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I am submitting herewith a thesis written by Kevin Timothy Leahy entitled "Effect of Addition of Fermentation Aids to Corn Silage on Dry Matter Recovery, Performance of Slaughter Heifers and Digestibility by Sheep." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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EFFECT OF ADDITION OF FERMENTATION AIDS TO
CORN SILAGE ON DRY MATTER RECOVERY, PERFORMANCE OF
SLAUGHTER HEIFERS AND DIGESTIBILITY BY SHEEP

A Thesis

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ABSTRACT

The effects of corn silage fermentation aids on dry matter recovery of silage, performance, and subsequent carcass data of beef heifers fed the silages and nutrient digestibility of the silages by wethers were determined in this study. Corn green chop in the late dough to early dent stage was harvested during August of 1979 and 1980. For each year, two silos were assigned to one of four silage treatments with or without fermentation aids added. The four experimental corn silage treatments were: (1) an untreated control silage; (2) treated with Silabac, a live lactobacillus preparation; (3) treated with Culbac, a dead lactobacillus preparation; and (4) treated with Crop Cure, sodium diacetate. Samples of the ensiled materials were taken for later determination of dry matter recovery. The ensiled materials were allowed to ferment for approximately 140 to 150 days before the first silo of each treatment was opened. Fresh silage samples were taken during both years when the silos were opened and at 28-day intervals thereafter. In addition, a sample of spoiled silage was taken from one silo of each treatment in 1980. These samples were taken in order to determine the dry matter recovery and nutrient composition of each treatment.

In the fall of 1979 and 1980, Angus beef heifer calves were purchased during the Tennessee fall feeder calf sales. In mid-December of each year heifers were allotted, using several parameters, to eight groups of five animals each, two groups per treatment, with the effort being made to have maximum equality of all parameters.

Two feedlot trials, designated as the 1979-80 trial and the 1980-81 trial, were then begun. These trials were partitioned into two phases--the silage-feeding phase and the full-feeding phase. At approximately 28-day intervals throughout each phase and at the end of each phase body weights were taken. Utilizing these weights and the feed intakes of the heifers during these intervals, the gains and feed efficiencies of the heifers of each treatment were calculated.

Backfat thicknesses of the heifers were measured using a somoscope prior to the beginning of the silage-feeding phase and at the end of the silage-feeding phase. Backfat was also measured during the full-feeding phase, initially at four-week intervals and later at two-week intervals as heifers approached 12 mm backfat thickness, which was predetermined as the criterion to send each heifer to slaughter. Backfat thickness data were also studied to determine if there were any treatment effects.

After chilling the carcasses of the slaughtered heifers for 48 hours, several carcass parameters were either measured or calculated and the data compared to determine possible treatment effects.

A total collection digestion trial was conducted concurrently with the 1979-80 feedlot trial. Some silage from one of the silos of each treatment was removed, stored, and then fed to mature wethers averaging 74.5 kg in body weight. Nutrient digestibility of the corn silage treatments by the wethers were determined and compared.

Two-year means of the dry matter recoveries of each treatment were not significantly different ($P > .05$); however, the statistical analyses were considered to be inconclusive due to a low number of replicates. The dry matter recovery after ensiling losses, after spoilage losses, and

total dry matter recovery for each corn silage treatment, respectively, were 88.3, 94.7, and 83.1% for the control; 89.3, 95.4, and 84.7% for Silabac; 94.9, 96.3, and 91.2% for Culbac; and 91.9, 93.3, and 85.2% for Crop Cure. It appears that, except for the Culbac-treated corn silage, addition of fermentation aids had little effect on improvement of dry matter recovery.

The nutrient composition of the corn silage treatments of the 1979-80 trial was similar among treatments for all constituents. In the 1980-81 trial, silages with additives were lower ($P < .01$) in dry matter as compared to the control. All other constituents, except lignin, were not different ($P > .05$) among treatments. The Silabac-treated silage was higher ($P < .05$) and the Crop Cure-treated silage was lower ($P < .05$) in lignin content than the control, the reason for which is not understood.

Fermentation aids added to the corn silages during ensiling did not significantly affect ($P > .05$) intake, gain, or feed efficiencies of the slaughter beef heifers as compared to the control during the silage-feeding phase. Also, there were no significant ($P > .05$) treatment effects in intake, gain, or feed efficiencies during the full-feeding phase.

There were no significant differences ($P > .05$) among treatments for two-year means of any of the backfat thicknesses, which were measured at various times, or for any of the carcass parameters, except for fat thickness and yield grades. Silabac and Culbac treatment backfat thicknesses and yield grades were found to be significantly lower ($P < .05$) than the control and Crop Cure treatments. Differences in fat thicknesses may have been due to changes in acetate levels in the silages due to the addition of fermentation aids and subsequent change in the rumen acetate

levels of the heifers. Yield grade differences were probably a function of the fat thickness differences.

In the total collection digestion trial, wethers fed the fermentation aid-treated silages consumed significantly less ($P < .05$) dry matter than wethers fed the control. No significant differences ($P > .05$) were found among rations in apparent nutrient digestion coefficients for any of the nutrient constituents except for those of crude protein and ether extract. Differences in ether extract digestibilities were considered inconclusive due to low ether extract contents in the rations. Crude protein digestibilities by wethers were depressed significantly ($P < .05$) in the Culbac- and Crop Cure-treated rations as compared to the control and Silabac-treated rations. Wethers offered the Crop Cure-treated ration had lower crude protein digestibility which was attributed to a low crude protein percentage in the ration and an increased acid-detergent fiber nitrogen percentage as compared to the other rations. Depression of crude protein digestibility by Culbac addition could not be explained.

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CHAPTER I

INTRODUCTION

Human population in the world is increasing very rapidly while the capacity to produce additional food is increasing at a slower rate. The direct consumption of grains by humans is more nutritionally efficient than the feeding of grains to animals and then having the animals and their products consumed by humans. Beef cattle commonly are fed both forages and grains. A reduction of grain feeding and an increase in forage feeding would result in less competition with humans for the grains which can be consumed by both species. The three main groups of forages are pasture, hay, and silages. Pasture forages are limited to their respective growing seasons and do not lend themselves for inclusion in intensive animal production systems. One means of achieving availability of forages throughout the year is their preservation in the form of silage. Silage is the feedstuff that results from the anaerobic preservation by acidification of moist forage crops and crop residues by themselves or in combination with each other. The objective of the ensiling process is to preserve the ensiled material with a minimum loss of nutrients. This process of anaerobic preservation by acidification is known as fermentation. If a silage is to be used by the farmer as a major source of feed for an extended period, it is imperative that the fermentation process yield a desirable feedstuff, that is, one which has a minimal loss of nutrients and an acceptable level of performance by the animal. It is in answer to this need for proper silage fermentation

that there has been an increase in the number of commercial silage fermentation aids available to producers.

The objectives of this study were to determine the effect of several corn silage fermentation aids on: (1) the recovery of corn silage dry matter; (2) the intakes, gains, feed efficiencies, and carcass characteristics of the corn silage by slaughter beef heifers; and (3) nutrient digestibility of the corn silages by wethers.

CHAPTER II

REVIEW OF LITERATURE

I. FERMENTATION OF FORAGES

Types of Feeds Usually Ensiled

One of the major reasons for the increased use of silages in the United States is that there are many crops which can be utilized in this form. Silage production in the United States is estimated to exceed 150 million tons. According to USDA Agricultural Statistics (1980), of this 150 million tons, 115 million tons was corn silage and 9 million tons was sorghum silage; these silages are known as grain or seed silages. Most of the remaining silage produced was "grass silage" or hay-crop silage, which refers to silage made from the vegetative parts of the plant. Perhaps it is because silage made from the whole corn plant yields more total digestible nutrients per acre than most forage crops which makes it a widely used stored feed for cattle (Ensminger, 1970).

Hay-crop silages in the United States are used extensively for dairy cows and heifers. This is due to the generally higher level of protein in hay-crop silages than that of corn or sorghum silages.

Morrison (1958) characterized the nutrient content of hay-crop silage in relation to corn silage. The percentage of dry matter in hay-crop silage varies greatly depending on how the hay crop was processed. Differences depend on whether or not the hay crop was wilted and on the crop's stage of maturity. Hay-crop silages tend to be lower in total

digestible nutrients, and net energy, than corn silage containing well-eared corn.

Hay crops tend to be low in soluble carbohydrates which are used by the bacteria to produce lactic acid which subsequently preserves the silage. Molasses, which is high in soluble carbohydrates, has been added to hay-crop silages for many years to increase lactic acid formed during fermentation (Carpintero et al., 1969; Watson and Nash, 1960). Molasses addition to hay-crop silages has also been shown to reduce pH (McCarrick, 1969; McCarrick, 1962). Archibald (1960) found that molasses reduced butyric acid and ammonia levels in green chop silage. All of these effects of molasses have been shown to improve the quality of the silage being produced (Archibald, 1960).

Sorghum silage when ensiled at the proper stage of maturity has been shown to produce a good quality, palatable silage (Duncan, 1960). In general, when compared to corn silage, sorghum silage tends to be lower in dry matter, sometimes as much as 20 percentage points lower, as much as 4 percentage points lower in crude protein, and as much as 10 percentage points higher in fiber (NRC, 1976). Cattle do not chew the seed in sorghum silage as well as that of corn silage (Morrison, 1958); this may partially explain why digestible dry matter of sorghum silage was considerably less than that of corn silage (McCullough, 1975). Danley and Vetter (1973) found that corn was significantly higher in total digestible nutrients and digestible energy, but there was no difference between corn and sorghum in digestible crude protein.

Corn silage, as with most silages, is primarily fed to beef and dairy cattle. Though corn silage is a good source of energy, it is

usually insufficient in meeting the calcium and protein requirements of dairy cattle and beef cattle (NRC, 1978; NRC, 1976). The incorporation of sources of calcium and nitrogen at the time of ensiling contribute to the nutritional requirements of the animal consuming the silage and may eliminate the need for feeding supplements with the corn silage.

Limestone has been added to corn silage in order to meet the calcium requirements of cattle. Also, limestone addition at ensiling has been shown to increase organic acids, especially lactic acid, benefiting the fermentation process (Brookes et al., 1966).

The addition of urea to corn green chop before ensiling was reported as early as 1944 (Wise et al., 1944; Woodward and Shephard, 1944). Urea has been added at rates of 5 to 15 pounds per ton of green chop to low-protein silages, such as corn, to improve the crude protein content of the silage.

Limestone and urea mixtures have been added at the time of ensiling to improve the nutritional value of corn silage. In fact, Barth et al. (1974) found that there was an additive effect of N utilization by cattle when .5% urea and .5% limestone were added over that of .5% urea alone to corn silage.

Besides the various hay crops and grain crops used to make silage, other crops and crop residues have been used, such as beets, cabbage, pea vine, sunflower, and various stovers (Morrison, 1958). Though many materials varying in nutritive quality can and have been ensiled, it is the success or failure of the ensiling process which will have the ultimate effect on preserving the nutritive quality of the silage produced.

The Ensiling Process

McCullough (1978) stated that the objectives of silage making should be based on the purpose for producing the silage, that is, to have efficient preservation and usefulness of the end product as animal feed. Noting that it is an oversimplification, McCullough (1975) further stated that the silage fermentation process has been explained as "the converting of starches and sugars to organic acids which lower the pH to 4.0 and preserve the ensiled mass." In hay-crop silages, which are low in starches and sugars, it is necessary to add either a fermentable carbohydrate source, which can be converted to organic acids, or add acids directly.

It should be noted that fermentation is a destructive process and, therefore, no silage produced can be expected to have a feeding value greater than the material ensiled. It is, therefore, the objective to minimize the nutrient losses of the ensiled material during ensiling, but it is also important that the silage end product results in an intake and utilization which is adequate in meeting an animal's nutritional needs. In order to minimize nutrient losses it is first necessary to achieve and maintain anaerobic conditions, thereby inhibiting the wasteful activities of aerobic microorganisms and oxidative enzymes on plant material (Whittenbury et al., 1967). Anaerobic conditions are necessary for the proper fermentation of soluble carbohydrates, which are the main source of nutrients for microorganisms.

McDonald and Edwards (1976) expected an ideal fermentation (minimum nutrient loss) to occur when a forage was ensiled with 28-34% dry matter, a water soluble carbohydrate content of 6-8%, a minimum buffer capacity,

a large population of lactic-acid-producing bacteria, and a temperature and degree of compaction suitable for an immediate bacterial population explosion. Under these conditions starches and sugars would be used primarily for lactic acid production.

Adequate consolidation or compaction is important since silage quality and maximum temperature have been related to extent of consolidation (Wood, 1971). The length of cut or fineness of cut are known to increase the density of packing in silos and the efficiency of fermentation (McCullough, 1978). Many workers have reported that lactic acid levels are higher, while butyric acid levels are lower, in chopped or cut silages as compared to uncut silages (Zimmer and Gordon, 1964; Gordon et al., 1959; Wieringa, 1959).

Hay crops contain a relatively smaller percentage of starches and sugars than do corn or sorghum silages; as a result, not enough acid is produced to preserve the silage properly (Morrison, 1958). In addition to the low acid production, hay crops have been shown to have an increased buffer capacity of that acid which is produced (Playne and McDonald, 1966). Inorganic acids such as hydrochloric and sulfuric have been added to hay-crop silages for many years in order to lower pH and preserve ensiled material by the selective inhibition of the growth of unwanted microorganisms.

Virtanen (1938) developed one of the first programs using inorganic acids as fermentation aids. This program consisted of applying a mixture of sulfuric and hydrochloric acids in a dilution of approximately 2 N. Enough of this acid mixture was added in order to reduce the forage pH to 4.0. Breirem and Ulvesli (1960) showed that use of Virtanen's

program resulted in reduced protein breakdown, and repression of coli aerogenes and butyric acid bacteria. However, McCullough (1977) noted that this program is somewhat undesirable in that the acid mixture used is extremely corrosive. Besides causing burns and destruction of clothing, this mixture is also very corrosive to metal silos and equipment used for unloading, mixing, hauling, and feeding livestock (Owen, 1971).

Sodium metabisulfite has also been added to hay-crop silages. The sodium metabisulfite is a powder which contains 65-67% sulfur dioxide by weight and is extremely soluble in water. Unlike sulfur dioxide, the sodium metabisulfite is safe and easy to handle. Bratzler et al. (1956) compared sodium metabisulfite-treated alfalfa in the bud stage to an untreated control and found that the addition of the bisulfite decreased dry matter loss due to ensiling from 33.4% to 16.5%.

Lambs fed sodium metabisulfite-treated alfalfa silage had significant increases ($P < .05$) in gains as compared to lambs fed sulfur dioxide- and molasses-treated alfalfa silages (Woolfolk et al., 1954). Increases were also present for the sodium metabisulfite-treated silage when compared to the other treatment in apparent dry matter, crude protein, crude fiber, and energy digestion by lambs.

Unlike hay-crop silages, corn green chop usually contains enough fermentable carbohydrates (starches and sugars) to produce a sufficient amount of acid for proper fermentation. These starches and sugars are then fermented by many types of microorganisms, including lactic-acid-producing bacteria. Wood (1961) classified the lactic-acid-producing bacteria into two types. The first is the homofermative type, which,

under anaerobic conditions, follows the glycolytic pathway forming two moles of lactic acid for each mole of glucose fermented. The second is the heterofermentative type, which follows the hexose monophosphate pathway producing one mole of lactic acid, one mole of carbon dioxide, and one mole of ethanol for each mole of glucose, also anaerobically. In the homofermentative type of fermentation, the recovery of dry matter should theoretically be 100%, while the heterofermentative type of fermentation should result in a recovery of only 76% dry matter (McCullough, 1977). Obviously, the desire would be to have the homofermentative lactic-acid-producing bacteria predominating over the heterofermentative and other types of bacteria.

The reason for the much improved recovery of the homofermentative type is that they inhibit the destructive activity of the clostridia by increasing lactic acid levels, thereby developing a low pH which results in the inhibition of clostridia which grow best in a higher pH environment (Whittenbury et al., 1967). The most widely used indication of clostridial action is the production of butyric acid by the saccharolytic varieties of clostridia from lactates and sugars (Vetter and Von Glan, 1978). Two moles of lactic acid are degraded to one mole of butyric acid, carbon dioxide, and hydrogen, resulting in an increase in pH towards neutrality. This increase in pH encourages the growth of clostridia (Whittenbury et al., 1967).

Problems with the Ensiling Process

Clostridial fermentation. There are several factors which lead to increased clostridial development resulting in the formation of a

low-grade silage. Whittenbury et al. (1967) stated that the extent of clostridial activity is controlled by the water content and acidity of the ensiled material. The dry matter content of an ensiled material is extremely important to good silage preservation. It has been stated that the critical pH for good silage preservation varies with the moisture content of the crop; the wetter the silage, the less inhibitory a given concentration of organic acids and hydrogen ions is to the clostridial activity (Vetter and Von Glan, 1978). This illustrates the need for rapid lactic acid production and a subsequent pH decrease in order to minimize clostridial activity with low dry matter silages.

Seepage loss. Besides the problem of increased clostridial activity in low dry matter silages, there is also the problem of seepage losses. Gordon (1967) suggested that seepage loss is the most obvious dry matter loss during ensiling. Seepage loss also results in a corresponding loss of nutrients. He described seepage loss and how it is affected as follows:

Excess water and cell sap is squeezed out by the pressure of the overlying parts of the silage mass. Water is also a product of respiration, fermentation, and oxidation in silage, but does not contribute significantly to the total seepage problem. Thus, seepage loss tends to increase with higher crop moisture levels and taller silos, regardless of the type of structure. Not only does forage of lower moisture content contain less excess fluid but the pressure of the overlying silage is less because of decreased weight.

It has been noted that seepage of effluent losses can be reduced or practically eliminated by ensiling at a dry matter content of 30-35% or more (Whittenbury et al., 1967; Brown and Kerr, 1965; Nash, 1959).

McDonald et al. (1968), however, suggested that there is little, if any, advantage in reducing dry matter loss by ensiling materials at a dry

matter of greater than 34%. Besides reducing or eliminating seepage losses of dry matter, ensiled material with increased dry matter contents produced a silage which is more acceptable to ruminants than ensiled low dry matter materials (Gordon et al., 1965).

Oxygen inclusion. Another factor which has been shown to lead to increased clostridial development is oxygen inclusion (Ruxton and McDonald, 1974). The increased clostridial development apparently occurs because starches are oxidized, making them unavailable to initiate and sustain lactic acid fermentation (Vetter and Von Glan, 1978). Any delay in the sealing of the silo, i.e., more entrapment of oxygen, has been shown to have detrimental effects on the fermentation process and the quality of silage produced (Lancaster and McNaughton, 1961; Miller et al., 1961; Cordukes et al., 1959). Kearney and Kennedy (1962) demonstrated that when chopped forage was allowed to wilt, for up to 30 hours before ensiling, there was a 50% reduction in fermentable carbohydrates, resulting in reduced lactic acid and increased butyric acid contents of the silages.

Yeasts and molds are also affected by the inclusion of oxygen. Yeasts are able to grow either aerobically or anaerobically, while molds can grow only in the presence of oxygen (Ruxton and McDonald, 1974). Mold growth is usually confined to the surface of the ensiled material but can usually be prevented by the rapid achievement and maintenance of anaerobic conditions (Vetter and Von Glan, 1978). The problem with yeast and mold activity is that they compete with lactic-acid-producing bacteria for the fermentable carbohydrates. This is a problem because

even though yeasts also produce lactic acid, they produce much less than do the lactic-acid-producing bacteria and make very little contribution to preservation of the silage (Ruxton and McDonald, 1974).

High temperatures. Ruxton et al. (1975) noted that it is difficult to separate the effect of temperature and the effect of oxygen. Oxygen reacts with fermentable carbohydrates, during the process of respiration, liberating heat which causes a rise in silage temperature. Beck (1969) found that clostridia and coliforms exhibited optimal growth at 37 C (99 F). Lanigan (1963) determined that the optimum temperature for lactic-acid-producing bacteria growth was similar to that of clostridia. However, the viability of the lactic-acid-producing bacteria was found to decrease more slowly with a fall in temperature, dropping as low as 20-25 C (68-77 F), than that of the clostridia and coliforms (Beck, 1969). Perhaps temperatures slightly below those required for optimum growth may be preferred since their inhibitory effect appears to be primarily on clostridia rather than lactobacillus bacteria.

High temperatures should be avoided for another reason. Protein digestibility has been found to be reduced in the presence of oxygen at high temperatures, thereby decreasing nutritive value (Donoso et al., 1962; Bratzler et al., 1960). The cause of reduced protein digestibility is accepted as being due to the Maillard reaction, also referred to as the non-enzymatic browning reaction, or the browning reaction (Darrah et al., 1977; Hodge, 1953). The Maillard reaction refers to the condensation reaction of carboxyl groups obtained from reducing sugars, with amino groups of protein (Darrah et al., 1977). The products of the

Maillard reaction have been shown to accumulate in the crude lignin (also known as artifact lignin) fraction of acid-detergent insoluble fiber (Van Soest, 1965). Georing et al. (1972) later demonstrated that the proportion of acid-detergent fiber nitrogen (ADFN) in a silage was a sensitive test for determining the extent of heat damage.

It is obvious from the preceding literature that there are many factors which relate to the effective preservation of a feedstuff during ensiling. Under "normal" farm conditions, it is difficult to attain the ideal conditions for optimum fermentation. Therefore, there has been much effort toward providing a more optimal acidity and toward controlling fermentation by addition of fermentation aids to minimize the production of undesirable end products.

II. FERMENTATION AIDS AND THEIR EFFECT

Bolsen (1978) described fermentation aids as those products that supply: (1) lactic-acid-producing microorganisms; (2) nutrients required by lactic-acid-producing microorganisms; and (3) enzymes and/or microorganisms that increase the availability of carbohydrates and other nutrients required by lactic-acid-producing microorganisms. In addition, acids are also considered as aids to fermentation in that they promote an environment which is optimal for the growth of lactic-acid-producing microorganisms (Owen, 1971). For the purpose of the following discussion, fermentation aids are assigned to one of three categories: (1) acids, (2) enzymes, and (3) microbial inoculants.

Acid Additives

There are two types of acids used as fermentation aids: mineral, or inorganic acids, and organic acids. The inorganic acids include such acids as hydrochloric and sulfuric acid. The organic acids include acids such as formic, acetic, and propionic. The purpose of both types of acids is the same, namely, the selective inhibition of the growth of unwanted microorganisms while, conversely, promoting lactic-acid-producing microorganisms because of lower pH.

This process of selective inhibition has been shown to cause increases in digestibility, N retention, and energy utilization (Derbyshire et al., 1971; Waldo et al., 1971; Valentine and Brown, 1973). Use of some acids has also been known to increase dry matter recovery in silages (Leaver, 1975; Waldo et al., 1971).

The use of organic acids has been much more widespread than that of inorganic acids in the United States. Most of the literature deals with the use of formic acid. Waldo (1978) noted that the transition from Virtanen's inorganic acid mixture to the organic, formic acid began in Norway. The use of formic acid and formic acid mixtures has become widespread, especially in Europe.

Waldo et al. (1971) showed consistently higher dry matter recoveries from several types of forages treated with formic acid than those of untreated silages. Improvement in dry matter recoveries ranged from 3 percentage units for a sorghum silage to 10 percentage units for an alfalfa silage as compared to their respective controls. Derbyshire and Gordon (1969) received a 6% increase in dry matter recovery of formic acid-treated wilted orchard grass over that of an untreated wilted orchard grass.

Many workers have reported that formic acid treatment has increased dry matter intake (Castle and Watson, 1970a, b; Derbyshire et al., 1971; Waldo et al., 1971). In contrast, Hinks et al. (1976) found no effect of formic acid treatment in terms of increasing dry matter intake. Furthermore, he found that formic acid did not increase digestibility, nitrogen retention, or metabolizable energy concentration. However, formic acid addition in other silage experiments increased digestibility (Castle and Watson, 1970a, b; Waldo, 1971), increased nitrogen balance (Waldo et al., 1973), and improved energy utilization (Waldo et al., 1968).

Propionic acid has been shown to not only lower pH but also improve silage fermentation by inhibiting fungal growth and thus heating (Britt et al., 1975; Yu and Thomas, 1975). Leaver (1975) reported that propionic acid treatment of corn silage reduced dry matter loss during ensiling by eight percentage units as compared to that of untreated control. Digestibility by wether sheep as well as intakes and growth rates of calves and heifers was not affected by this treatment. However, Huber and Soejono (1976) reported that propionic acid addition improved corn silage intakes over those of a high dry matter control and a high dry matter silage with added water. Yu and Thomas (1975), however, found no significant difference in dry matter consumption between propionic-treated and control silages. Dry matter digestibilities of corn silages treated with 1% propionic acid and an untreated control were not different (Otterby and Murphy, 1973). However, improved dry matter digestion of alfalfa haylage treated with .4% propionic acid was reported by Yu and Thomas (1975).

Crop Cure¹ contains 50% sodium diacetate, which is sometimes referred to as sodium acid acetate, as its active ingredient. Sodium diacetate has been described as a "bound" compound of sodium acetate and acetic acid. It is soluble in water and liberates 42.25% available acetic acid (The Merck Index, 1968). Acetic acid treatment of silages with medium dry matter (34-39%) slightly increased silage intake of dairy cows (Huber et al., 1972). When acetic and propionic acids were mixed and used to treat corn silage, there was a decrease of the anti-fungal effect as compared to a 100% propionic acid treatment (Britt et al., 1975). When hay crop silages were treated with either formic or acetic acid, there was little difference in the recovery of dry matter between the treatments (Yahara and Nishibe, 1975). In general, the use of propionic acid over formic and acetic acid is suggested as being more profitable in terms of recovery of silage nutrients and animal performance (Huber and Soejono, 1976).

Enzyme Additives

Enzymes are added to silages in order to promote the rapid growth of the naturally occurring lactic acid microorganisms. The enzymes are designed to increase the availability of carbohydrates in the ensiled plant materials, thereby increasing the nutrients available to lactic-acid-producing bacteria. Leatherwood et al. (1963) noted that commercial concerns claimed that enzymes improved preservation and utilization of silages.

¹Domain Industries, Inc., New Richmond, Wisconsin.

The addition of cellulolytic enzymes to crops at the time of ensiling has been reported by several workers (Autrey et al., 1975; McCullough, 1964; Owen, 1962). Cellulase addition with acids has been shown to increase the water soluble carbohydrate content in silages (Vaista et al., 1978; Henderson and McDonald, 1977). Cellulolytic enzymes have yielded silages with a characteristic color, odor, and pH of good quality silage (Leatherwood et al., 1963).

The reported effect of enzyme additives on dry matter recovery is inconclusive. LaBarbera et al. (1980) and Gross (1969) reported that enzyme additives had little effect on dry matter recovery. Conversely, several investigators have reported relatively large increases in dry matter recovery of enzyme-treated silages over control silages (Bolson, 1980; McCullough, 1975; Owen and Appleman, 1971).

The results concerning utilization of enzyme-treated silages appears to be different for sheep and cattle. Wethers fed feeds treated with two different commercial enzyme additives showed no effect of the additives on dry matter digestibility (Bolsen, 1980; Burghardi et al., 1977; McCullough, 1975). Work conducted by Olson and Voelker (1962), however, showed that calves fed alfalfa silage consumed more enzyme-treated silage and had improved average daily gains. However, Burghardi et al. (1977) reported that mixed lactic acid ferment enzymes did not improve the feedlot performance of steers fed corn silage.

Microbial Additives

It has been generally assumed that fresh forages are adequately supplied with lactic-acid-producing bacteria. However, studies have

shown that the number of these bacteria on fresh forages may sometimes be extremely low (Anderson, 1956; Stirling, 1953). Results of these studies indicate that a logical aid to lactic acid fermentations would be the use of lactic-acid-producing microorganisms. It is important that the lactic-acid-producing microorganisms establish themselves and reach optimum numbers rapidly because until they do, undesirable anaerobes will be active (McCullough, 1977). There are many types of lactobacilli used as silage additives, including *Lactobacillus acidophilus*, *Lactobacillus bulgaricus*, *Lactobacillus brevis*, and *Lactobacillus plantarum*. Many of these lactobacillus strains are sold commercially, either individually or as mixtures, under various trade names. O'Leary and Bull (1977) found that addition of lactobacillus microorganisms caused a more rapid decrease in pH and readily available carbohydrates concurrently with a more rapid increase in lactic acid during the early fermentation period of ensiling, when compared to control silage. However, Burghardi et al. (1977) could not detect significant changes in pH and lactic acid concentrations of corn silage due to the level or type of several lactobacillus microorganisms. Thonney et al. (1977) obtained results similar to those of Burghardi (1977) when mature alfalfa-timothy forage was ensiled with and without microbial additives.

The effect of microbial additives on dry matter recovery has also been varied. Waldo and Goering (1976) reported no effect of a lactic-acid-producing bacteria silage additive on dry matter recovery for alfalfa, orchard grass, or corn. Other workers have reported similar results using several other types of lactobacillus microorganisms

(LaBarbera et al., 1980; Burghardi et al., 1977). One commercial lactobacillus silage additive, Sila-lator,¹ has been reported to increase alfalfa silage dry matter recovery by 4 percentage units over a control (Bolsen et al., 1980a), while another, Silagain,² added to corn silage was found to increase dry matter recovery by 12 percentage units (McCullough, 1975). However, work conducted by Zinn et al. (1979) has shown wet weight and spoilage losses to be greater for a lactobacillus inoculated corn silage than for a noninoculated control.

A commercial lactobacillus additive, Silabac,³ increased crude protein recovery in alfalfa silage as compared to a control when added at 1.5 gm/kg and 2.5 gm/kg of fresh forage (LaBarbera et al., 1980). In the same study, however, when Silabac was added at 0.5 gm/kg the crude protein recovery was less than that of the control. In another study, crude protein recovery in corn silage was not affected by inoculation of several types of lactobacillus additives (Burghardi et al., 1977). In contrast, corn silage crude protein recovery was found to be 23 percentage units higher for lactobacillus-treated silages over untreated controls in two separate studies (Bolsen, 1976; McCullough, 1975).

No differences in digestibility of dry matter or crude protein were reported by McCullough (1975) or Burghardi et al. (1977) when treating corn silage with commercial lactobacillus silage additives as compared

¹Anchor Laboratories, Inc., St. Joseph, Missouri.

²NuLabs Division, Pioneer H-Bred International, Inc., Des Moines, Iowa.

³Pioneer H-Bred International, Inc., Des Moines, Iowa.

to untreated controls. LaBarbera et al. (1980) also noted no difference in alfalfa silage digestibility between treated and untreated Silabac silages. Bolsen et al. (1980a) reported a three percentage unit increase in dry matter digestibility by wether lambs fed Sila-lator-treated alfalfa silage above that of the control. Waldo and Goering (1976) using ram lambs reported average dry matter digestibilities for untreated and Silagain silages were 48.2 and 52.9% for alfalfa, 53.7 and 55.2% for orchardgrass, and 68.5 and 69.5% for corn. Silagain numerically improved dry matter digestibility of alfalfa but not orchardgrass or corn.

Workers comparing treated and untreated lactobacillus corn silages reported no significant differences in gains (Bolsen et al., 1980b; Bolsen, 1976). Burghardi et al. (1980) also found similar intakes, gains and feed efficiencies for steers fed treated and untreated lactobacillus corn silages.

CHAPTER III

EXPERIMENTAL PROCEDURE

Two feedlot trials were conducted at The University of Tennessee's Tobacco Experiment Station at Greeneville, Tennessee. Trial 1 began in the fall of 1979 and ended in the summer of 1980 while trial 2 began in the fall of 1980 and ended in the summer of 1981. The feeding system used was the same for both trials and consisted of two phases. The first phase of each trial was the silage-feeding phase. During this phase, heifers were fed one of four experimental silages ad libitum. The four experimental treatments were: (1) an untreated control corn silage; (2) Silabac¹-treated corn silage; (3) Culbac²-treated corn silage; and (4) Crop Cure³-treated corn silage. Heifers were also fed two pounds of grass-legume hay per head per day and a protein supplement designed to meet NRC protein requirements for normal growth.

The second phase of the feeding program for both trials was the full-feeding phase. The full-feeding phase began with a two-week transition period in which, as the proportion of silage in the ration decreased, the proportion of concentrate in the ration increased until the silage supply was depleted and the heifers were then on a full feed of ground corn, hay, and enough soybean meal to meet NRC requirements. When an individual heifer's backfat thickness reached 12 mm or more,

¹Pioneer H-bred International, Inc., Des Moines, Iowa.

²TransAgra Corporation, Memphis, Tennessee.

³Domain Industries, Inc., New Richmond, Wisconsin.

she was removed from the experiment and sold for slaughter. In addition, a digestion trial was conducted concurrently with the first year's feeding trial to determine the effect of silage fermentation aids on nutrient digestibility of the experimental corn silages.

Feedlot Trials

Experimental silages. Pioneer Hybrid 31 was the corn variety used to make the silages for both trials. The plant population averaged 17,000 plants per acre. The corn was grown on two fields designated as the "lower" and "upper" fields. The soil taxonomy classification of the upper field was 80% Cumberland silt loam and 20% Emory silt loam. The lower field was classified as 80% Emory silt loam and 20% Hermitage silt loam. In the fall, the fields were planted with small grain following silage harvest. This crop was used as pasture for beef cows and heifers during the wintering period, as weather permitted. In the spring, the small grain residue was plowed under. Before planting, 125 pounds of nitrogen, 60 pounds of potassium, and a "medium" level of phosphorus were applied to both fields, in accordance with soil test recommendations.

The precipitations for the two crop years were extremely different and had an obvious effect on the amount and stage of development of the corn ears produced. The precipitation for the first crop year was approximately 23.2 inches and 16.6 inches for the second crop year. The ears of the first crop year were relatively numerous and well developed as compared to the small and less numerous ears in the second crop year.

In trial 1, the corn green chop was harvested in the late dough to early dent stage. The green chop was harvested from the lower field,

in trial 2, was in the late dough to early dent stage while the green chop harvested from the upper field was in the late dent stage. Before the green chop was blown into the silo, each filled silage wagon, which had its tare weight taken previously, was reweighed to determine the amount of green chop it contained. When required, Silabac, Culbac, or Crop Cure was broadcast by hand over each load at the rate of one pound per ton on a wet basis, as suggested by the manufacturers.

In both trials, representative samples of the green chop were taken from each wagon load. The silos in trial 1 were filled in the morning and then, after settling of the silo contents, were filled further (i.e., capped) the afternoon of that same day. In trial 2, the two control silos were filled on the first day of harvesting, then capped on the second day. Also on this second day the silos designated for the treated green chop were filled and then capped on the third day of harvesting.

Two upright brick silos measuring 6- x 30-foot contained 11 to 12 tons of silage in trial 1 and 8 to 9 tons of silage in trial 2 for each treatment. Green chop samples were obtained for both trials. The green chop was allowed to ferment for approximately 140 days in trial 1 and approximately 150 days in trial 2 before the first silo in each treatment was opened. In both trials, the amount of spoiled silage in each silo was determined and, in trial 2, a sample of the spoiled silage was taken from one silo of each treatment for dry matter determination. Fresh silage samples were taken in both trials when the silos were opened and at 28-day intervals thereafter.

All forage samples (green chop, fresh, and spoiled silage) were dried with forced air at 60 C for 72 hours and allowed to air equilibrate for the same period of time. Air-equilibrated dry matter was determined and samples were ground through a 1 mm mesh screen of a Wiley Mill.

The air-equilibrated silage samples were composited by treatment for both trials. Residual dry matters determined at 100 C and complete Proximate Analyses (AOAC, 1975) were conducted on the composited silage samples and the green chop samples of trial 2. In addition, acid-detergent fiber, acid-detergent-fiber nitrogen, and lignin determinations according to AOAC (1975) methods were conducted on the silage and green chop samples of trial 2.

Dry matter recoveries. Dry matter recovery was determined for each treatment in both trials. First, dry matter recovery after the ensiling process was calculated; second, recovery of edible silage as a proportion of dry matter recovered after the ensiling process was calculated with the use of spoiled silage dry matter; and finally, the two losses were combined in the calculation of edible dry matter as a proportion of dry matter ensiled.

Dry matter recovery from the ensiling process was the quotient of the amount of dry matter recovered after ensiling and the amount of dry matter ensiled. Amount of dry matter ensiled was calculated as the product of the amount of wet green chop ensiled and percent dry matter. Similarly, dry matter recovered after ensiling was the product of wet silage removed from the silo and its dry matter percentage.

Dry matter lost due to spoilage was obtained from the amount of spoiled silage determined after the silo was first opened and

throughout the emptying of the silo and, in trial 2, from the dry matter percentage of that spoiled silage. In trial 1, percent dry matter of the appropriate edible silage was used because spoiled silage samples had not been chemically analyzed. Amount of dry matter lost due to spoilage and, conversely, edible dry matter recovery were also expressed as a proportion of ensiled dry matter.

Experimental animals. During the month of September 1979, 60 Angus beef heifer calves were purchased during the Tennessee fall feeder calf sales for use in trial 1. Twenty extra heifers were purchased, in order to be able to exclude all pregnant and off-type animals. The heifers were of the Good grade and had a mean weight of approximately 560 pounds. The heifers were placed on permanent pastures until the start of the silage-feeding phase. The pregnancy status of the heifers was determined in mid-December. Sixteen heifers were pregnant, and excluded from the experiment.

In order to decrease the initial financial investment in cattle, it was decided, for trial 2, to purchase only 50 Angus beef heifer calves and to abort the pregnant ones. They were purchased during the months of September and October 1980. The heifer calves graded Good and weighed an average of 460 pounds. A 25 mg dose of lutalyse (prostaglandin $F_{2\alpha}$) was administered to all of the heifers on October 13, 1980. The reason that all the heifers were administered the lutalyse was to equalize any possible effect that the abortafacient might have on subsequent animal performance. As in trial 1, these heifers were also placed on permanent pastures until the start of the silage-feeding phase.

In mid-December, in both trials, body weight, type score, and backfat thicknesses were determined for each heifer, and gain, average daily gain, and backfat gain were calculated. The parameters used for the allotment of the heifers as listed in their order of importance were: (1) weight, (2) backfat thickness, (3) average daily gain, (4) backfat gain, (5) frame score, and (6) muscling score. The heifers were allotted to eight groups of five animals each. Two groups of heifers were then randomly allotted to each treatment. The effort was made to have maximum equality of all parameters among groups within treatment.

Conduct of trial. Prior to the beginning of the silage-feeding phase, each of the eight groups of heifers were placed in 20- x 25-foot adjacent feedlots, which were located, four on each side, within the Tobacco Experiment Station's beef cattle feeding barn.

During the silage-feeding phase, the heifers allotted to one of the four treatments were fed the appropriate experimental corn silage ad libitum once a day. Increases or decreases in the amount of feed offered were determined by the previous day's refusal. Two pounds of hay per head per day was also fed. In addition, soybean meal was fed. Its amount was based on the crude protein content of the silage and hay samples determined at the beginning of the trial and on the crude protein requirements of feeding heifers of the appropriate body weight (NRC, 1978). The consumption of individual ration constituents (silage, concentrate, and hay) was recorded daily by lots.

At approximately 28-day intervals and at the end of the silage-feeding phase, body weights were taken. At the end of the silage-feeding

phase, the heifers were weighed on two consecutive days, with the mean weight of both days being considered as the animal's weight. Also, at the conclusion of the silage-feeding phase, all heifers were measured to determine backfat thicknesses. The length of the silage-feeding phase for the heifers during trial 1 was 103 days and, for trial 2, 84 days.

The full-feeding phase started after the end of the silage-feeding phase. The first 7 to 14 days of the full-feeding grain period were an adjustment period during which silage feeding was gradually reduced and grain was increased. Analyses were conducted on a sample of the full-feed ration and used to determine the amount of protein supplement necessary to meet NRC requirements. Also, an average of approximately three pounds of hay per heifer were fed. The length of the full-feeding phase for the heifers during trial 1 averaged from 66 to 71 days and, for trial 2, from 61 to 65 days. It was predetermined that when each individual heifer attained a backfat thickness of 12 mm or greater, she was to be removed from the experiment and sent to slaughter. Before slaughter, they were weighed on two consecutive days, again with the mean weight considered as the animal's weight, and sent to slaughter at Lay's packing plant in Knoxville, Tennessee, and carcass data were obtained.

Parameters determined. For both trials, frame and muscling scores were taken just prior to the initiation of each trial. This was the only time during each trial that these parameters were determined since they were not expected to change during the remainder of the animal's lifetime. The frame and muscling scores were used only as tools for allotting the heifers.

Backfat thicknesses were also measured just prior to the beginning of each trial, at the end of the silage-feeding phase, and initially at four-week intervals in the full-feeding phase, and later at two-week intervals as heifers approached the 12 mm backfat thicknesses. Although the initial backfat thicknesses were used in the allotting of the animals, subsequent measurements were also considered as measures of the effect of the corn silage additives. Body weights of the heifers were taken in mid-December for both trials; these weights were used in allotting the heifers. Body weights were also taken at the beginning and end of the silage-feeding phase and at 28-day intervals throughout the trials. As with the backfat thicknesses, body weights were taken more frequently as heifers approached slaughter condition.

Hot carcass weights were obtained at the slaughterhouse. Carcass grades, conformation, maturity, and marbling scores were made by a USDA grader after the carcasses had chilled 48 hours. Ribeye area, fat thickness, and percent kidney fat were estimated according to procedures set forth by the American Meat Science Association (Schoonover et al., 1967).

Weight gains, average daily gain, and increases in backfat thickness were calculated for subsequent 28-day periods for the silage phase and for the full-feeding phase. Feed efficiencies (feed/gain; gain/feed) were calculated for each lot and each treatment from daily feed intake of the animals by lot, and the average daily gains of each lot.

Statistical analyses. Data from the two trials were pooled by treatment and significant treatment effects were determined by an

analysis of variance. When necessary, Student Newman Keuls multiple range test was used for mean separation. When the individual heifer was the experimental unit (daily body weight gains, carcass characteristics, etc.), the following model was used:

$$Y_{ijkl} = \mu + y_i + t_j + (y \times t)_{ij} + l(y \times t)_{ijk} + e_{ijkl}$$

where Y is the dependent variable; μ is the overall mean; y is the effect due to year, $i = 1-2$; t is the effect due to treatment, $j = 1-4$; (y X t) is year-treatment interaction; $l(y \times t)$ is the lot within year-treatment interaction; and e is the error term. When lot was the experimental unit (feed intake, feed efficiency) the following model was used:

$$Y_{ijk} = \mu + y_i + t_j + (y \times t)_{ij} + e_{ijk}$$

where, again, Y is the dependent variable; μ is the overall mean; y is the effect due to year, $i = 1-2$; t is the effect due to treatment, $j = 1-4$; (y X t) is the year-treatment interaction; e is the error term.

Significance of treatment effects on all parameters within each trial was also determined.

Digestion Trial

Experimental design. A total-collection digestion trial was conducted concurrently with the 1979-80 feedlot trial. This study was conducted in order to determine dry matter intake and nutrient digestibility of corn silages treated with fermentation aids by mature wether sheep. The same four experimental silages that were fed the heifers in the feedlot trials were also fed to these sheep, that is,

the untreated control corn silage, Silabac-treated corn silage, Culbac-treated corn silage, and Crop Cure-treated corn silage.

Experimental silages. The silages fed to the sheep were obtained on two separate days from those silos containing the silages fed to the heifers on the feedlot trial. On both days, eight 55-gallon drums, two for each treatment, had their tare weights taken. Silage was removed from each of four treatment silos and packed, by hand, into two-layer plastic bags lining the drums. After filling and exclusion of air above the ensiling mass, the bags were sealed and the lid locked on the drum. The drums, containing the silages, were then transported from Greeneville to Knoxville, where the digestion and metabolism studies were conducted.

In Knoxville, the drums were reweighed and the tare weight subtracted to determine the amount of silage removed from each silo. This was done so that all the silage being removed from each silo would be accounted for when determining dry matter recovery.

Conduct of trial. Sixteen mature Hampshire-cross wether sheep were used. These sheep averaged 74.5 kg in body weight and were all approximately five years old. Four wethers were allotted, by weight and age, to each of the silage treatments. The sheep were placed in metabolism crates (Briggs and Gallup, 1955) and maximum silage intakes were determined during an eight-day preliminary period. The animals were fed twice daily with one-half of the ration being fed at both 8 a.m. and 4 p.m. Water was offered one-half hour before each feeding, then removed shortly before feeding. A trace mineralized salt block was offered free choice. The preliminary period was immediately followed by a seven-day

collection period during which feed, refusal, feces, and urine samples were collected. Daily representative samples of feeds and refusals were taken and composited. Ten percent aliquot samples of the daily fecal outputs were measured, by weight, and composited daily for each sheep. Mold growth was inhibited by the addition of a few thymol crystals daily. The daily urine excretions were measured and a 10% aliquot, by volume, was taken and composited for each sheep. In order to preserve the urine samples, 10 ml of 6N hydrochloric acid was added daily to each of the urine collection vessels. All composite samples were refrigerated until analyzed.

Chemical analyses. Feed and fecal samples were dried at 60 C for 72 hours and allowed to air equilibrate for the same period of time. The samples were then ground through a 1 mm mesh screen of a Wiley Mill. Complete Proximate Analysis according to AOAC (1975) methods was conducted on feed and fecal samples while only crude protein was determined on the urine samples. Acid-detergent fiber was determined according to AOAC (1975). Since refusal samples were negligible, chemical analyses were not conducted on them. Apparent digestion coefficients of each respective nutrient and percent total digestible nutrients were calculated.

Statistical analyses. Significance of treatment effects on digestibility parameters were determined by an analysis of variance and a Student Newman Keuls multiple range test.

CHAPTER IV

RESULTS AND DISCUSSION

Dry Matter Recovery

The effect of the corn silage fermentation aids on dry matter recovery for both years are presented in Table 1 while the data for individual years are presented in Appendix Tables A1 and A2.

In Table 1, the loss and recovery figures for each treatment are presented as the mean of four silos (two silos per treatment per year) except for the Crop Cure treatment for which three silos were used to calculate the treatment mean, because the replicate silo for 1980-81 had been infested by rats. Recoveries alone will be discussed, since loss figures are calculated as a function of the recovery figures.

There were no differences ($P>.05$) among treatments for any of the recovery parameters; however, the statistical analyses are considered to be inconclusive due to the low number of replicates. However, there were obvious numerical differences in magnitude. The addition of Culbac to corn silage resulted in a numerical improvement of 6.53 percentage units in dry matter recovery. This improvement was observed in both years (Appendix Tables A1 and A2). Only slight numerical improvements in dry matter recovery due to Silabac and Crop Cure addition were observed and responses were not similar in individual years (Appendix Tables A1 and A2).

McCullough (1977) reported 12 and 14 percentage unit improvements in dry matter recovery, after ensiling losses, resulting from the addition of either a microbial or an enzymatic fermentation aid to corn

Table 1. Effect of Corn Silage Fermentation Aids on Dry Matter Recovery, % - 2-Year Means

	Corn silage ^a			
	Control	+Silbac	+Culbac	+Crop cure ^b
Dry matter lost during ensiling	11.66	10.74	5.14	8.97
Dry matter recovery after ensiling losses	88.44	89.26	94.86	91.04
Dry matter lost due to spoilage	5.28	4.59	3.70	7.00
Dry matter recovery after spoilage losses	94.72	95.41	96.30	93.00
Total dry matter lost	16.95	15.33	8.84	15.97
Total dry matter recovery	83.05	84.67	91.16	84.03

^aThere were no significant differences in treatments ($P > .05$).

^bFigures are presented for three silos only because the replicate silo for 1980-81 had been infested by rats.

silage. Also, an organic acid-treated corn silage was reported to have an 8 percentage unit improvement in dry matter recovery after ensiling losses (Leaver, 1975).

Spoilage losses between treatments are also somewhat different in magnitude. The Silabac- and Culbac-treated corn silage had slightly lower losses due to spoilage as compared to the control, while the Crop Cure-treated corn silage had a dry matter recovery less than that of the control. The lower dry matter losses due to Culbac addition were noted in both years.

After accounting for both ensiling and spoilage losses, all three fermentation aids resulted in at least a small numerical improvement in dry matter recovery as compared to that of the control. Silabac and Crop Cure addition to corn silage resulted in a slight numerical improvement of 1.62 and 0.98 percentage units, respectively, in total dry matter recovery. However, the Culbac-treated corn silage had an 8.11 percentage unit improvement in total dry matter recovery compared to that of the control; this figure is 1.5 percentage units greater than the percentage unit improvement figure reported by Bolsen et al. (1980b) for an enzymatic fermentation aid compared to that of an untreated control. Thus, it appears that the addition of Culbac (a dead lactobacillus preparation) to corn green chop resulted in a marked numerical improvement in total dry matter recovery after ensiling and spoilage losses. This numerical improvement might well have been statistically significant if sufficient replicates had been included. Effects of the addition of Silabac or Crop Cure are inconclusive at this point.

Silage Composition

The nutrient composition of the experimental corn silage of the 1979-80 trial and the 1980-81 trial are presented in Table 2. The dry matter contents of the four corn silage treatments of the 1979-80 trial were similar. All Proximate Analyses, acid-detergent fiber (ADF), and lignin constituent percentages were similar among the four silage treatments. On a dry matter basis, the crude protein content of the corn silage treatments were nearly identical at 9.22% for the control, 9.23% for Silabac and Crop Cure, and 9.18% for Culbac. These crude protein percentages are slightly higher than the average crude protein value for corn silage reported by the NRC (1976).

Ether extract (EE) and ash values are slightly lower than those values reported by the NRC (1976) for a corn silage. The crude fiber (CF) values of the corn silage treatments were approximately 5 percentage units lower, on a dry matter basis, than that value reported by the NRC (1976) for a corn silage. The nitrogen-free extract (NFE) values of the corn silage treatments were approximately 5 percentage units higher, on a dry matter basis, than that value reported by the NRC (1976) for a corn silage.

The ADF contents for each corn silage treatment were slightly lower than other ADF values of corn silage reported by several workers; however, the percentage of dry matter of these other corn silages were much higher, 7 (Baxter et al., 1979) to 18 (Culvahouse et al., 1975) percentage units higher than the dry matter percentages of the corn silage treatments reported here.

Table 2. Nutrient Composition of Rations, %

	Corn silage			
	Control	+Silbac	+Culbac	+Crop cure
1979-80 trial				
Dry matter ^a	23.19	24.19	24.96	24.54
Crude protein ^b	9.22	9.23	9.18	9.23
Crude fiber ^b	20.87	21.02	20.89	20.44
Ether extract ^b	2.86	2.84	2.82	3.05
Ash ^b	5.71	5.02	5.37	5.49
Nitrogen-free extract ^b	61.34	61.89	61.74	61.76
Acid-detergent fiber ^b	26.72	25.81	25.67	25.70
ADF-nitrogen ^b	6.56	5.90	9.41	6.92
Lignin ^b	2.74	2.59	2.52	2.42
1980-81 trial				
Dry matter ^a	36.37 ^c	33.62 ^d	32.10 ^d	32.89 ^d
Crude protein ^b	8.54	8.12	8.51	8.69
Crude fiber ^b	23.05	22.62	22.26	23.27
Ether extract ^b	2.20	2.00	2.20	2.09
Ash ^b	4.13	4.48	4.67	4.84
Nitrogen-free extract ^b	62.08	62.78	62.37	61.13
Acid-detergent fiber ^b	36.72	37.42	38.17	36.22
ADF-nitrogen ^b	16.25	14.19	14.04	14.86
Lignin ^b	4.14 ^f	4.58 ^e	4.27 ^f	3.95 ^g

^a Fresh basis.^b Dry matter basis^{c,d} Means in the same row with different superscripts are different (P<.01).^{e,f,g} Means in the same row with different superscripts are different (P<.05).

The acid-detergent fiber nitrogen (ADFN) percentages were similar to ADFN percentages reported by Baxter et al. (1979) and Culvahouse et al. (1975) for corn silages, except for the Culbac treatment, which was slightly higher.

The lignin percentages were also similar to lignin percentages of corn silages as reported by other workers (Baxter et al., 1979; Culvahouse et al., 1975).

In the 1980-81 trial, statistical analyses were done to determine differences among corn silage treatment. No differences ($P > .05$) were found among corn silage treatments, on a dry matter basis, for CP, CF, EE, Ash, NFE, ADF, and ADFN. The percent dry matters of the treated corn silages were found to be less ($P < .05$). The ADF percentages of the corn silages in the 1980-81 trial were 10 to 12 percentage units higher than those of the 1979-80 trial, indicating that the silages produced in 1980-81 were much more mature than those of 1979-80.

The ADFN percentages in the 1980-81 trial were also higher than those of the 1979-80 trial; 5 to 10 percentage unit differences were found among corresponding treatments. This increase in ADFN in 1980-81 may be due to the increased amount of dry matter of the corn silages, which, when ensiled in the smaller than conventional experimental silos, increased the opportunity of inclusion of oxygen. This increased inclusion of oxygen can cause subsequent rises in temperature (Ruxton et al., 1975), which in turn can cause increases in the amount of ADFN produced. All other listed nutrient components of the rations for the 1980-81 corn silage treatments were similar to those of the 1979-80 corn silage treatments.

The differences between the silages can be somewhat explained by the differences in climactic conditions during the growing seasons of the two trials. There was a six-inch decline in the amount of rainfall during the 1980-81 trial as compared to the 1979-80 trial. This difference in rainfall is reflected in the compositions of the silages of the two trials. Also there were slightly higher crude protein contents in the corn silages of 1979-80 as compared to those of 1980-81. The higher ADF and ADFN contents and lower crude protein content in utilizable form of silages in 1980-81 indicate that they were of lower quality than those of the previous year.

Animal Performance

Silage phase. The animal performance and feed consumption data for both years are presented as two-year means in Table 3. The individual period and silage phase performance data for 1979-80 can be found in Appendix Tables A3 through A7 and in Appendix Tables A8 through A11 for 1980-81. The average daily corn silage intake on an as-fed basis per head was not different ($P > .05$) among treatments. In 1980-81, however, the heifers fed the control silage consumed less ($P < .05$) than those animals fed the treated corn silages. In addition, the as-fed corn silage consumed by the heifers of the Culbac-treated corn silage was more ($P < .05$) than the consumption of the other two treated silages, in 1980-81. These differences in intake can be attributed in part to the differences in the dry matter content of the individual treatments, of which intake is a function.

Table 3. Animal Performance and Feed Consumption (Silage Phase) 2-Year Means

	Corn silage ^a			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	20	20	20	20
Average daily feed intake/head, lb.				
Corn silage-as fed	33.5	34.3	34.2	33.9
Corn silage-AEDM	10.4	10.5	10.5	10.4
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.3	1.3	1.3	1.3
Total AEDM	13.7	13.8	13.8	13.7
Average weight and gain/head, lb.				
Initial	558	552	564	555
Final	746	729	741	725
Total	188	177	177	170
Average daily gain	2.00	1.90	1.88	1.84
Feed efficiency				
Feed/gain	6.88	7.24	7.27	7.44
Gain/feed	0.146	0.138	0.138	0.135
Pounds of beef/pound of DM ensiled ^b	0.163	0.151	0.157	0.150

^aThere were no significant differences in treatments ($P>.05$).

^bIntake of hay and soybean meal were not considered.

No differences ($P > .05$) were found among the treatment two-year means for corn silage intake per head on an air-equilibrated dry matter (AEDM) basis; however, there were differences ($P < .05$) in individual year intakes of corn silage. In 1979-80, the AEDM intakes of the Silabac- and Crop Cure-treated corn silages were not different ($P > .05$) from the control; however, Culbac-treated corn silage AEDM intake was more ($P < .05$), by 0.4 pounds per head, than that of the control while not being different ($P > .05$) from either Silabac- or Crop Cure-treated corn silage. In 1980-81, the AEDM intake of the Culbac- and Crop Cure-treated corn silages was less ($P < .05$), by 0.3 and 0.2 pounds per head, respectively, than that of the control or Silabac-treated corn silage. Consumption by the heifers of hay and soybean meal on an AEDM basis were identical for each treatment for both years. Hay was fed at the rate of two pounds per head daily for both years while 1.3 pounds of soybean meal per head was fed daily in 1979-80 and 1.2 pounds per head was fed daily in 1980-81. The two-year means were therefore the same for all treatments at 2.0 pounds and 1.3 pounds for hay and soybean meal, respectively.

Finally, since hay and soybean meal intakes were constant among treatments, the daily total AEDM intake per head was found to have the same differences ($P < .05$) as those of the corn silage intake on an AEDM basis for each year. This is understandable since the total AEDM is the sum of the hay, soybean meal, and corn silage intakes on an AEDM basis. For the same reason there were no significant differences among the two-year treatment means. The two-year means therefore indicate that the fermentation aids did not affect the average daily feed consumptions of the heifers.

There were no differences ($P>.05$) in either initial or final body weights within each year or as a single two-year mean among treatments. Nor were there any differences ($P>.05$) among treatments in total gain or average daily gain for 1980-81 and for the two-year means. Daily gain data are comparable to those reported by Bolsen (1980) for heifers fed Silabac-treated corn silage and corn silage treated with the enzyme additive Silo-best; the daily gain for both treated silages was identical to that of the control at 2.16 pounds. In 1979-80, the daily gains of heifers fed the treated silages were lower ($P<.05$) than those heifers fed the control silage. The daily gains of heifers fed the Culbac- and Silabac-treated silage were not different ($P>.05$) from each other; however, the Crop Cure-treated corn silage was less than the Culbac-treated corn silage while not being different from the Silabac-treated corn silage ($P>.05$).

Feed efficiency was calculated as the quotients of the total AEDM intake per head and the daily gains per head (feed/gain) and also as the inverse (gain/feed). Feed efficiency was also expressed as total gain per pound of dry matter ensiled. For the two-year means and for 1980-81, no differences ($P>.05$) were found among treatments in feed/gain or gain/feed efficiencies. However, in 1979-80, animals fed all treated silages were less ($P<.05$) efficient in converting feed into gains than animals fed the control silage. These differences are understandable since daily gains of animals fed the control silage was greater than those fed the treated silage while the daily feed intake of the control corn silage was less than that of the treated silage. The "pounds of beef per pound of dry matter ensiled" parameter, which did not consider

hay and soybean meal intake, was not different ($P>.05$) among treatments for the two-year means.

In conclusion, the two-year means indicate that Silabac, Culbac, and Crop Cure addition to corn green chop before ensiling did not significantly affect intake, gain, or feed efficiencies of slaughter beef heifers. This is consistent with results reported by Burghardi et al. (1980) and Leaver (1975). Burghardi et al. (1980) found that daily intakes, daily gains, and feed efficiencies of steers fed a control or a lactobacillus and lactic acid ferment enzyme-treated corn silage were nearly identical. Leaver (1975) reported that organic acid treatment of corn silage yielded similar intakes and growth rates by heifers when compared to a control.

Full-feeding phase. The animal performance and feed consumption data, from the beginning of the full-feeding phase to the last day all the heifers were present, for both trials, are presented as two-year means in Table 4. This period was 54 days in 1979-80 and 44 days in 1980-81. The animal performance data for individual periods and this portion of the full-feeding phase can be found in Appendix Tables A12 through A14 for 1979-80 and Appendix Table A15 for 1980-81. No difference ($P>.05$) occurred among treatments for any of the previously discussed parameters for either trial or for the two trials combined. Since animal performance data per trial were not different ($P>.05$) among treatments, this indicates that those differences ($P<.05$) in daily intake, daily gains, and feed efficiency in 1979-80 and daily intake and feed efficiency in 1980-81, which occurred in the silage feeding phase, did not carry over into the full-feeding phase.

Table 4. Animal Performance and Feed Consumption (Partial Full-Feeding Phase)^a
2-Year Means

	Corn silage ^b			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	20	20	20	20
Average daily feed intake/head, lb.				
Corn silage-as fed	4.7	4.7	4.7	4.7
Corn silage-AEDM	1.6	1.5	1.5	1.5
Hay	3.3	3.3	3.3	3.3
Corn	14.5	14.6	14.5	14.5
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	20.6	20.6	20.5	20.5
Average weight and gain/head, lb.				
Initial	746	729	741	726
Final	836	829	831	825
Total	90	100	90	99
Average daily gain	1.86	2.05	1.85	2.03
Feed efficiency				
Feed/gain	11.09	10.02	11.24	10.12
Gain/feed	0.09	0.10	0.09	0.10

^aRefers to the beginning of the full-feeding phase to the last day all the heifers were present.

^bThere were no significant differences in treatments ($P>.05$).

The daily gains, from the beginning of the full-feeding phase to the last day all the heifers were present, were 1.86, 2.05, 1.85, and 2.03 for the control, Silabac, Culbac, and Crop Cure corn silages, respectively. There does appear to be some indication of compensatory gains during this portion of the full-feeding phase. The heifers that previously had been fed the Silabac and Crop Cure silage and had gained less than those fed the control silage in the silage phase had a numerical improvement in daily gains of 0.15 and 0.19 pounds, respectively, during that portion of the full-feeding phase. It is not known why Culbac-fed heifers did not respond similarly.

The animal performance and feed consumption data for the entire full-feeding phase, for both years, are presented as two-year means in Table 5. The individual period and full-feeding phase animal performance data for 1979-80 can be found in Appendix Tables A16 and A17 and in Appendix Tables A18 and A19 for 1980-81. Parameters of the full-feeding phase were found not to be different ($P>.05$) among treatments for each year individually and for the two years combined. The average days on full feed are also presented in Table 5 and in Appendix Tables A17 and A19. There were no differences ($P>.05$) of the average number of days on full feed among treatments for either year or for the two-year means.

Carcass parameters. Estimated backfat thicknesses in millimeters (mm) and carcass data are presented as two-year means in Table 6. The backfat thicknesses in mm and carcass data for each year individually are presented in Appendix Tables A20 and A21. Initial, intermediate, and final backfat thicknesses are presented. The term "intermediate"

Table 5. Animal Performance and Feed Consumption (Full-Feeding Phase) 2-Year Means

	Corn silage ^a			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	20	20	20	20
Average daily feed intake/head, lb.				
Corn silage-as fed	3.5	3.5	3.6	3.5
Corn silage-AEDM	1.1	1.1	1.1	1.1
Hay	3.5	3.5	3.5	3.5
Corn	14.8	14.8	14.7	14.8
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	20.6	20.6	20.5	20.6
Average weight and gain/head, lb.				
Initial	746	729	741	726
Final	865	853	864	847
Total	119	124	123	121
Average daily gain	1.89	1.89	1.90	1.81
Feed efficiency				
Feed/gain	10.92	10.94	10.83	11.47
Gain/feed	0.09	0.09	0.09	0.09
Average days on full-feed	64	66	65	68

^aThere were no significant differences in treatments ($P>.05$).

Table 6. Estimated Backfat Thickness and Carcass Data 2-Year Means

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	20	20	20	20
Days on silage	94	94	94	94
Days on full-feed ^a	64	66	65	67
Total days on experiment	158	160	159	161
Average daily gain, lb. ^b	1.91	1.92	1.89	1.83
Backfat thickness, mm ^a				
Initial	2.9	2.6	3.0	3.0
End of silage phase	5.8	6.1	6.0	5.5
Backfat gain (silage phase)	2.9	3.5	3.0	2.5
Intermediate ^c	10.7	10.8	10.8	10.0
Backfat gain (intermediate period)	4.9	4.7	4.8	4.5
Final ^d	11.9	12.0	12.0	11.8
Backfat gain (final period)	1.2	1.2	1.2	1.8
Total backfat gain	9.0	9.4	9.0	8.8
Carcass data				
Hot carcass weight, lb.	486	482	488	477
Fat thickness, in.	0.47 ^e	0.41 ^f	0.42 ^f	0.46 ^e
Loineye, in. sq.	10.5	10.9	10.7	10.4
Conformation grade ^g	13.0	12.8	12.8	13.0
Marbling score ^h	5.3	4.9	4.8	5.5
Carcass grade ^g	12.1	11.7	11.7	12.3
Kidney fat, %	2.5	2.5 ^f	2.6 ^f	2.6
Yield grade	2.6 ^e	2.3 ^f	2.5 ^f	2.6 ^e

^aThere were no significant differences in treatments ($P > .05$).

^bRefers to average daily gain for the entire trial.

^cRefers to last date backfat thickness data were available for all animals.

^dRefers to final backfat thickness of animals just prior to slaughter.

^{e,f}Means in the same row with different superscripts are different ($P < .05$).

^gLow choice - 12; Ave. choice = 13; High choice - 14.

^hSlight - 4; Small = 5; Modest = 6.

refers to the last date backfat thickness data were available for all the heifers, while the term "final" refers to the final backfat thickness of the heifers just prior to slaughter. There were no differences ($P > .05$) among treatments in either initial or the "end of silage phase" backfat thickness for each year individually or when expressed as two-year means. The backfat gains among treatments were also not different ($P > .05$) for both 1980-81 and the two-year means. Though non-significant, there were magnitude differences in backfat gains by the heifers at intervals throughout the silage phase, when expressed as two-year means. These differences ranged from 2.5 mm for the Crop Cure treatment to 3.5 mm for the Silabac treatment, with the control and Culbac treatments at 2.9 and 3.0 mm, respectively. These magnitude differences are probably due to differences ($P < .05$) among treatments which occurred in the silage phase backfat gains during 1979-80. In 1979-80, the Silabac treatment heifers gained more ($P < .05$) backfat, 3.2 mm more, than the other three treatments. Heifers of the Culbac treatment gained 2.5 mm of backfat which was not significantly different from the 1.9 mm of backfat gain by heifers of the control treatment. Heifers of the Crop Cure treatment gained 1.6 mm of backfat which was also not significantly different from the control heifers' backfat gains. A possible explanation for the superior gains of the heifers of the Silabac treatment during 1979-80 is that the initial backfat thickness of the Silabac treatment heifers, though not different ($P > .05$) than that of the other treatments, was 0.6 mm less at 2.5 mm than the initial 3.1 mm of backfat for the other three treatments.

Differences ($P < .05$) in backfat gains did not carry over into either intermediate or final backfat gains for 1979-80. No differences ($P > .05$) occurred, in either 1979-80 or 1980-81, and in the two-year means, among treatments for intermediate and final backfat thicknesses and intermediate period, final period, and total backfat gains.

Hot carcass weights, in pounds, were not different ($P > .05$) among treatments in either 1979-80 or 1980-81 and in the two-year means. The backfat thicknesses expressed as two-year means of the Silabac- (0.41 in.) and Culbac- (0.42 in.) fed heifers were less ($P < .05$) than those of the control- (0.47) and Crop Cure- (0.46 in.) fed heifers. These two-year differences are the result of differences in the second year only. In the first year, no significant differences were observed and numerical differences, when present, were in different directions than those of the two-year means.

A possible explanation for the lower backfat thicknesses of the carcasses of the Silabac and Culbac treatments is decreased rumen acetate levels. Work conducted by Burghardi (1980) indicated that inoculation of corn silage with high levels of *Lactobacillus acidophilus* organisms decreased ($P < .05$) acetate levels when compared to corn silage inoculated with a lower level of *Lactobacillus acidophilus* organisms. If this decrease in acetate levels also occurs in the rumen, then there could be a resulting decrease in carcass backfat thickness, since acetate is the primary precursor of fat. Other two-year data that express fatness of the carcass (marbling scores, carcass grade, and yield grade) show the same trends, that is, carcasses of the Silabac- and Culbac-fed cattle were leaner than those of control- and Crop Cure-fed cattle. The kidney

fats were not related to overall fatness measurements of the carcass, which is often the case. Conversely, loineye areas of Silabac- and Culbac-fed heifers were not larger ($P>.05$) than those of control and Crop Cure-fed heifers, again emphasizing the overall pattern that the addition of lactobacillus-derived fermentation aids to corn silage might result in leaner carcasses. However, results are still inconclusive and further studies are required.

Apparent nutrient digestibility. Dry matter intakes and apparent nutrient digestibilities are presented in Table 7. Dry matter intakes by wethers fed the treated corn silages were lower ($P<.05$) than those fed the untreated control. This is in contrast to results reported by several workers. Bolsen et al. (1980b) reported no differences ($P>.05$) in dry matter intakes of cattle fed corn silage treated with an enzyme additive to those fed a control. Burghardi et al. (1980) reported similar intakes among steers fed corn silages treated with lactobacillus acidophilus organisms and those fed an untreated control. Dry matter intake of calves and heifers offered an organic acid-treated corn silage or an untreated control were also shown to be similar (Leaver, 1975). Dry matter intakes of the treated silages were 1.17, 1.06, and 1.20 kg/day for the Silabac-, Culbac-, and Crop Cure-treated silages, respectively, while the intake of the control silage was 1.37 kg/day. Intakes of the treated silages were slightly lower than the maintenance requirement of 1.25 kg/day suggested for 75 kg ewes (NRC, 1975).

No differences ($P>.05$) among treatments were found for digestibility of dry matter, organic matter, CF, NFE, or ADF. McCullough (1977) and

Table 7. Apparent Nutrient Digestibility

Variable	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
Number of wethers	4	4	4	4
Body weight, kg	74.4	73.7	73.6	76.3
Dry matter intake, kg/day	1.37 ^a	1.17 ^b	1.06 ^b	1.20 ^b
Apparent digestion coefficients, %				
Dry matter	68.1 ^a	69.7 ^a	67.7 ^a	66.6 ^a
Organic matter	67.1 ^a	68.1 ^a	68.5 ^a	69.3 ^a
Crude protein	56.8 ^a	57.6 ^a	54.3 ^b	54.9 ^b
Ether extract	75.7 ^a	85.4 ^b	82.4 ^c	83.7 ^{b,c}
Crude fiber	57.6 ^a	62.5 ^a	55.9 ^a	55.4 ^a
N-free extract	75.2 ^a	75.2 ^a	75.0 ^a	73.8 ^a
Acid-detergent fiber	49.1 ^a	47.3 ^a	50.6 ^a	47.6 ^a
Total digestible nutrients, % ^d	68.2 ^a	69.8 ^a	68.7 ^a	68.5 ^a

a,b,c Means on the same line with the same superscript are not significantly different (P>.05).

^dDry basis.

Burghardi et al. (1980) reported similar dry matter digestibility of corn silage treated with microbial and enzymatic fermentation aids as compared to data received in this trial. In addition, digestibilities of individual nutrients obtained in this trial were similar to those reported by McCullough (1977), who also found no differences ($P > .05$) among treatments from wethers fed microbial-treated, enzyme-treated, or untreated control corn silages.

The CP digestibility by wethers fed the Crop Cure diet was depressed ($P < .05$) as compared to wethers fed the control diet. This depression of CP digestibility may be explained by work conducted by Holter and Reid (1959), who indicated that CP digestibility decreased when the CP percent of the diet was lower, which was the case with the Crop Cure silage. Also, the ADFN percentage of the Crop Cure diet was approximately 1 to 3 percentage units higher than that of the other diets, indicating that a smaller proportion of the CP in the Crop Cure silage was in a digestible form. The CP digestibility of the Culbac silage was also depressed; however, the reason for this is not understood. The Silabac silage should have had a depressed CP digestibility because of a lower CP content; however, this did not occur. These inexplicable differences in CP digestibility tend to indicate that the CP digestibility data are inconclusive.

The EE content of the silages were all lower than the average EE content reported by the NRC (1976) for corn silage. Since the EE contents of the silages were so low, the differences ($P < .05$) in EE digestibilities are considered as inconclusive. Total digestible nutrients were not affected ($P > .05$) by dietary treatment, and the total

digestible nutrients of all the silages were higher than the 55% total digestible nutrients required for maintenances of 75 kg ewes (NRC, 1975).

CHAPTER V

SUMMARY

The effects of corn silage fermentation aids on dry matter recovery of silage, performance, and subsequent carcass data of beef heifers fed the silages and nutrient digestibility of the silages by wethers were determined in this study. Corn green chop in the late dough to early dent stage was harvested during August of 1979 and 1980. For each year, two silos were assigned to one of four silage treatments with or without fermentation aids added. The four experimental corn silage treatments were: (1) an untreated control silage; (2) treated with Silabac, a live lactobacillus preparation; (3) treated with Culbac, a dead lactobacillus preparation; and (4) treated with Crop Cure, sodium diacetate. Samples of the ensiled materials were taken for later determination of dry matter recovery. The ensiled materials were allowed to ferment for approximately 140 to 150 days before the first silo of each treatment was opened. Fresh silage samples were taken during both years when the silos were opened and at 28-day intervals thereafter. In addition, a sample of spoiled silage was taken from one silo of each treatment in 1980. These samples were taken in order to determine the dry matter recovery and nutrient composition of each treatment.

In the fall of 1979 and 1980, Angus beef heifer calves were purchased during the Tennessee fall feeder calf sales. In mid-December of each year heifers were allotted, using several parameters, to eight groups of five animals each, two groups per treatment, with the effort being made to have maximum equality of all parameters.

Two feedlot trials, designated as the 1979-80 trial and the 1980-81 trial, were then begun. These trials were partitioned into two phases--the silage-feeding phase and the full-feeding phase. At approximately 28-day intervals throughout each phase and at the end of each phase body weights were taken. Utilizing these weights and the feed intakes of the heifers during these intervals, the gains and feed efficiencies of the heifers of each treatment were calculated.

Backfat thicknesses of the heifers were measured using a somoscope prior to the beginning of the silage-feeding phase and at the end of the silage-feeding phase. Backfat was also measured during the full-feeding phase, initially at four-week intervals and later at two-week intervals as heifers approached 12 mm backfat thickness, which was predetermined as the criterion to send each heifer to slaughter. Backfat thickness data were also studied to determine if there were any treatment effects.

After chilling the carcasses of the slaughtered heifers for 48 hours, several carcass parameters were either measured or calculated and the data compared to determine possible treatment effects.

A total collection digestion trial was conducted concurrently with the 1979-80 feedlot trial. Some silage from one of the silos of each treatment was removed, stored, and then fed to mature wethers averaging 74.5 kg in body weight. Nutrient digestibility of the corn silage treatments by the wethers were determined and compared.

Two-year means of the dry matter recoveries of each treatment were not significantly different ($P > .05$); however, the statistical analyses were considered to be inconclusive due to a low number of replicates. The dry matter recovery after ensiling losses, after spoilage losses, and

total dry matter recovery for each corn silage treatment, respectively, were 88.3, 94.7, and 83.1% for the control; 89.3, 95.4, and 84.7% for Silabac; 94.9, 96.3, and 91.2% for Culbac; and 91.9, 93.3, and 85.2% for Crop Cure. It appears that, except for the Culbac-treated corn silage, addition of fermentation aids had little effect on improvement of dry matter recovery.

The nutrient composition of the corn silage treatments of the 1979-80 trial was similar among treatments for all constituents. In the 1980-81 trial, silages with additives were lower ($P < .01$) in dry matter as compared to the control. All other constituents, except lignin, were not different ($P > .05$) among treatments. The Silabac-treated silage was higher ($P < .05$) and the Crop Cure-treated silage was lower ($P < .05$) in lignin content than the control, the reason for which is not understood.

Fermentation aids added to the corn silages during ensiling did not significantly affect ($P > .05$) intake, gain, or feed efficiencies of the slaughter beef heifers as compared to the control during the silage-feeding phase. Also, there were no significant ($P > .05$) treatment effects in intake, gain, or feed efficiencies during the full-feeding phase.

There were no significant differences ($P > .05$) among treatments for two-year means of any of the backfat thicknesses, which were measured at various times, or for any of the carcass parameters, except for fat thickness and yield grades. Silabac and Culbac treatment backfat thicknesses and yield grades were found to be significantly lower ($P < .05$) than the control and Crop Cure treatments. Differences in fat thicknesses may have been due to changes in acetate levels in the silages due to the addition of fermentation aids and subsequent change in the rumen acetate

levels of the heifers. Yield grade differences were probably a function of the fat thickness differences.

In the total collection digestion trial, wethers fed the fermentation aid-treated silages consumed significantly less ($P < .05$) dry matter than wethers fed the control. No significant differences ($P > .05$) were found among rations in apparent nutrient digestion coefficients for any of the nutrient constituents except for those of crude protein and ether extract. Differences in ether extract digestibilities were considered inconclusive due to low ether extract contents in the rations. Crude protein digestibilities by wethers were depressed significantly ($P < .05$) in the Culbac- and Crop Cure-treated rations as compared to the control and Silabac-treated rations. Wethers offered the Crop Cure-treated ration had lower crude protein digestibility which was attributed to a low crude protein percentage in the ration and an increased acid-detergent fiber nitrogen percentage as compared to the other rations. Depression of crude protein digestibility by Culbac addition could not be explained.

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APPENDIX

Table A1. Effect of Corn Silage Fermentation Aids on Dry Matter Recovery 1979-1980

	Corn silage			
	Control	+Silabac	+Culbac	+Crop Cure
<u>Dry matter placed in silos</u>				
Green chop, lb.	47,330	46,925	48,020	47,700
Total dry matter, %	25.00	25.36	25.69	24.61
Total green chop dry matter, lb.	11,833	11,900	12,336	11,739
<u>Dry matter lost during ensiling</u>				
Silage removed from silo, lb.	41,743	41,983	42,119	42,029
Total dry matter, %	24.29	24.92	27.49	26.10
Silage dry matter removed from silo, lb.	10,139	10,462	11,579	10,970
Dry matter lost during ensiling, lb.	1,694	1,438	758	770
Dry matter loss, %	14.31	12.08	6.14	6.55
Dry matter recovery, %	85.69	87.92	93.86	93.45
<u>Dry matter lost due to spoilage</u>				
Spoiled silage, lb.	2,492	2,842	1,925	2,689
Total dry matter, %	24.29	24.92	27.49	26.10
Spoiled silage dry matter, lb.	605	708	529	702
Dry matter loss, %	5.11	5.95	4.28	5.98
Dry matter recovery, %	94.89	94.05	95.72	94.02
<u>Dry matter lost due to ensiling and spoilage</u>				
Total dry matter loss, lb.	2,299	2,146	1,287	1,471
Total dry matter loss, %	19.42	18.03	10.42	12.53
Total dry matter recovery, %	80.58	81.97	89.58	87.47

Table A2. Effect of Corn Silage Fermentation Aids on Dry Matter Recovery 1980-1981

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure ^a
<u>Dry matter placed in silos</u>				
Green chop, lb.	30,260	35,595	31,310	16,515
Total dry matter, %	36.43	32.49	32.81	33.52
Dry matter ensiled, lb.	11,024	11,564	10,272	5,536
<u>Dry matter lost during ensiling</u>				
Silage removed from silo, lb.	27,577	31,165	30,675	14,990
Total dry matter, %	36.37	33.62	32.10	32.73
Silage dry matter removed from silo, lb.	10,030	10,478	9,847	4,906
Dry matter lost during ensiling, lb.	994	1,086	425	630
Dry matter loss, %	9.02	9.39	4.14	11.38
Dry matter recovery, %	90.98	90.61	95.86	88.62
<u>Dry matter lost due to spoilage</u>				
Spoiled silage, lb.	3,257	1,870	2,020	1,120
Total dry matter, %	18.42	19.90	15.86	39.62
Spoilage dry matter removed from silo, lb.	600	372	320	444
Dry matter loss, %	5.44	3.22	3.11	8.02
Dry matter recovery, %	94.56	96.78	96.89	91.98
<u>Dry matter lost due to ensiling and spoilage</u>				
Total dry matter loss, lb.	1,594	1,458	745	1,074
Total dry matter loss, %	14.46	12.61	7.25	19.40
Total dry matter recovery, %	85.54	87.39	92.75	80.60

^aFigures for only one silo are presented because its replicate silo had been infested by rats.

Table A3. Animal Performance and Feed Consumption-Period 1 (Silage Phase) 28 Days

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
Average daily feed intake/head, lb.				
Corn silage-as fed	30.8	32.2	31.4	29.7
Corn silage-AEDM	7.8	8.5	8.5	7.9
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.5	1.5	1.5	1.5
Total AEDM	11.3	12.0	12.0	11.4
No. animals/treatment	10	10	10	10
Average weight and gain/head, lb.				
Initial	542	535	548	540
Final	622	593	612	596
Total	80	58	64	56
Average daily gain	2.87	2.05	2.27	2.00
Feed efficiency				
Feed/gain	3.94	5.85	5.28	5.64
Gain/feed	0.25	0.17	0.19	0.18

Table A4. Animal Performance and Feed Consumption-Period 2 (Silage Phase) 29 Days

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	37.8	36.8	36.8	36.8
Corn silage-AEDM	9.6	9.7	9.9	9.8
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.3	1.3	1.2	1.3
Total AEDM	12.9	13.0	13.1	13.1
Average weight and gain/head, lb.				
Initial	622	593	612	596
Final	654	636	653	637
Total	32	43	41	41
Average daily gain	1.10	1.50	1.41	1.41
Feed efficiency				
Feed/gain	11.72	8.67	9.29	9.29
Gain/feed	0.09	0.12	0.11	0.11

Table A5. Animal Performance and Feed Consumption-Period 3 (Silage Phase) 27 Days

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	42.2	41.2	41.1	41.2
Corn silage-AEDM	10.7	10.8	11.2	11.0
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	13.9	14.0	14.4	14.2
Average weight and gain/head, lb.				
Initial	654	636	653	637
Final	715	682	689	706
Total	61	46	37	69
Average daily gain	2.26	1.70	1.35	2.56
Feed efficiency				
Feed/gain	6.15	8.24	10.67	5.54
Gain/feed	0.16	0.12	0.09	0.18

Table A6. Animal Performance and Feed Consumption-Period 4 (Silage Phase) 19 Days

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	44.6	43.6	42.4	42.5
Corn silage -AEDM	11.3	11.5	11.5	11.4
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	14.5	14.7	14.7	14.6
Average weight and gain/head, lb.				
Initial	715	682	689	706
Final	758	721	746	719
Total	43	39	57	13
Average daily gain	2.24	2.06	2.97	0.68
Feed efficiency				
Feed/gain	6.47	7.14	4.95	21.47
Gain/feed	0.15	0.14	0.20	0.05

Table A7. Animal Performance and Feed Consumption (Silage Phase) 103 Days 1979-1980

	Corn silage			
	Control	+Silbac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	38.9 ^a	38.5 ^a	37.9 ^a	37.6 ^a
Corn silage-AEDM	9.9 ^a	10.1 ^{a,b}	10.3 ^b	10.1 ^{a,b}
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.3	1.3	1.3	1.3
Total AEDM	13.2 ^a	13.4 ^{a,b}	13.6 ^b	13.4 ^{a,b}
Average weight and gain/head, lb.				
Initial	542 ^a	535 ^a	548 ^a	540 ^a
Final	758 ^a	721 ^a	746 ^a	719 ^a
Total	216 ^a	186 ^b	198 ^{a,b}	179 ^b
Average daily gain	2.10 ^a	1.81 ^{b,c}	1.92 ^b	1.74 ^c
Feed efficiency				
Feed/gain	6.28 ^a	7.40 ^b	7.08 ^b	7.53 ^b
Gain/feed	0.160 ^a	0.135 ^b	0.141 ^b	0.130 ^b
Pounds of beef/pound of DM ensiled ^d	0.182	0.157	0.161	0.152

^{a,b,c} Means in the same row with different superscripts are different (P<.05).

^d Intake of hay and soybean meal were not considered. The total amount of dry matter ensiled for each of the rations were 1) Control - 11,833 lb.; 2) Silabac-11,900 lb; 3) Culbac-12,336 lb; 4) Crop cure-11,739.

Table A8. Animal Performance and Feed Consumption-Period 1 (Silage Phase) 28 Days

	Corn silage			
	Control	+Silbac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	26.0	27.5	27.5	27.5
Corn silage-AEDM	10.2	10.0	9.5	9.7
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.3	1.3	1.3	1.3
Total AEDM	13.5	13.3	12.8	13.0
Average weight and gain/head, lb.				
Initial	574	568	580	570
Final	623	627	625	621
Total	49	59	45	51
Average daily gain	1.74	2.09	1.60	1.84
Feed efficiency				
Feed/gain	7.76	6.36	8.00	7.06
Gain/feed	0.13	0.16	0.13	0.14

Table A9. Animal Performance and Feed Consumption-Period 2 (Silage Phase) 28 Days

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. of animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	26.4	28.1	28.3	28.3
Corn silage-AEDM	10.3	10.2	9.9	10.1
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	13.6	13.4	13.1	13.3
Average weight and gain/head, lb.				
Initial	623	627	625	621
Final	674	672	665	676
Total	51	45	40	55
Average daily gain	1.82	1.62	1.43	1.96
Feed efficiency				
Feed/gain	7.47	8.27	9.16	6.79
Gain/feed	0.13	0.12	0.11	0.15

Table A10. Animal Performance and Feed Consumption-Period 3 (Silage Phase) 28 Days

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	31.6	34.8	35.6	34.8
Corn silage-AEDM	12.3	12.6	12.4	12.3
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	15.5	15.8	15.6	15.5
Average weight and gain/head, lb.				
Initial	674	672	665	676
Final	734	736	736	732
Total	60	64	71	56
Average daily gain	2.13	2.27	2.52	1.99
Feed efficiency				
Feed/gain	7.28	6.96	6.19	7.79
Gain/feed	0.14	0.14	0.16	0.13

Table All. Animal Performance and Feed Consumption (Silage Phase) 84 Days 1980-1981

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	28.0 ^a	30.1 ^b	30.5 ^c	30.2 ^b
Corn silage-AEDM	10.9 ^b	10.9 ^b	10.6 ^a	10.7 ^a
Hay	2.0	2.0	2.0	2.0
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	14.1 ^b	14.1 ^b	13.8 ^a	13.9 ^a
Average weight and gain/head, lb.				
Initial	574	568	580	570
Final	734	736	736	732
Total	159	168	156	162
Average daily gain	1.89	2.00	1.86	1.93
Feed efficiency				
Feed/gain	7.46	7.05	7.42	7.20
Gain/feed	0.134	0.142	0.135	0.139
Pounds of beef/pound of D.M. ensiled ^d	0.144	0.145	0.152	0.148

^{a,b,c} Means in the same row with different superscripts are different (P<.05).

^d Intake of hay and soybean meal were not considered. The total amount of dry matter ensiled for each of the rations were: 1) Control - 11,024 lb; 2) Silabac - 11,564 lb; 3) Culbac - 10,272 lb; 4) Crop cure - 10,934 lb.

Table A12. Animal Performance and Feed Consumption-Period 5 (Full-Feeding Phase) 26 Days

	Treatment			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	8.9	8.9	8.9	8.9
Corn silage-AEDM	2.3	2.3	2.4	2.3
Hay	2.6	2.6	2.6	2.6
Corn	11.7	12.0	11.7	12.1
Soybean mean	1.0	1.0	1.0	1.0
Total AEDM	17.6	17.9	17.7	18.0
Average weight and gain/head, lb.				
Initial	758	721	746	719
Final	781	764	789	757
Total	23	43	43	38
Average daily gain	0.88	1.65	1.65	1.46
Feed efficiency				
Feed/gain	20.00	10.84	10.72	12.33
Gain/feed	0.05	0.09	0.09	0.08

Table A13. Animal Performance and Feed Consumption-Period 6 (Full-Feeding Phase) 28 Days

	Treatment			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	0	0	0	0
Corn silage-AEDM	0	0	0	0
Hay	4	4	4	4
Corn	14.8	14.8	14.8	14.8
Soybean meal	1.2	1.2	1.2	1.2
Total AEDM	20.0	20.0	20.0	20.0
Average weight and gain/head, lb.				
Initial	781	764	789	757
Final	851	829	837	823
Total	70	65	48	66
Average daily gain	2.50	2.32	1.71	2.36
Feed efficiency				
Feed/gain	8.00	8.62	6.83	8.47
Gain/feed	0.13	0.12	0.15	0.12

Table A14. Animal Performance and Feed Consumption (Full-Feeding Phase) 54 Days^a

	Treatment ^b			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	4.3	4.3	4.3	4.3
Corn silage-AEDM	1.1	1.1	1.2	1.2
Hay	3.3	3.3	3.3	3.3
Corn	13.3	13.5	13.3	13.5
Soybean meal	1.1	1.1	1.1	1.1
Total AEDM	18.8	19.0	18.9	19.1
Average weight and gain/head, lb.				
Initial	758	721	746	719
Final	851	829	837	823
Total	93	108	91	104
Average daily gain	1.72	2.00	1.69	1.93
Feed efficiency				
Feed/gain	10.93	9.50	11.18	9.90
Gain/feed	0.09	0.10	0.09	0.10

^aRefers to the beginning of the full-feeding phase to the last day all the heifers were present.

^bThere were no significant differences in treatments of any of the parameters ($P>.05$).

Table A15. Animal Performance and Feed Consumption-Period 4 (Full-Feeding Phase) 44 Days^a

	Treatment ^b			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	5.0	5.0	5.1	5.0
Corn silage-AEDM	2.0	1.8	1.8	1.8
Hay	3.3	3.3	3.3	3.3
Corn	15.7	15.7	15.7	15.5
Soybean meal	1.3	1.3	1.3	1.3
Total AEDM	22.3	22.1	22.1	21.9
Average weight and gain/head, lb.				
Initial	734	736	736	732
Final	822	828	824	826
Total	88	92	88	94
Average daily gain	2.00	2.10	2.00	2.13
Feed efficiency				
Feed/gain	11.15	10.52	11.05	10.28
Gain/feed	0.09	0.10	0.09	0.10

^aRefers to the beginning of the full-feeding phase of the last day all the heifers were present.

^bThere were no significant differences in treatment of any of the parameters ($P>.05$).

Table A16. Animal Performance and Feed Consumption-Period 7 (Full-Feeding Phase) 25 Days

			Treatment			
			Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment						
6/16-30/80	15 days		6	6	7	9
7/ 1-11/80	10 days		3	3	1	3
Average daily feed intake/head, lb.						
Corn silage-as fed			0	0	0	0
Corn silage-AEDM			0	0	0	0
Hay			4	4	4	4
Corn			14.8	14.8	14.8	14.8
Soybean meal			1.2	1.2	1.2	1.2
Total AEDM			20.0	20.0	20.0	20.0
Average weight and gain/head, lb.						
Initial			814	814	846	812
Final			844	827	876	823
Total			30	13	30	11
Average daily gain			1.20	0.52	1.20	0.44
Feed efficiency						
Feed/gain			16.67	38.46	16.67	45.45
Gain/feed			0.06	0.03	0.06	0.02

Table A17. Animal Performance and Feed Consumption (Full-Feeding Phase) 79 Days^a

	Treatment ^b			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	3.5	3.5	3.6	3.6
Corn silage-AEDM	0.9	0.9	1.0	1.0
Hay	3.4	3.4	3.4	3.4
Corn	13.6	13.7	13.5	13.7
Soybean meal	1.1	1.1	1.1	1.1
Total AEDM	19.0	19.1	19.0	19.2
Average weight and gain/head				
Initial	758	721	746	719
Final	869	836	857	829
Total	111	115	111	110
Average daily gain	1.68	1.72	1.68	1.55
Feed efficiency				
Feed/gain	11.30	11.10	11.30	12.39
Gain/feed	0.09	0.09	0.09	0.08
Average days on full feed	66	67	66	71

^aRefers to the maximum number of days a heifers could be on full-feed.

^bThere were no significant differences in treatments of any of the parameters (P>.05).

Table A18. Animal Performance and Feed Consumption-Period 5 (Full-Feeding Phase) 34 Days

		Treatment ^a			
		Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment					
5/13-6/1/81	20 days	7	7	7	7
6/2-6/15/81	14 days	3	5	4	4
Average daily feed intake/head, lb.					
Corn silage-as fed		0	0	0	0
Corn silage-AEDM		0	0	0	0
Hay		3.8	3.8	3.8	3.8
Corn		16.3	16.4	16.3	16.3
Soybean meal		1.4	1.4	1.4	1.4
Total AEDM		21.5	21.6	21.5	21.5
Average weight and gain/head, lb.					
Initial		802	796	815	826
Final		843	833	861	866
Total		41	37	46	40
Average daily gain		1.21	1.09	1.35	1.18
Feed efficiency					
Feed/gain		17.77	19.82	15.93	18.22
Gain/feed		0.06	0.05	0.06	0.05

^aThere were no significant differences in treatment of any of the parameters ($P>.05$).

Table A19. Animal Performance and Feed Consumption (Full-Feeding Phase) 78 Days^a

	Treatment ^b			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Average daily feed intake/head, lb.				
Corn silage-as fed	3.4	3.4	3.5	3.4
Corn silage-AEDM	1.3	1.2	1.2	1.2
Hay	3.6	3.6	3.6	3.6
Corn	15.9	15.9	15.9	15.8
Soybean meal	1.3	1.3	1.3	1.3
Total AEDM	22.1	22.0	22.0	21.9
Average weight and gain/head, lb.				
Initial	734	736	736	732
Final	860	869	870	865
Total	126	133	134	133
Average daily gain	2.07	2.04	2.09	2.08
Feed efficiency				
Feed/gain	10.67	10.78	10.52	10.53
Gain/feed	0.09	0.09	0.09	0.09
Average days on full feed	61	65	64	64

^aRefers to the maximum number of days a heifer could be on full-feed.

^bThere were no significant differences in treatment of any of the parameters ($P>.05$).

Table A20. Estimated Backfat Thickness and Carcass Data 1979-1980

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Days on silage	103	103	103	103
Days on full-feed	66 ^a	67 ^a	66 ^a	71 ^a
Total days on experiment	169	170	171	174
Average daily gain ^d	1.83	1.85	1.76	1.74
Backfat thickness, mm				
Initial (12/13/79)	3.1 ^a	2.5 ^a	3.1 ^a	3.1 ^a
End of silage phase (4/22/80)	5.0 ^a	5.7 ^a	5.6 ^a	4.7 ^a
Backfat gain (12/79-4/80)	1.9 ^{b,c}	3.2 ^a	2.5 ^b	1.6 ^c
Intermediate (6/16/80) ^e	10.9 ^a	11.0 ^a	10.9 ^a	10.3 ^a
Backfat gain (4/80-6/80)	5.9 ^a	5.3 ^a	5.3 ^a	5.6 ^a
Final (various dates) ^f	12.2 ^a	12.0 ^a	12.0 ^a	11.8 ^a
Backfat gain (6/80-)	1.3 ^a	1.0 ^a	1.1 ^a	1.5 ^a
Total backfat gain	9.1 ^a	9.5 ^a	8.9 ^a	8.7 ^a
Carcass data ^g				
Hot carcass weight, lb.	484	475	488	468
Fat thickness, in.	0.45	0.45	0.45	0.42
Loineye, in. sq.	10.5	10.6	10.8	10.7
Conformation grade ^h	13.5	13.1	13.4	13.7
Marbling score ⁱ	5.1	5.1	5.0	5.3
Carcass grade ^h	11.9	11.8	11.9	12.1
Kidney fat, %	2.6	2.4	2.8	2.7
Yield grade	2.6	2.3	2.5	2.6

^{a,b,c} Means in the same row with different superscripts are different ($P < .05$).

^d Refers to average daily gain for the entire trial.

^e Refers to last date backfat thickness data was available for all animals.

^f Refers to final backfat thickness of animals just prior to slaughter.

^g There were no significant differences in treatments of any of the parameters ($P > .05$).

^h High good = 11; Low choice = 12; Ave. choice = 13; High choice = 14.

ⁱ Slight = 4; Small = 5; Modest = 6.

Table A21. Estimated Backfat Thickness and Carcass Data 1980-1981

	Corn silage			
	Control	+Silabac	+Culbac	+Crop cure
No. animals/treatment	10	10	10	10
Days on silage	84	84	84	84
Days on full-feed ^a	61	65	64	64
Total days on feed ^b	145	149	148	148
Average daily gain ^b	1.93	2.02	1.92	2.01
Backfat thickness, mm ^a				
Initial (12/16/80)	2.7	2.6	2.8	2.8
End of silage phase (3/30/81)	6.6	6.4	6.3	6.3
Backfat gain (12/80-3/81)	3.9	3.8	3.5	3.5
Intermediate (5/11/81) ^c	10.5	10.5	10.6	9.9
Backfat gain (3/81-5/81)	3.9	4.1	4.3	3.6
Final (various dates) ^d	11.7	11.7	11.9	11.8
Backfat gain (5/81-)	1.2	1.2	1.3	1.9
Total backfat gain	9.0	9.1	9.1	9.0
Carcass data				
Hot carcass weight, lb.	487 ^e	489 ^e	488 ^e	485 ^e
Fat thickness, in.	0.49 ^e	0.37 ^f	0.39 ^f	0.49 ^e
Loineye, in. sq.	10.5 ^{f,g}	11.1 ^e	10.6 ^{e,f}	10.09
Conformation grade ^h	12.6 ^e	12.4 ^e	12.2 ^e	12.3 ^e
Marbling score ⁱ	5.5 ^e	4.6 ^f	4.6 ^f	5.6 ^e
Carcass grade ^h	12.3 ^e	11.5 ^e	11.5 ^e	12.4 ^e
Kidney fat, %	2.4 ^e	2.6 ^e	2.4 ^e	2.4 ^e
Yield grade	2.7 ^e	2.3 ^f	2.4 ^f	2.8 ^e

^aThere were no significant differences in treatments ($P > .05$).

^bRefers to average daily gain for the entire trial.

^cRefers to last date backfat thickness data were available for all animals.

^dRefers to final backfat thickness of animals just prior to slaughter.

^{e,f,g}Means in the same row with different superscripts are different ($P < .05$).

^hHigh good = 11; Low choice = 12; Ave. choice = 13; High choice = 14.

ⁱSlight = 4; Small = 5; Modest = 6.

VITA

Kevin Timothy Leahy was born in Jersey City, New Jersey, on June 18, 1956. After his birth, his family relocated to Montville, New Jersey, where he attended primary and secondary school, the latter being Montville Township High School. In the fall of 1974 he entered Berry College, located in Mount Berry, Georgia, graduating in the fall of 1978 with Bachelor of Science degrees in both Animal Science and Chemistry. In September 1979, he began graduate studies, as a graduate research assistant, at The University of Tennessee in Knoxville, in the Department of Animal Science. In December 1981, he received the Master of Science degree in Animal Science.