $P = 0.01$.

^aDegrees of freedom for samples/additions of pooled samples.

cellulose digestibility of the samples within each silage, but during the second and third years this difference was not statistically significant ($P > .10$).

As might be expected, there were significant differences ($P < .01$) between trials, but the same general trend occurred when comparing treatments within trials. Addition of the protein supplement significantly increased ($P < .01$) digestibility of the cellulose in the corn and alfalfa silages the first year, but there was no significant difference ($P > .10$) the second and third years.

IV. RELATIONSHIP OF TECHNIQUES

A summary of the nutritive evaluation of the control and antibiotic-treated corn and alfalfa silages supplemented with cottonseed meal, as determined by feedlot trials, digestion trials, and in vitro trials is shown in Table XXXXIII. All three years' work indicated that ✓
daily gains of steers fed the silages ad libitum supplemented with 1 ✓
pound of cottonseed meal per day in the feedlot were highly correlated to ✓
digestion coefficients determined by steers fed the same rations in the ✓
metabolism stalls. Even though there was only a small number of ✓
observations (seven degrees of freedom), digestible dry matter, crude
fiber, nitrogen-free extract, and energy were significantly correlated
to daily gains obtained in the feedlot, as shown in Table XXXXIV. A
significant correlation coefficient of 0.80 was obtained for average
daily gains in the feedlot, when compared to total digestible nutrients
of the silage rations; but crude protein digestibility of the silage

TABLE XXXXIII

A SUMMARY OF THE NUTRITIVE EVALUATION OF THE CONTROL AND ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES WHEN SUPPLEMENTED WITH COTTONSEED MEAL, AS DETERMINED BY FEEDLOT TRIALS, DIGESTION TRIALS, AND IN VITRO INVESTIGATIONS, 1961-64

	Control Corn	Antibiotic Corn (Zinc Bacitracin)	Control Alfalfa (Kylage)	Antibiotic Alfalfa (Zinc Bacitracin)				
Feedlot trials:								
No. of trials	2	2	3	3				
No. of animals	20	20	30	30				
ADG, lb.	1.28	1.23	0.91	0.80				
Av. silage consumption, lb. ^a	8.22	8.42	7.82	7.37				
Feed/lb. gain, lb.	8.94	9.46	12.15	14.58				
Digestion trials: ^b								
	S	W	S	W	S	W	S	W
No. of trials	3	2	3	1	4	2	4	2
No. of animals	9	6	9	3	12	6	12	6
DDM	67.6	60.8	68.8	64.4	55.5	54.8	54.2	54.7
DCP	62.6	62.4	65.7	61.0	62.9	64.3	62.9	67.6
DCF	62.2	48.7	64.0	53.9	45.7	42.6	45.9	46.6
DEE	80.1	70.1	86.2	84.4	64.8	55.6	62.8	65.8
DNFE	72.6	67.6	74.0	71.4	60.5	60.6	59.8	60.6
DE	66.8	61.5	68.6	65.0	55.9	56.2	54.8	58.0
TDN ^c	18.4	17.3	19.6	20.9	13.7	13.8	13.5	13.3
Caloric value of TDN ^d	1967	2028	1966	2014	2190	2348	2180	2202
In vitro trials:								
No. of trials	6	4	6	6				
Cellulose digestion, per cent	47.0	49.8	57.8	59.0				

^aAir-dry basis.

^bS = steers, W = wethers.

^cAs-fed basis.

^dKilocalories per pound.

TABLE XXXIV

CORRELATION COEFFICIENTS OF CATTLE GAINS IN THE FEEDLOT TO IN VITRO
CELLULOSE DIGESTION AND DIGESTIBILITY COEFFICIENTS OBTAINED
FROM CATTLE AND SHEEP DIGESTION TRIALS, 1961-64

	Cattle (CSM Supplement)	Sheep (CSM Supplement)	Cattle (Concentrate Supplement)	Sheep (Concentrate Supplement)
df	7	4	4	4
<u>In vitro cellulose digestion</u>	-0.04	-	-0.77	-
DDM	0.87**	0.53	0.08	0.40
DCP	0.05	-0.64	0.59	-0.26
DCF	0.90**	0.31	0.65	0.78
DNFE	0.87**	0.73	0.78	0.65
DE	0.88**	0.58	0.64	0.76
TDN	0.80**	0.64	0.76	0.36

**P < .01.

rations was not significantly correlated to average daily gains of steers in the feedlot. This indicated that the ration with the least amount of digestible protein contained sufficient protein to meet the requirements of the steers. The correlation coefficient of 0.90 for digestible crude fiber and daily gains in the feedlot indicates that digestible crude fiber was the best simple indicator of daily gains in the feedlot. In these studies, microbial activity, as measured by in vitro cellulose digestion of the silages, was not significantly correlated with feedlot gains, which could probably be attributed to environmental stress under laboratory conditions.

While daily gains of steers in the feedlot were significantly correlated to digestion coefficients determined by the steers, these gains were not significantly correlated to digestion coefficients determined by the wethers. Observed differences in correlation coefficients could probably be attributed to the limited number of observations used to test significance of the data, since digestion coefficients of the silage rations determined by steers were significantly correlated ($P < .01$) to those by the wethers. Digestibility coefficients for all components of the rations, with the exception of crude protein, were significantly correlated when comparing the two species. Correlation coefficients determined for digestible dry matter, crude fiber, nitrogen-free extract, energy, and total digestible nutrients were 0.89, 0.85, 0.91, and 0.94, respectively, and a highly significant correlation coefficient of 0.97 for digestible energy and total digestible nutrients was determined from both the steer and wether digestion trials. The lack

of correlation for digestible crude protein of the ration might possibly be due to the difference in protein requirement of the two species, as the wethers were mature and required less protein than did the immature steers.

A summary of the nutritive evaluation of the control and antibiotic-treated corn and alfalfa silages supplemented with the concentrate mixture, as determined by feedlot trials, digestion trials, and in vitro trials, is shown in Table XXXXV. Average daily gains of heifers fed the silages ad libitum supplemented with 5 pounds of the concentrate mixture in the feedlot were not significantly correlated ($P > .05$) to the digestion coefficients of the same rations, as determined by both the steers and wethers, which was probably due to the limited number of observations. In vitro cellulose digestion of the silages supplemented with the concentrate mixture was not significantly correlated to the average daily gains in the feedlot.

Data presented in Table XXXXIII and XXXXV indicated that alfalfa silages supported more microbial activity than did corn silage rations, as determined by in vitro cellulose digestion. However, in vitro studies indicated that the crude fiber of corn silage rations was more readily available to the animal than that of alfalfa silages. Many research workers have found that good quality alfalfa is an excellent substrate for bacterial growth under in vitro conditions. It is possible that alfalfa substrates result in more favorable conditions for normal metabolic processes in vitro than do corn silage substrates; however, these conditions are already present in the live animal. Results of this

TABLE XXXV

A SUMMARY OF THE NUTRITIVE EVALUATION OF THE CONTROL AND ANTIBIOTIC-TREATED CORN AND ALFALFA SILAGES WHEN SUPPLEMENTED WITH CONCENTRATE MIXTURE, AS DETERMINED BY FEEDLOT TRIALS, DIGESTION TRIALS, AND IN VITRO INVESTIGATIONS, 1961-64

	Control Corn		Antibiotic Corn (Zinc Bacitracin)		Control Alfalfa (Kylage)		Antibiotic Alfalfa (Zinc Bacitracin)	
Feedlot trials:								
No. of trials	2		2		3		3	
No. of animals	20		20		30		30	
ADG, lb.	1.38		1.39		1.34		1.26	
Av, silage consumption, lb. ^a	5.66		5.96		5.09		5.49	
Feed/lb. gain, lb.	8.58		9.36		9.26		10.01	
Digestion trials: ^b								
	S	W	S	W	S	W	S	W
No. of trials	1	1	1	1	2	2	2	2
No. of animals	3	3	3	3	6	6	6	6
DDM	72.5	72.2	71.1	74.3	66.7	65.4	67.6	65.6
DCP	75.6	64.1	74.4	64.9	71.6	67.4	71.9	67.8
DCF	60.7	47.5	59.3	55.2	43.5	35.8	45.8	37.2
DEE	86.5	85.1	84.7	81.6	75.0	71.6	73.4	67.8
DNFE	77.5	80.6	71.2	82.1	76.2	71.1	76.9	78.6
DE	71.8	71.7	69.9	73.6	66.2	65.3	67.2	65.5
TDN ^c	28.5	27.0	27.5	28.9	21.6	20.6	22.6	20.6
Caloric value of TDN ^d	1859	1992	1851	1978	2076	2140	2087	2209
In vitro trials:								
No. of trials	4		2		4		4	
Cellulose digestion, per cent	41.2		47.8		53.8		54.4	

^aAir-dry basis.

^bS = steers, W = wethers.

^cAs-fed basis.

^dKilocalories per pound.

experiment indicate that the in vitro technique may have serious limitations as an indicator of potential nutritive value of feed when comparing widely different types of forage, especially grasses and legumes.

The correlation coefficients obtained from this study are statistically weak, but there are, in most cases, definite trends which could be strengthened with a greater number of observations and by refinement of techniques employed to evaluate the forages.

V. GENERAL DISCUSSION

The ultimate goal of this study was to determine the feeding value of corn and alfalfa silages and the effect of the antibiotic preservative on nutritive value of the silages. Performance of the cattle fed the silages in the feedlot was the primary objective of the study. Digestion and in vitro trials were also conducted in order to assist in explaining variations in the feedlot performance, as well as to investigate the reliability and relationship of methods for predicting nutritive value of the silages. Variation in the feedlot performance data is due to individuality of the cattle, quality and palatability of the silage, weather conditions, and management practices which cannot be duplicated with conventional digestion trials or in vitro investigations. Digestion data and in vitro data cannot fully explain the nutritive value of the silage, but can assist in explaining results in the feedlot.

Usefulness of the digestion data, as well as the proximate analysis of the silages, was limited because neither total digestible

nutrients nor digestible energy consistently described the effective value of the silages, as measured by performance of the cattle. The primary reason for this could probably be that digestibility data did not depend on or consider the total dry matter intake of the silages under feedlot conditions, which was of greater significance in the economics of the silage feeding than was the nutrient or useful energy concentration of silage rations fed in the feedlot. Yield of energy and total digestible nutrients are highly correlated with digestible dry matter in the silages, and all of these components were dependent upon the animal's consumption for subsequent performance.

Feedlot results indicated that the corn silage supplemented with 1 pound of cottonseed meal produced higher gains when fed to steer calves than did similarly supplemented alfalfa silages. Silages of acceptable palatability were fed ad libitum, with salt and dicalcium phosphate mixture free choice; therefore, the essential nutrients for maintenance and growth were supplied in sufficient quantities to meet these requirements. Digestible crude protein is often used as an important criteria when evaluating a ration, but because of the protein level of these rations, it was not significantly correlated with animal gains.

Additional animal gains over and above maintenance were then dependent upon the added energy supplied by the silage rations. Steers fed the corn silage rations consumed significantly more dry matter than those fed the alfalfa silage rations, and digestibility data indicated that the corn silage rations had significantly more digestible dry matter

and energy than alfalfa silage rations. Therefore, the additional dry matter and energy supplied by the corn silage rations produced the added daily gains, above those of the alfalfa silage rations, that were observed in the feedlot. This increase in daily gains in turn influenced the other traits observed in the feedlot.

Differences in consumption of the steers fed corn and alfalfa silage rations were probably due to physiological factors of the rumen, rather than palatability of the silage rations. It has been postulated that recurring hunger is closely associated with the degradation of the rumen ingesta load. This load is reduced at varying rates which are probably correlated with the rate of degradation of cellulose and hemicellulose content of the ration. Since the crude fiber, which makes up approximately 50 per cent of the energy in a forage, was digested more extensively in the corn silage rations, the rumen ingesta was degraded faster, with a resultant recurring hunger, and consumption of the high-energy corn silage ration was greater than that of the more highly lignified alfalfa silage ration.

Heifer calves fed the silage supplemented with the concentrate mixture gained faster than did steer calves fed the silage supplemented with cottonseed meal. When dry matter consumption of the alfalfa silage was equal to that of the corn silage fed with the high-energy concentrate mixture, daily gains of heifers in the feedlot tended to be equal for both rations, as indicated by the second year study. The first and third year studies indicated higher corn silage consumption which resulted in higher feedlot gains and supported the theory that dry matter

consumption was the limiting factor in the feeding value of the silages regardless of concentrate levels.

The in vitro studies indicated that alfalfa silage rations supported significantly more microbial activity, as indicated by cellulose breakdown in the fermentation flasks, than did the corn silages. Additional energy supplied by the nitrogen-free extract and other components of the corn silage does not explain these results, because addition of the concentrate--which constituted approximately 50 per cent of the dry matter medium of the fermentation flask--did not alter cellulose digestibility of either silage. This observed difference in cellulose digestibility did not support other data concerning the feeding value of the silages. A better estimate of the nutritive value would probably be in vitro volatile fatty acid production. Thus, the amount and proportion of acids produced from the silage substrates might help explain differences in animal performance.

The feedlot, digestion, and in vitro trials generally indicated that although the addition of the antibiotic preservative did not significantly alter feeding value of the silages, it checked undesirable fermentation that would have occurred in the alfalfa silage, but did not enhance the quality of the silage over that of the chemically-preserved alfalfa silage or the naturally-preserved corn silage.

This study strongly indicates that digestibility data does help explain results obtained in the feedlot. However, until a method can be devised to insure similar environments for animals on digestion trials and feedlot trials, digestibility data can only support the actual

feedlot data. Also, the in vitro technique is not suitable for measuring nutritive feeding value of unrelated forage species, but it can be used to evaluate similar forages. Perhaps the technique could be revised to compare a wider range of forage species using the in vitro gas production or volatile fatty acid production as a criterion of measurement.

CHAPTER V

SUMMARY

This experiment was designed to determine the nutritive value of control and antibiotic-treated corn and alfalfa silage when supplemented with either a low level of cottonseed meal or a moderate level of a concentrate mixture. The three methods of investigation used to evaluate the silage rations included feedlot performance of stocker calves, digestion trials by both steers and wethers, and a washed suspension in vitro technique. Silages used during the experiment were Dixie 29 corn cut at the dent stage of maturity and Buffalo alfalfa "direct cut" at the one-tenth bloom stage of maturity.

A total of 110 Hereford and Angus steer calves, weighing from 500 to 550 pounds, with a condition grade of Good to Choice, were fed the silages ad libitum supplemented with 1 pound of cottonseed meal and 2 pounds of alfalfa-orchardgrass hay; and 110 Hereford and Angus heifer calves, weighing 375 to 525 pounds, with a condition grade of Medium to Good, were fed the silage ad libitum supplemented with 5 pounds of a concentrate mixture (4 parts corn and 1 part cottonseed meal) and 2 pounds of alfalfa-orchardgrass hay. Feedlot studies were conducted for three consecutive years, and performance traits used to evaluate the silage rations were average daily gain, average daily feed consumption, feed efficiency, and change in condition grade. During the same three year period, six cattle digestion trials and four sheep digestion trials,

utilizing a randomized block design with three animals per treatment, were conducted to determine digestibility of the silage rations. Steers and wethers were placed in individual metabolism stalls and a ten-day preliminary period followed by a seven-day collection period was used during the course of each digestion trial. In all trials, silage consumption and concentrate level were adjusted in proportion to the silage dry matter and concentrate ratio fed in the feedlot. The washed suspension technique was used for the in vitro studies, and 16 trials were conducted to determine the amount of microbial activity supported by the silages, as indicated by the extent of cellulose digestion. Silages were supplemented with cottonseed meal or the concentrate mixture in the same ratio as was fed in the feedlot phase of the study.

The results of this study indicated that:

1. The steers fed the corn silage supplemented with 1 pound of cottonseed meal gained significantly faster and required less feed per hundred pounds of gain than did the steers fed similarly supplemented alfalfa silage.
2. Generally, the average daily silage consumption and condition grades were significantly higher for steers fed the corn silage.
3. Heifers fed the corn silage supplemented with 5 pounds of the concentrate mixture gained significantly faster and required less feed per hundred pounds of gain than did those fed similarly supplemented alfalfa silages, with the exception of the second year when these traits were not significantly different.
4. Average daily silage consumption and condition grades of the

heifers were not significantly different for the first and second year, but the third year's results indicated a significant difference ($P < .01$) for heifers fed the corn silage.

5. Generally, all components of the corn silage ration supplemented with cottonseed meal were more digestible than those of similarly supplemented alfalfa silage ration, with the exception of digestible crude protein.

6. When the concentrate mixture was used as a supplement, digestible dry matter, energy, and total digestible nutrients of the corn silage ration were significantly higher, but digestible crude protein, crude fiber, and nitrogen-free extract varied from year to year without a consistent trend.

7. The in vitro results indicated that alfalfa silage supported significantly more microbial activity, as measured by cellulose digestion, than did the corn silage. However, addition of the concentrates to the medium did not significantly increase or decrease microbial activity.

8. Feedlot data, digestibility data, and in vitro data generally indicated that the addition of antibiotic preservative to the corn and alfalfa silages did not enhance silage quality.

9. Feedlot gains of the steer calves fed silages supplemented with cottonseed meal were significantly correlated with digestibility coefficients of the components of that ration, with the exception of crude protein.

10. Feedlot gains of heifer calves fed silages supplemented with the concentrate mixture were not significantly correlated to digestion coefficients of the components of that same ration.

11. The in vitro cellulose digestion of the silage rations was not significantly correlated to feedlot gains or digestion coefficients obtained from those same rations.

12. With the exception of digestible crude protein, digestion coefficients of the silage rations obtained by both the steers and wethers were significantly correlated, and a correlation coefficient of +0.97 for TDN to digestible energy was obtained for both steers and wethers.



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