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I am submitting herewith a thesis written by Walter Stephen Damron entitled "Crop Residues for Wintering Dry Pregnant Beef Cows." I 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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Thesis

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CROP RESIDUES FOR WINTERING DRY PREGNANT BEEF COWS

A Thesis

Presented for the

Master of Science

Degree

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ABSTRACT

Conservative estimates indicate that 1.5 million tons of potential livestock feed could be realized yearly from corn and soybean residue and cotton gin trash in the state of Tennessee. The purpose of this research was: (1) to compare the feeding value of corn stalklage, dry corn stover, NH_3 -treated corn stover and NaOH-treated corn stalklage; and (2) to compare the feeding value of cotton gin trash and soybean stalk residue.

The results of experiment I indicated that dry corn stover harvested in large round bales, supplemented with soybean meal, salt, dicalcium phosphate and vitamin A provides adequate nutrition for the mature dry pregnant beef cow. The failure of NH_3 treatment of corn stover to significantly alter the plant variables considered indicated that this treatment is probably not feasible. Storing the stover as stalklage reduced its feeding value, probably as a result of poor packing and fermentation. NaOH addition at ensiling time apparently increased the digestibility of the stover but problems encountered with the feeding of the material overrode any advantage gained.

The results of experiment II indicated that soybean stalk residue and cotton gin trash, when supplemented with protein blocks and minerals, apparently provided adequate amounts of nutrients for mature dry pregnant beef cows. Two cows being fed soybean stalk residue died of veterinary diagnosed mycotoxin poisoning.

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CHAPTER I

INTRODUCTION

Recently, fluctuating grain and forage prices have caused the livestock industry to feel intense pressure in the market place, which not only affects the feasibility of actual grain feeding but also forces pasture and hay acreage to compete for fertilizer, irrigation waters and land. Alternative sources of economical feedstuffs must be found to decrease the cost of beef production. It would be advantageous if these new sources could be either unacceptable for direct consumption by man or would be used more efficiently as livestock feed than for human food.

Large quantities of by-products from industry and agriculture which have possible applications as livestock feeds are wasted or under-utilized every year. Many are important causes of environmental pollution (Guggolz et al., 1971).

Crop residues appear to be a logical alternative for livestock feed (Guyer, 1976), especially since more residues will be available with the expected increased grain production. In 1974, there were 570,000 acres of corn, 540,000 acres of cotton and 1.62 million acres of soybeans harvested in the state of Tennessee. Conservative estimates indicate that 1.5 million tons of potential livestock feed could be realized yearly from the residues of these three crops.

However, virtually all crop residues are highly lignified and, therefore, are low-quality roughages. This fact renders them

virtually useless to the monogastric species and severely limits application to ruminant feeding systems. Many methods for altering the chemical composition thereby increasing digestibility of residue feeds have been explored to date and have met with varying degrees of success. However, the ruminant's ability to hydrolyze cellulose, its ability to function under extensive management conditions, and the complimentary nature of some aspects of ruminant and plant production place the ruminant in a unique position regarding these residues.

Corn stover, soybean residue and gin trash are three abundant and manageable crop residues available in the state of Tennessee. All three have been found to be of marginal value in growing and finishing rations for livestock (Vetter, 1973; Klopfenstein, 1973a, b; Holloway et al., 1974). However, since spring-calving beef cows can lose considerable weight during winter with very little effect on production, they could utilize these low quality feedstuffs. The usefulness of sodium hydroxide and ammonium hydroxide as chemical treatments of roughages has been satisfactorily demonstrated. However, very little work has been reported to substantiate the relative value of corn stover treated with these two chemicals as a feedstuff for pregnant wintering beef cows.

The objectives of this study were:

- (1) To measure the performance of dry pregnant beef cows maintained on various crop residues supplemented with protein, vitamins and minerals,
- (2) To measure the influence of certain physical and chemical treatments on the feeding value of crop residues,

(3) To physically and chemically characterize these forages by laboratory analyses.

CHAPTER II

LITERATURE REVIEW

I. HARVESTING AND STORAGE METHODS

Utilization of crop residues as livestock feed has probably been practiced to some degree since the advent of organized agriculture. In recent history, grazing livestock on residual crop materials has certainly been a common practice.

Grazing is the simplest and least expensive method of utilizing crop residues (Ayres, 1973; Henderson, 1973) but may not be the most economical method because of several inherent problems. (1) Inclement weather may prevent adequate utilization. (2) Grazing animals waste large proportions of available forage. Ayres (1973) and Petritz et al. (1975) estimate that only 15 to 20% of the dry matter available in a corn stalk field is utilized by grazing animals. (3) Fall plowing is delayed. (4) The residue cannot be employed as a source of summer feed (Henderson, 1973). (5) Fields must be fenced and sources of water must be provided. (6) Some residues are not feasibly managed by grazing. For example, a risk in grazing milo residues is prussic acid poisoning (Perry, 1973).

If the collection, storage and feeding of low-quality crop residues is to become widespread, the nutritive value of the materials must be available at a cost low enough to justify the materials and equipment needed for processing (Guyer, 1976). An aid in accomplishing

this would be the utilization of equipment common to farming operations. Several companies in the U.S. produce large package haying machines which can be used quite effectively for harvesting residue feeds. These packages can be successfully stored without shelter until feeding time (Ayres, 1973). If residues are to be stored in the "dry" form, the moisture level should be at most 30% (Petritz et al., 1975). Therefore, inclement weather conditions and subsequent high moisture content may delay harvest. Delays in harvest result in progressive deterioration in nutritive value because the highly digestible cellular contents of the plant material tend to deteriorate very quickly following grain harvest, thus leaving material containing a higher proportion of cell walls (Perry, 1973).

A system for preventing these losses involves harvesting the residue in the wet form and storing in a silo as a stalklage. Petritz et al. (1975) recommended a moisture level of at least 50% if the residue is to be successfully preserved. The best utilization of this system would appear to be in conjunction with the harvest of high-moisture corn (Ayres, 1973). If corn grain is harvested at 15% moisture, however, the forage part of the plant will contain approximately 30% moisture and require large additions of water for adequate preservation. Grain sorghum provides a better residue for this system because once the grain is harvested, the plant continues to grow, often until killing frost, and thus maintains a relatively high moisture level at the time of residue harvest. Many conventional silage harvesters seem adequately suited to collect this material.

Not all systems collect and store the entire residue. Husklage is the name given to the forage discharged from the rear of the combine harvesting corn grain. It has a higher proportion of grain, husks and cobs than the total plant residue. Ayres (1973) reported successful results in collecting this material with a straw buncher of the kind used to collect the chaff and grain from wheat harvest. Albert et al. (1968) reported good results using a four-row combine equipped with a recutting blower that was powered by an auxilliary motor. The product can either be stored in dump piles or as an ensiled product.

Methods for Increasing the Nutritional Value of Low Quality Forages

Klopfenstein (1973a) suggested three methods for increasing the digestibility of crop residues: (1) Management, including attention to maturity at harvest and type of storage; (2) Plant breeding programs; and (3) Chemical and/or physical treatment of the residues.

Lignin has been implicated as a primary factor inhibiting the digestibility of poor-quality roughages. The mechanisms by which lignin decreases digestibility are not known (Van Soest, 1964), although many theories have been proposed. Godden (1920), Crampton (1939) and Dehority et al. (1962) suggested that lignin encrusts the digestible carbohydrate fractions, spatially preventing enzyme action. Van Soest (1964) and Pearl (1967) suggested that lignin may be physically and/or chemically bound with the more digestible plant fractions inhibiting their digestion. The molecular nature of these relationships remains unknown.

Regardless of how lignin is complexed with other plant fractions, considerable evidence indicates that delignification of plant products increases *in vitro* and *in vivo* cellulose digestibility (Kamstra et al., 1958; Saarinen et al., 1959; Sullivan and Hershberger, 1959). However, a review of the literature indicates a high variability in the response of different plant substrates to delignifying treatments, probably due to differences in type and extent of lignification.

This explanation is consistent with the variable response noted for the lignified portions of various plant residues to chemical treatment. Jones and Klopfenstein (1967) and Klopfenstein et al. (1972) found that treatment with either 4% Na_2O_2 or NaOH reduced ($P < .01$) the levels of acid-detergent lignin (ADL) and cell-wall constituents (CWC) in corn cobs. NaOH treatment failed to have any significant effect on acid detergent fiber (ADF) or ADL but did reduce ($P < .05$) the CWC of corn stover (Klopfenstein et al., 1972). However, Jones and Klopfenstein (1967) and Klopfenstein et al. (1972) found that neither 4% NaOH, 4% Na_2O_2 nor 4% NaOH + 3% H_2O_2 had any effect on CWC or ADL of alfalfa stems. Baker (1973) found that a larger percent of lignin needs to be removed from softwood than from hardwood species to obtain equivalent digestibility changes.

The lignin in grasses is more alkali soluble than that in legumes (Van Soest, 1964). Hemicellulose of plant tissue becomes more water soluble with alkali treatment (Sullivan et al., 1960; Gaillard, 1962). Gaillard (1962) suggested that the xylan portion of different

residues could also contribute to the varying responses to chemical treatment.

Chemical Methods of Increasing Residue Digestibility

According to Pearl (1967), the first process patented for the digestion of lignin was that developed by Watt and Burgess in 1854 for the purpose of producing cellulosic pulp from wood. The method involved the application of aqueous sodium hydroxide under pressure and became known as the "soda" process. Later modified by replacing aqueous sodium hydroxide with sodium sulfate, the process became known as the "sulfate" process, then later as the "Kraft" (German for strength) process. The first worker to apply these processes to animal feedstuffs is not known. However, Godden (1920) reported that in 1899 Kellner in Germany was the first to publish on the subject. Kellner showed that straw pulp, as prepared by the sulfate process for papermaking, was 88.3% digestible. Archibald (1924) reviewed the German literature extensively. Several observations are worthy of mention from this early work. Most of the processes employed NaOH as the chemical treatment; however, HCl, Ca(OH)_2 , NaCO_3 , CaCl_2 had all been used with some degree of success. Most required draining of the treatment solution before the product could be fed. Most systems before 1918 required either long reaction times, stirring, heating or pressure treatment. Many different potential feedstuffs were treated including small grain straws, pea vines, seed beet residue, corn cobs, grapevine shoots, hemp, wood meal, sawdust, cottonseed hulls, and flax shives.

Beginning in 1918 most of the German literature dealt with the Beckmann process or some slight variation. The Beckmann process involved treating the residue with eight times its weight of 1.5% NaOH in open vats for three hours. The product was drained and then washed until the water failed to turn red litmus paper blue. This process quickly preempted any others being used. Godden (1920) described a system applicable to farm conditions. This system involved treating materials with NaOH, removing the alkali and then steam treating. Several later workers have reported processes involving NaOH treatment, but each required washing of the residues, thereby reducing nutritive value (McNally, 1942; Woodman and Evans, 1947; Stone et al., 1966). Wilson and Pigden (1964) and Donefer (1968) attempted to simplify the existing procedures by using less moisture initially and not washing the residues.

A substantial body of recent work indicates that chemical treatment of many feedstuffs can have a beneficial effect on digestibility. Because of the high variability in residue response to treatment, several of the more available residues will be discussed on an individual basis. The levels of chemical added will be expressed as percent (weight/weight) on a dry matter basis.

Corn cobs. The addition of 4% NaOH to corn cobs has been shown to increase *in vivo* dry matter digestibility (DDM) by 8.6% ($P < .01$, Jones and Klopfenstein, 1967; Klopfenstein et al., 1972). Klopfenstein et al. (1972), Koers et al. (1972) and Rounds and Klopfenstein (1974) have shown that treating corn cobs with 4% NaOH

increased ($P < .05$) *in vitro* dry matter digestibility (IVDMD) by 14.1, 10.6 and 9.1%, respectively. Chandra and Jackson (1971) treated corn cobs with 0 to 10% (weight:weight) NaOH and observed an approximate linear increase from 46 to 93% digestibility as determined by the *in vivo* silk bag technique.

Rounds and Klopfenstein (1974) found higher gains ($P < .001$) of lambs fed 4% NaOH-treated corn cobs than of those fed the untreated control cobs. Koers et al. (1972) reported an average daily gain (ADG) of .14 kg for lambs on a 4% NaOH-treated corn cob ration as compared to .13 kg ADG on a corn silage control diet. Feed/gain were 8.4 and 7.5, respectively.

Although Ca(OH)_2 treatment of corn cobs has been shown not to influence ($P > .05$) IVDMD (Rounds and Klopfenstein, 1974), several workers have reported good results in the feeding of corn cobs treated with mixtures of Ca(OH)_2 and NaOH. Rounds and Klopfenstein (1974) fed lambs corn cobs treated with 4% NaOH, 3% NaOH, 3% NaOH + 1% Ca(OH)_2 and 2% NaOH + 2% Ca(OH)_2 . The best gains and feed efficiencies were observed for the 2:2 treatment followed by the 3:1 treatment. The poorest performance was noted for the 4% NaOH treatment. Lamm et al. (1976) reported gains of .86 and .85 kg/calf/day and feed efficiencies of 7.55 and 7.87 respectively for animals initially weighing 261 kg which were fed 3% NaOH + 1% Ca(OH)_2 or 1% NaOH + 3% Ca(OH)_2 treated corn cobs as the only roughage source. Ward et al. (1976) fed 3% NaOH + 1% Ca(OH)_2 treated corn cobs to lactating beef cows, with corn silage and sweet clover silage as

controls. A trend toward reduced weight gains of both cows and calves for the hydroxide treated cob group was noted, although the differences were not significant ($P > .05$). Klopfenstein (1973a) found ADG and feed/gain of .3 kg/day and 14.3 for untreated control and .7 kg/day and 7.5 for 4% NaOH treated and ensiled corn cobs.

Other chemicals have been shown to beneficially affect the digestibility of corn cobs. Rounds and Klopfenstein (1974) reported increased IVDMD with NH_4OH treatment. Lambs fed mixtures of corn silage and NH_4OH treated cobs gained equally as well as lambs on corn silage control. Jones and Klopfenstein (1967) and Klopfenstein et al. (1972) found that 4% treatment with Na_2O_2 increased ($P < .05$) DDM 12.2% over untreated control cobs. H_2O_2 treatment lowered the IVDMD of corn cobs. Mixtures of 4% Na_2O_2 + 3% H_2O_2 increased ($P < .05$) IVDMD over untreated controls but no advantage ($P > .05$) was noted when compared to the 4% Na_2O_2 treatment.

Corn stover. Klopfenstein et al. (1972) found an increase ($P < .05$) in organic matter digestibility of corn stover treated with 3 and 5% NaOH and ensiled, as compared to either dry or ensiled corn stover. No differences ($P > .05$) in DDM were observed between the 3 and 5% NaOH treated stovers. IVDMD was also increased ($P < .05$) by the two treatments by the 5% treatment caused a further increase ($P < .01$) above the 3% treatment. Krause et al. (1968) reported IVDMD of 54.5, 67.3 and 74.0% when corn stover was treated with 0, 3 and 5% NaOH and ensiled. Ololade et al. (1970) treated corn stover with 0 to 8% NaOH and found IVDMD increased ($P < .01$) progressively

from 62.8 to 84.3% with increasing levels of NaOH concentration. Koers et al. (1972) reported an improvement in IVDMD of 5.5% for 4% NaOH treated corn stover as compared to untreated stover. Koers et al. (1970) reported no ($P > .05$) effect on DDM of 4% NaOH treatment on corn stover silage.

Lamm et al. (1976) reported gains of .02, .09, .09 and .06 kg/day for lambs fed control, 4% NaOH, 3% NaOH + 1% Ca(OH)_2 and 1% NaOH + 3% Ca(OH)_2 treated corn stover, respectively. Koers et al. (1972) found ADG of .07 kg/day for lambs on a diet composed of 80% stover (treated with 4% NaOH) and 20% soybean meal. Lambs on the corn silage control diet gained at the rate of .13 kg/day. Feed/gain were 16.2 and 7.5 for the respective treatments. Koers et al. (1970) reported increased ($P < .05$) steer ADG from .30 kg/day for untreated compared to .41 kg/day for 4% NaOH treated corn stalklage.

Klopfenstein (1973a) compared the performance of steers fed either nontreated and ensiled or 4% NaOH treated and ensiled corn stover. He found that steers fed the hydroxide-treated material gained .109 kg more per day and required 2.68 kg less dry matter per kg of gain than steers fed the nontreated silage.

Wheat straw. Chandra and Jackson (1971) treated wheat straw with concentrations of 0 to 10% NaOH and observed an approximate linear increase from 51 to 89% digestibility as determined by the *in vivo* silk bag technique. Hasimoglu et al. (1969) showed an increase ($P > .05$) in IVDMD of 15 percentage units when wheat straw was treated with 4% NaOH and a DDM increase of 10 percentage units. When the

untreated control and 4% NaOH treated straws were fed to 30 kg lambs on a growth trial, ADG of 107 and 213 gm/day respectively were observed. Klopfenstein and Woods (1970) showed increased ($P < .05$) gains from 0 gm/day by lambs on untreated control to 90 g/day for those on 5% hydroxide (1.25% KOH and 3.75% NaOH) treated wheat straw.

Grain sorghum stubble. Sherrod and Summers (1974) ground (12.7 mm) grain sorghum stubble and then: (1) treated it with 5% NaOH before ensiling, (2) soaked it in .5% NaOH solution, drained, rinsed and dried it, or (3) ground it further to 1 mm and treated it with 5% NaOH. IVDMD values of CWC for untreated control and treatments 1, 2 and 3 were 26.9, 29.3, 29.9 and 47.2% respectively. DDM values for control, 1 and 2 were 26.1, 68.0 and 32.3. Chandra and Jackson (1971) treated grain sorghum stubble with concentrations of NaOH ranging from 0 to 10% and found an approximate linear increase of from 59 to 87% digestibility as determined by the *in vivo* silk bag technique.

Alfalfa stems. Jones and Klopfenstein (1967) showed a 6.8% increase ($P < .01$) over untreated controls in DDM for 4% NaOH treated alfalfa stems. Klopfenstein et al. (1972) found an increase ($P < .05$) in IVDMD of 4.9 and in DDM of 6.8% for alfalfa stems treated with 4% NaOH. Ololade et al. (1970) treated alfalfa stems with 0 to 8% NaOH and found IVDMD increased progressively with NaOH concentration from 48.6 to 57.1%.

Jones and Klopfenstein (1967) showed a 4.8% increase ($P < .01$) over untreated controls in DDM for 4% Na_2O_2 treated alfalfa stems. No

further improvement was shown for a 4% Na_2O_2 + 3% H_2O_2 treatment. Klopfenstein et al. (1972) found an increase ($P < .05$) in IVDMD of 5.2% and in DDM of 4.8% for alfalfa stems treated with 4% Na_2O_2 .

Physical Methods of Increasing Residue Digestibility

Krause et al. (1968) reported improvement in IVDMD of 7.9% for simple ensiling of corn stover. This is in contrast to results by Hungate (1966).

Albert and Cox (1968) found that corn stover ensiled with 3.75% ground corn, 1.25% dried molasses and urea or biuret, to raise the crude protein (CP) content to 11%, provided an approximate maintenance ration for mature dry pregnant wintering beef cows. Vetter and Ayres (1973) found that mature dry gestating beef cows maintained body weight when fed stalklage and protein supplement but some grain was needed if weight gains were desired.

Gay et al. (1973) reported the results of wintering pregnant long-yearling heifers on corn stover silage. On a 98-day test, 345 kg heifers gained .3 kg/day with .91 kg/day of grain as a supplemental protein and energy source. Heifers weighing 352 kg gained .448 kg/day on the same test with 1.82 kg/day grain. Lactating beef cows on a similar 91-day test required 3.64 kg corn and .91 kg protein supplement to maintain body weight. Dry pregnant cows and bred heifers gained 9.09 and 39.55 kg respectively on free choice stalklage and 1.95 kg corn and .227 kg of a urea, mineral-vitamin supplement in a 114-day trial.

Ayres et al. (1973) reported results of feeding 404 kg pregnant long yearling heifers for 63 days on corn stover ensiled with urea-whey, followed by 21 days feeding of corn stover ensiled with 45.45 kg dried molasses/ton fed with 68 kg soybean meal/day. The heifers had an ADG of .05 kg/day.

Dehority and Johnson (1961) and Dehority et al. (1962) have found that ball milling greatly improves the IVDMD of the carbohydrate fraction of timothy, alfalfa and orchardgrass. *In vivo* studies with this type material are hampered by the difficulties in preparing large quantities of the material (Hungate, 1966).

Feeds may be ground as a means of physically increasing the digestibility. However, the turnover rate in the rumen is also increased which counteracts the effect. Animals may gain better, however, due to increased intake. Intake and gain are further facilitated by pelleting of bulky forages. The increased concentration of dry matter within the rumen caused by pelleting brings about a greater fermentation rate per unit volume (Hungate, 1966).

II. SUMMARY AND CONCLUSION

Crop residues are potential alternatives to more conventional forages as feed for some classes of ruminants. Several systems of collection and storage have been devised. For stover residues, storage in large hay packages, if harvested when moisture is less than 30%, or as residue stalkage if harvested when moisture is 50% or above and stored in a silo, seem the most practical at present.

Crop residue feeds are generally low in protein, vitamins and minerals as well as high in lignified fibrous portions. Delignification through chemical or physical treatments appears to have potential in increasing the feeding value of crop residues. The hydroxides, especially NaOH, seem particularly suited both in terms of cost analysis and efficiency of action. Ammonium hydroxide not only increases the potential for utilization of residue feeds but raises the CP content as well. Alkali treatment seems to have more effect on monocotyledons than on dicotyledons probably because the type and extent of the lignification mechanisms are different (Sullivan, 1962; Mowat et al., 1969; Sullivan, 1969). Relatively large differences have also been observed within class of residue. Some residues, treated and untreated, show potential for use in finishing rations while others seem ill-suited for this use.

Much of the work characterizing the feeding value of residues has been conducted under closely controlled laboratory conditions. While this type of approach is necessary, care should be exercised when trying to relate results to field situations. Goering et al. (1971) found treatment with NaClO_3 to be less efficient in silo situations than in controlled laboratory processes. Ward et al. (1976) found cow and calf performance on hydroxide treated cobs in two drylot trials to be lower than expected from results of more controlled growth trials. Koers et al. (1970) encountered a spoilage problem when 4% NaOH treated corn stalklage was stored in a concrete stave silo. Steers being fed the material as 66% of their total diet failed

to gain any more than the control animals. Klopfenstein (1973a) encountered variation in qualities of NaOH treated husklage due to cold wet weather and muddy ground conditions. However, calves fed the material performed 90% as well as corn silage-fed control animals.

Discrepancies between IVDMD and DDM are common in the literature (Hasimoglu et al., 1969; Koers et al., 1970; Klopfenstein et al., 1972; Koers et al., 1972). One explanation for this is that the mineral constituents of the hydroxides have an adverse effect on the animals above a certain concentration. This is substantiated by the observation that concentrations of hydroxide above 4% generally show improvement in IVDMD but not DDM. Mixtures of the hydroxide so that no single mineral element is in excess shows promise in remedying this problem. Another possible explanation is that the hydroxide treatment simply increases the solubility of the substrate without subsequent increased microbial attack or absorption by the animal. Smith et al. (1969, 1970), Ololade et al. (1970) and Hutanwatr et al. (1974) have all reported increased *in vitro* solubilities of plant materials with hydroxide treatment without corresponding improvement in microbial degradation.

Most of the feeding studies reported to date have been of short duration which do not provide adequate data on the effect of long-term feeding of crop residues. Very little work has been reported with regard to hydroxide treated feedstuffs being fed to dry pregnant brood cows.

CHAPTER III

MATERIALS AND METHODS

I. EXPERIMENT I

Description and Storage of Forage

Five dietary treatments were used:

- (1) Dry corn stover. After grain was harvested the stover was chopped with a rotary mower, raked into windrows and packaged with a Vermeer round baler at 78% dry matter. The bales were stored and sealed in black plastic for 30 days prior to feeding.
- (2) NH_3 -treated corn stover. This stover was handled identically to the dry corn stover with the exception that 50% aqueous ammonia (NH_3) was sprayed onto the windrows at 5% of dry matter weight just prior to baling. Random 300-cm lengths of windrow were weighed for calibration of the field sprayer for the NH_3 application.
- (3) Corn stalklage. This stover was handled identically to the above treatments prior to harvest. It was harvested at 75% dry matter with a silage harvester. Water was added while the material was blown into a 14-foot diameter upright concrete silo to bring the moisture level to approximately 50%.
- (4) NaOH-corn stalklage. This stover was handled identically to the corn stalklage with the exception of the addition of NaOH

at 4% of the stover dry matter as the water was added. No mixing was done before the material entered the blower.

- (5) Corn silage. Corn silage was used as a control treatment. The silage was made from whole corn plant harvested at 35% dry matter.

The stover for the treatments was harvested from agronomic corn plots after the corn was picked, and due to the fact that different fields were used for harvesting feed for the various treatments some confounding of corn variety and treatment could have occurred. Several varieties were included in each treatment.

Description of Cows

Pregnant, spring-calving, Angus females ranging in age from 3 to 15 years with a mean age of 9.85 years were used. Only one immature (< 4 years) female was included. Initial weights of the cows ranged from 368 to 582 kg with a mean weight of 489 kg. Initial condition score of the cows ranged from 6 to 14 (1-17 scale with 17 being the fattest) with a mean score of 8.4.

Conduct of Trial

Forty cows were allotted to two replications of four animals each, per treatment, according to expected parturition date as determined by rectal palpation. The cows were placed on the experiment on December 16, 1975 and maintained on experimental forage until parturition, at which time they were removed to a drylot where 18 kg of corn silage/head/day, grass hay *ad libitum* and trace mineralized salt were

fed until sufficient spring pasture was available. The number of days on treatment for the cows ranged from 33 to 101 with a mean of 54 days.

The cows were maintained in a drylot feeding facility with pens that were covered on one end. The feeding troughs were under shelter. Individual groups of cattle were hand-fed a measured quantity of forage daily. Females fed the corn stover and stalklage rations were allowed *ad libitum* consumption with an approximate 20% refusal allowed. The corn silage control cows were limit fed at 100% NRC (1970) recommendations.

Refused feed was removed from troughs and weighed twice weekly. Soybean meal was fed to meet the NRC (1970) requirement of crude protein according to the average weight and consumption of individual pens of cows. This amount was adjusted on a weekly basis. Trace mineralized salt and dicalcium phosphate were fed *ad libitum*. Each cow was injected at the onset of the trial with one million IU of Vitamin A.

Parameters Measured

Cow condition scores were obtained by visual appraisal at the initiation of the experiment, within one week after calving, and at the mean calf age of 90 days. Initial weights were taken at the beginning of the trial after the animals were allowed overnight shrink. Cows were weighed within 24 hours after parturition and again when the average post-partum interval was 90 days.

Calves were weighed within 24 hours of birth, at a mean age of 90 days and again at weaning. Ninety and 220 day adjusted calf weights were calculated by the formula:

$$\left[\frac{(\text{actual weight} - \text{birth weight})}{\text{actual age}} \times 90 \text{ or } 220 \text{ days} \right] + \text{birth weight}.$$

Weights of the calves were adjusted for sex and age of dam by least squares procedures.

II. EXPERIMENT II

Description and Storage of Forages

Three dietary treatments were used:

- (1) Cotton gin trash. Cotton gin trash is an industrial waste by-product produced in the cleaning of cotton and contains some leaf, stalk, bowl, seed and cotton material. The gin trash was moved from a local gin to the feeding area and stored under shelter.
- (2) Soybean residue. The soybean residue consisted primarily of stalk material but some pod and leaf material was also present. The soybean residue was harvested after bean harvest (at approximately 70% dry matter) as a large package round bale by a Vermeer baler and stored outside.
- (3) Control silage. The control silage was made from forage planted at the ratio of one row of forage sorghum to three rows of corn and harvested at 37% dry matter.

Description of Cows

Pregnant, spring-calving, Angus females ranging in age from 4 to 15 years with a mean age of 7.2 years were used. Initial weights of the cows averaged 455 kg with a range from 339 to 545 kg. The initial condition scores ranged from 5 to 10 with a mean of 6.8.

Conduot of Trial

Forty-two cows were allotted to three treatments of 14 cows each according to expected parturition date as determined by rectal palpation. The cows were placed on the experiment on December 22, 1975 and maintained there until parturition, except for two cows that were removed before parturition due to insufficient supply of cotton gin trash. The cows were maintained in drylot with access to shelter.

The cotton gin trash and control silage were fed under shelter. The soybean residue was fed in a covered feeder. The quantity of forages fed were weighed but refusals were not weighed. All forages were fed on an *ad libitum* basis.

Parameters Measured

Cow condition scores were obtained by visual appraisal at the initiation of the experiment and within one week after calving. The scores were based on a scale of 1 to 17, with higher scores indicating fatter animals. Cows were weighed at the initiation of the experiment and again at parturition. Calves were weighed at parturition and again at weaning. Adjusted calf weights were calculated by the formula:

$$\left[\frac{(\text{actual weight} - \text{birth weight})}{\text{actual age}} \times 220 \text{ days} \right] + \text{birth weight.}$$

Weights of the calves were adjusted for sex and age of dam by least square procedures.

III. FORAGE PARAMETERS MEASURED--EXPERIMENTS I AND II

The measures of nutritive value obtained on the forages were dry matter (DM), ash, ether extract (EE), crude protein (CP), cell-wall constituents (CWC), acid detergent fiber (ADF), acid detergent lignin (ADL) and *in vitro* dry matter digestibility (IVDMD). DM, ash, EE and CP were analyzed by procedures of A.O.A.C. (1975). CWC were determined by the method of Van Soest and Marcus (1964) as modified by Van Soest and Wine (1965). ADF and ADL were determined by the method of Van Soest (1962). IVDMD was determined by the method of Tilly and Terry (1963) as modified (North Central--64, 1968). Rumen innoculum was collected from four rumen fistulated wethers maintained on alfalfa hay.

IV. STATISTICAL PROCEDURE--EXPERIMENTS I AND II

Analysis of variance procedures were used to assess the effect of the independent variables (treatment, pen within treatment, age of cow, days on treatment, sex of calf, initial condition of cow, initial weight of cow) on the dependent variables (animal gain, feed intake, birth weight of calf). When significant differences among treatment

means with respect to a variable were indicated by the analysis of variance, mean separation was done by the Student Newman-Keuls' multiple range test.

CHAPTER IV

RESULTS AND DISCUSSION

I. EXPERIMENT I

Effect of Treatment on Corn Stover

Effect of H₂O addition with ensiling on corn stover. The results of the proximate, Van Soest and IVDMD analyses are given in Table 1 for the ensiled corn stover. The ash content of the ensiled corn stover was 12.3 percentage units higher ($P < .1$) than samples of the same material taken before ensiling. A similar increase (12.0 percentage units) was observed for the stover treated with NaOH at ensiling (Table 2). Since the pre-treatment samples used as controls were taken just previous to the water and/or chemical additions at the silo, this increase possibly represents a sampling error. This is indicated by the fact that individual ash values as low as 9.0% were observed in some of the treated samples and values as high as 18.0% were observed in the after-treatment samples. For this reason all other parameters in this experiment will be expressed on an organic matter basis (OM).

EE was not significantly ($P > .1$) reduced by the treatment. CP was increased by 1.4 percentage units ($P < .05$), but since no N was added to the material and the magnitude of increase was low this was probably a random occurrence.

TABLE 1. CHANGES IN CONSTITUENTS OF CORN STALKLAGE AS A RESULT OF ENSILING

Item	Before Ensiling	After Ensiling	Approximate Standard Error
Number of Samples	4	5	--
Dry Matter ^a	76.95	46.30	--
Ash	6.18 ^c	18.62 ^d	7.530
Crude Protein ^b	3.74 ^e	5.16 ^f	.201
Ether Extract ^b	7.46	6.73	.838
Cell Wall Constituents ^b	87.74	91.65	2.485
Acid Detergent Fiber ^b	56.27 ^e	71.28 ^f	3.927
Acid Detergent Lignin ^b	7.79 ^e	10.05 ^f	.583
<i>In vitro</i> Dry Matter ^b Digestibility	54.33	46.39	3.193
pH ^a	--	4.58	--

^aNo statistical analysis performed.

^bPercent of organic matter.

^{cd}Means superscripted with different letters are significantly different ($P < .1$) by Student Newman-Keuls' Multiple Range Test.

^{ef}Means superscripted with different letters are significantly different ($P < .05$) by Student Newman-Keuls' Multiple Range Test.

TABLE 2. CHANGES IN CONSTITUENTS OF CORN STALKLAGE AS A RESULT OF ENSILING AND NaOH TREATMENT

Item	Before NaOH Addition and Ensiling	After NaOH Addition and Ensiling	Approximate Standard Error
Number of Samples	5	5	--
Dry Matter ^a	75.00	48.62	--
Ash	10.07	22.06	5.270
Crude Protein ^b	4.57	4.06	.649
Ether Extract ^b	7.15 ^c	4.25 ^d	.611
Cell Wall Constituents ^b	85.58	81.02	3.603
Acid Detergent Fiber ^b	55.38 ^c	74.76 ^d	2.494
Acid Detergent Lignin ^b	7.10 ^c	11.64 ^d	.502
<i>In vitro</i> Dry Matter ^b Digestibility	60.84 ^c	79.16 ^d	5.027
pH	--	9.65	--

^aNo statistical analysis performed.

^bPercent of organic matter.

^{cd}Means superscripted by different letters are significantly different ($P < .05$) by Student Newman-Kuels' Multiple Range Test.

CWC was apparently not affected ($P > .1$) by the treatment. This was in contrast to the 9.3 percentage unit decrease ($P < .05$) observed by Klopfenstein et al. (1972). ADF increased by 15.01 percentage units ($P < .05$) and ADL increased by 2.26 percentage units ($P < .05$). Klopfenstein et al. (1972) found no change in ADF or ADL due to simple ensiling of corn stover.

IVDMD decreased ($P > .1$) by 7.9 percentage units. This was not wholly unexpected due to the increases in ADF and ADL observed. Krause et al. (1968) reported an improvement in IVDMD of 7.9 percentage units for ensiling of corn stover. Klopfenstein et al. (1972) reported an increase in true organic matter digestibility of 7.1 percentage units due to ensiling of corn stover. However, the forages in both of these experiments were ensiled in small containers. In an experiment where the stover was ensiled in bunker and upright silos more nearly like in the present work, Smith et al. (1975) reported a decrease in IVDMD of 9.0 percentage units. A problem with molding of the material was also reported. Since the material in the present study did not keep well and considerable molding was observed, it is speculated that this contributed to the decrease in IVDMD and the increases in ADF and ADL. It is also possible that volatile fatty acids produced in the fermentation process were lost in the drying of the ensiled material. No runoff from the silos was observed.

Effect of NaOH and H₂O addition with ensiling on corn stover. The results of the proximate, Van Soest, IVDMD and pH determinations are given in Table 2 for NaOH treated corn stover. The high pH values

for the NaOH-treated stover indicate that proper ensiling of the material did not occur. Treatment with NaOH apparently increased ($P < .05$) the ash content of the material. When a correction was made for the quantity of NaOH added to the material the ash content was still higher but not significantly ($P > .1$).

CP was not affected by NaOH treatment ($P > .1$) but EE was lowered 2.9 percentage units ($P < .05$). This could possibly be explained by saponification of portions of the EE material. Saponification produces a polar molecule which is less soluble in non-polar solvents such as diethyl ether (Morrison and Boyd, 1974).

NaOH addition was associated with a 4.75 percentage unit increase ($P > .1$) in CWC. Ololade et al. (1970) reported no change in this parameter due to NaOH treatment. However, Klopfenstein et al. (1972) found decreases in CWC of 13.9 and 20.5 percentage units respectively for 3 and 5% additions of NaOH to corn stover. The ADF fraction was increased ($P < .05$) 19.38 percentage units and ADL increased ($P < .05$) 4.54 percentage units by the addition of NaOH. This is in contrast to the results reported by Ololade et al. (1970) and Klopfenstein et al. (1972) who reported no change in these two constituents of corn stover when equivalent levels of NaOH were added. This discrepancy is not easily explained. Any change in the ADF fraction, without a concomitant change in the CWC fraction, would indicate an alteration in hemicellulose content. In this case it would indicate a change in hemicellulose to cellulose or lignin. Sullivan et al. (1960), Gaillard (1962) and Ololade et al. (1970) have indicated an increase

in solubility of hemicellulose after hydroxide treatment. However, factors such as heating or pressure can cause the hemicellulose fraction to become horn-like and insoluble and therefore mistakenly being determined in the ADF and ADL fractions (Gaillard, 1962). It is possible that temperatures within the silo could have risen high enough to have affected this change. It is also speculated that solubilized hemicellulitic particles could be more sensitive to the drying temperatures used in the laboratory.

IVDMD increased by 18.32 percentage units ($P < .05$). This is similar to the increase observed by Krause et al. (1968) for 5% addition of NaOH to corn stover but higher than the 5-11% increases reported by Ololade et al. (1970), Klopfenstein et al. (1972) and Koers et al. (1972) for 4% NaOH treatments. Whatever changes occurred to the ADF and VDL fractions apparently had no adverse effect on the digestibility of the material.

Effect of storing as large package bales on corn stover. The forage parameters for the dry stover are given in Table 3. CP was lower ($P < .05$) by 0.62 percentage units for the stored forage as compared to the before-storage samples, but since the magnitude of the decrease was so small and no good reason can be offered for any deterioration, this was probably a random occurrence. None of the other parameters were affected by the treatment ($P > .1$) indicating the suitability of large package round bales for storing corn stover.

Effect of storing as large package bales and NH_3 treatment on corn stover. The results of the forage parameters tested are in

TABLE 3. CHANGES IN CONSTITUENTS OF CORN STOVER AS A RESULT OF STORAGE IN LARGE PACKAGE ROUND BALES

Item	Before Storage	After Storage	Approximate Standard Error
Number of Samples	4	5	--
Dry Matter ^a	78.67	76.80	--
Ash ^b	4.98	4.64	1.360
Crude Protein ^b	5.19 ^c	4.57 ^d	.132
Ether Extract ^b	6.32	5.78	.522
Cell Wall Constituents ^b	89.47	88.57	.930
Acid Detergent Fiber ^b	57.86	55.19	1.828
Acid Detergent Lignin ^b	7.90	7.92	.553
<i>In vitro</i> Dry Matter Digestibility	49.17	49.05	1.998

^aNo statistical analysis was performed.

^bPercent of organic matter.

^{cd}Means superscripted by different letters are significantly different ($P < .05$) by the Student Newman-Keuls' Multiple Range Test.

Table 4. CP showed an increase of 1.16 percentage units for an approximate 25% increase ($P < .1$). Waiss et al. (1972) reported a 200% increase in CP content for equivalent additions of NH_3 to wheat straw, but this was in an entirely closed system with additions of 30% H_2O . CWC was significantly lowered ($P < .05$) by 3.85 percentage units most of which can be roughly accounted for by a 1.13 percentage unit decrease ($P > .1$) in ADF and a 1.14 percentage unit decrease ($P < .1$) in ADL. These changes were reflected in a slight ($P > .1$) increase in IVDMD. Larger increases in CP and IVDMD and decreases in the fibrous portions were expected. However, portions of the ammonia probably escaped from the material before the reactions went to completion since the stover was not completely sealed.

Characteristics of Experimental Forages

All stovers compared to corn silage. As can be seen in Table 5 the corn stovers as a group are of much lower quality than the corn silage. Crude protein values were lower ($P < .05$) for all but the NH_3 -treated stover. Cell-wall constituents, ADF and ADL were all higher ($P < .05$) for the stover treatments. Of the stover treatments, only NaOH-treated corn stover compared to corn silage in IVDMD with all other treatments being considerably lower ($P < .05$).

All stovers compared to each other. The CP value for the NH_3 -treated stover tended to be higher than the other three stovers but was significantly higher ($P < .05$) than only NaOH-treated stover and dry stover. The ether extract value for the ensiled corn stover was

TABLE 4. CHANGES IN CONSTITUENTS OF CORN STOVER AS A RESULT OF STORAGE IN LARGE PACKAGE ROUND BALES AND NH_3 TREATMENT

Item	Before Storage	After Storage	Approximate Standard Error
Number of Samples	5	4	--
Dry Matter ^a	76.80	76.98	--
Ash	4.64	4.60	1.020
Crude Protein	4.56 ^c	5.72 ^d	.365
Ether Extract	5.77	4.18	.718
Cell Wall Constituents	88.43 ^e	84.58 ^f	1.075
Acid Detergent Fiber	55.10	53.97	2.029
Acid Detergent Lignin	7.91 ^c	6.77 ^d	.434
<i>In vitro</i> Dry Matter Digestibility	49.66	51.56	.855

^aNo statistical analysis was performed.

^bPercent of organic matter.

^{cd}Means superscripted by different letters are significantly different ($P < .1$) by the Student Newman-Keuls' Multiple Range Test.

^{ef}Means superscripted by different letters are significantly different ($P < .05$) by the Student Newman-Keuls' Multiple Range Test.

TABLE 5. PROXIMATE, VAN SOEST AND IVDMD ANALYSIS FOR PLANT PARAMETERS

Item	Stalklage	NaOH Stalklage	Dry Stover	NH ₃ Treated Dry Stover	Corn Silage	Approximate Standard Error
Number of Samples	5	5	5	4	4	--
Dry Matter ^a	51.62	48.62	76.80	76.98	34.13	--
Ash ^b	18.62 ^c	22.06 ^c	4.64 ^d	4.60 ^d	2.80 ^d	6.06
Crude Protein ^b	5.16 ^{de}	4.06 ^f	4.57 ^{ef}	5.72 ^{cd}	6.33 ^c	.259
Acid Deterent ^b Fiber	71.28 ^c	74.76 ^c	55.19 ^d	53.97 ^d	32.40 ^e	2.950
Acid Detergent ^b Lignin	10.05 ^d	11.64 ^c	7.92 ^e	6.77 ^e	4.15 ^f	.498
Cell Wall ^b Constituents	91.65 ^c	81.01 ^d	88.57 ^c	84.58 ^{cd}	59.04 ^e	1.939
Ether Extract ^b	6.73 ^c	4.25 ^d	5.78 ^{cd}	4.18 ^d		.767
<i>In vitro</i> Dry Matter ^b Digestibility	46.39 ^d	79.16 ^c	48.41 ^d	51.56 ^d	74.21 ^c	2.794

^aNo statistical analysis was performed.^bPercent of organic matter.^{cdef}Means superscripted by different letters are significantly different ($P < .05$) by the Student Newman-Keuls' Multiple Range Test.

higher ($P < .05$) than either NaOH-treated corn stover or NH_3 -treated corn stover with the dry corn stover of intermediate ($P > .05$) value.

The CWC fraction was lower for both NH_3 and NaOH treatments compared to the treatments receiving no chemical additions. However, for ADF and ADL, the two stalklage treatments were similar and higher than the two dry stovers indicating an effect of ensiling which overrode the effects of chemical additions. Lower IVDMD values for the two stalklage treatments were expected due to the higher levels of ADF and ADL. The NaOH-treated stover, however, was much higher ($P < .05$) than the other stovers for IVDMD indicating that NaOH reaction resulted in a shift in cell-wall constituents and possibly a change in the relationship of lignin and cellulose. The IVDMD of the stalklage tended to be lower ($P > .05$) than the two dry stovers.

Results of Feeding Trial

The NaOH-treated stalklage portion of the experiment was discontinued after 10 days due to the death of three cows being fed the material. A necropsy was conducted on two of these cows. Although no clear-cut explanation can be offered for the deaths, the following are possibilities:

- (1) A mycotoxin present in the feed. Quick death of all three cows and muscular hemorrhaging of one cow suggested this.
- (2) Ketosis due to low feed consumptions (1.7 kg of dry matter/cow/day). Large weight losses of the remaining cows (88 kg average) and fatty livers of the dead animals point to this.

- (3) Hypocalcemia or hypomagnesemia possibly caused by increased gut pH and rate of passage. Although the classic tetany symptoms were not observed there was stiffness, increased heart rate and rapid death once the animals went down. One animal responded temporarily to Ca, Mg, K gluconate.
- (4) Dehydration possibly due to high Na intake. Distended gut, diarrhea and dark colored blood (hemoconcentration) suggest this.
- (5) An acid-base imbalance possibly caused by the high levels of Na intake and the high pH of the hydroxide treated material. Diarrhea, apparent high intake of water, polyuria and rapid death suggested this.

It is possible that all or combinations of several of the above maladies could have contributed to the deaths. The animals removed from the treatment suffered no apparent permanent damage.

Cow intake. The daily intakes of the experimental forages are shown in Table 6. Dry matter intakes of the dry corn stover and NH_3 -treated corn stover treatments were similar. However, the cows on the stalklage treatment consumed only half as much ($P < .05$) dry matter as those fed corn stover. Their consumptions were similar ($P < .05$) to that of cows fed corn silage.

The daily estimated total digestible nutrient (TND) intakes were all within the NRC (1976) TND requirements (4.2 to 4.5 kg/day for cows of the age and weight range) except for corn stalklage. Estimated digestible dry matter as calculated from IVDMD and intakes were 2.47,

TABLE 6. ESTIMATED DAILY TOTAL DIGESTIBLE NUTRIENTS, CRUDE PROTEIN AND DRY MATTER CONSUMPTION PER COW BY TREATMENT (DRY MATTER BASIS)

Item	Stalklage	Dry Stover	NH ₃ -treated Dry Stover	Corn Silage	Approximate Standard Error
Dry matter consumed from forage (kg/cow/day)	5.33 ^a	10.69 ^b	10.61 ^b	7.05 ^a	.678
Dry matter consumed from soybean meal (kg/cow/day)	.42 ^a	.46 ^a	.37 ^a	.30 ^a	.027
Total digestible nutrients consumed from forage (kg/cow/day)	3.26 ^a	6.31 ^b	6.26 ^b	4.94 ^b	.404
Total digestible nutrients consumed from soybean meal (kg/cow/day)	.30 ^{ab}	.38 ^a	.25 ^a	.24 ^b	.022
Total digestible nutrients consumed from forage and soybean meal (kg/cow/day)	3.56 ^a	6.64 ^a	6.61 ^b	5.22 ^{ab}	.426
Crude protein consumed from forage (kg/cow/day)	.22 ^a	.44 ^b	.62 ^c	.42 ^b	.028
Crude protein consumed from soybean meal (kg/cow/day)	.21 ^a	.23 ^a	.19 ^a	.15 ^a	.013

TABLE 6 CONTINUED

Item	Stalklage	Dry Stover	NH ₃ -treated Dry Stover	Corn Silage	Approximate Standard Error
Crude protein consumed from forage and soybean meal (kg/cow/day)	.43 ^a	.67 ^{bc}	.81 ^c	.57 ^{ab}	.041

^{abc}Means superscripted with different letters in a row are significantly different (P < .05) as determined by the Student Newman-Keuls' Multiple Range Test.

^dTotal digestible nutrients based on values from NRC (1976).

5.18, 5.47 and 5.23 kg respectively for stalklage, dry stover, NH_3 -treated stover and corn silage. Enough soybean meal was fed to insure that the daily allowance for CP was met for cows consuming each forage. Total crude protein (TCP) intakes differed among treatments. Cows fed NH_3 -treated stover consumed more ($P < .05$) TCP/day than the other groups. This is a partial reflection of the higher CP value in the NH_3 -stover.

Cow and Calf Performance. Cow performance data are shown in Table 7. The cows fed dry stover, NH_3 -treated stover or stalklage lost more weight ($P < .05$) during the test period than did the cows fed corn silage. There was no difference ($P < .05$) in weight loss among the stover and stalklage treatments. All cows lost less than 20% of their fall weight allowable (Pinney 1962) for cows of this age. Since all treatments except corn stalklage met the estimated TDN requirement, the weight losses are difficult to understand. However, the estimates of TND were calculated from NRC (1976) values for the forages used and could thus have overestimated the actual forages that were fed. Cow weight recovery measured at three months postpartum was not affected ($P > .05$) by wintering treatment, although there was a trend for the cows with higher weight loss while on experiment to gain more rapidly postpartum.

Cows fed corn silage lost less condition ($P < .05$) than those on the three corn stover treatments. No difference for condition score change among cows fed the three stover treatments was detected.

TABLE 7. LEAST SQUARE MEANS OF COW PERFORMANCE DATA

Item	Stalklage	Dry Stover	NH ₃ -treated Dry Stover	Corn Silage	Approximate Standard Error
Number of Cows	8	7	4	8	--
Initial Weight (kg) ^d	492	507	473	478	15.497
Weight Change (kg) ^e	-59 ^a	-59 ^a	-62 ^a	-3.3 ^b	6.116
Body Weight Change ^e as % of Initial Weight, %	-11.99 ^a	-11.63 ^a	-13.10 ^a	-6.9 ^b	.012
Initial Condition ^{cd}	7.87	9.90	6.67	8.40	.750
Condition Loss ^e	2.43 ^a	1.84 ^a	1.16 ^a	.69 ^b	.399
Cow Weight Gain 3 ^f Months Post Partum, kg	10	22	23	4	6.824
Cow Condition Recovery ^f 3 Months Post Partum	1.66	1.10	1.20	1.02	.335

^{ab}Means superscripted with different letters are significantly different. ($P < .05$) as determined by Student Newman-Keuls' Multiple Range Test.

^cCondition score ranged from 1 to 17 with 17 being the fattest.

^dTo obtain least square values a model was fitted which contained replication within treatment and cow age.

^eTo obtain least square values a model was fitted which contained replication within treatment, days on treatment, cow age, birth weight of calf, initial condition score and initial weight of cow.

TABLE 7 CONTINUED

^fTo obtain least square values a model was fitted which contained replication within treatment, days on treatment, cow age, birth weight of calf, initial condition and initial weight of cow and cow weight change while on test.

Recovery of condition measured at 90 days postpartum was not affected by treatment or by condition loss while on test ($P > .05$). No trends were observed. A rectal palpation 90 days postpartum indicated that every cow that had been fed a corn residue had ovulated.

Birth weight and ADG of calves are given in Table 8. There was no treatment effect on birth weight ($P > .05$). This is similar to results by Nelson *et al.* (1954), who reported that reduced energy level of the dam prior to calving did not affect birth weight. Joubert (1954) has reported lowered birth weights of calves due to depressed energy levels prepartum but this work was done with first-calf heifers. Wiltbank *et al.* (1962) reported similar results with adult cows but the decrease in birth weights were not as great. However, these animals were allowed to lose over 20% of their fall weight. Neither weights nor average daily gains of calves at 90 or 220 days were affected ($P > .05$) by forage treatment. This agrees with results of Nelson *et al.* (1954).

II. EXPERIMENT II

Characteristics of Experimental Forages

Comparison of cotton gin trash and soybean residue to control silage. As can be seen in Table 9 cotton gin trash and soybean residue are of generally lower quality than the control silage. The CP value of the three feedstuffs were all different ($P < .05$), with the cotton gin trash being the highest, probably due to seed material. The soybean residue was the lowest in CP being 1.6 percentage units

TABLE 8. LEAST SQUARE MEANS FOR WEIGHT MEASUREMENTS ON CALVES^a

Item	Stalklage	Dry Stover	NH ₃ -treated Dry Stover	Corn Silage	Approximate Standard Error
Birth Weight, kg ^b	29.9	31.9	32.5	31.7	1.459
Adjusted Daily Gain to 90 days, kg/day ^c	.81	.76	.79	.83	.046
Adjusted Daily Gain to 220 days, kg ^d	.91	.96	.98	.98	.039

^aNone of the variables were significantly different ($P < .05$).

^bTo obtain least square values a model was fitted which included replication within treatment, days on treatment, cow age, initial cow weight, initial cow condition and sex of calf.

^cTo obtain least square values a model was fitted which included replication within treatment, calf age, birth weight, initial weight of cow, cow age and sex of calf.

^dTo obtain least square values a model was fitted which included replication within treatment, calf age, birth weight, initial weight of cow, cow age, sex of calf, and weaning age.

TABLE 9. PROXIMATE, VAN SOEST AND IVDMD ANALYSIS FOR PLANT CONSTITUENTS

Item	Control Silage	Soybean Residue	Cotton Gin Trash	Approximate Standard Error
Number of Samples	3	5	4	--
Dry Matter ^a	37.0	83.7	63.2	--
Ash	5.8 ^{bc}	3.4 ^b	8.6 ^c	1.30
Crude Protein	7.3 ^b	5.7 ^c	11.2 ^d	.15
Ether Extract	--	8.8 ^b	6.8 ^b	3.32
Cell Wall Constituents	56.4 ^b	82.7 ^c	75.5 ^d	1.45
Acid Detergent Fiber	35.7 ^b	66.9 ^c	66.3 ^c	1.46
Acid Detergent Lignin	5.6 ^b	17.2 ^c	26.5 ^d	1.46
<i>In vitro</i> Dry Matter Digestibility	72.2 ^b	25.5 ^c	33.8 ^c	2.57

^aNo statistical analysis was performed.

^{bcd}Means superscripted with different letters are significantly different ($P < .05$) by Student Newman-Keuls' Multiple Range Test.

below the control silage. The EE values of the two experimental forages were similar ($P > .05$).

Both of the experimental feeds were higher in the fibrous constituents than the control silage. The CWC value of the soybean residue was the highest of the three ($P < .05$) feedstuffs being 7.2 percentage units higher than the cotton gin trash and 26.3 percentage units higher than the control silage. The cotton gin trash was lower than the soybean residue in CWC ($P < .05$) but 19.1 percentage units higher ($P < .05$) than the control silage. The two experimental forages were similar in ADF ($P > .05$) but considerably higher ($P < .05$) than the control silage. The feedstuffs were all different ($P < .05$) in ADL with cotton gin trash being the highest followed by the soybean residue. Both were considerably lower ($P < .05$) than the control silage.

Results of Feeding Trial

Cow and calf performance. Cow and calf performance data are shown in Table 10. Cows fed the silage control ration lost less weight ($P < .05$) than did the cows on the experimental forages and lost a smaller percentage of their fall weight ($P < .05$). The cows all lost less than the 20% of their fall weight allowable for cows of this age (Pinney, 1962). Although no statistical difference ($P > .1$) in cow condition change could be attributed to treatment, the control animals tended to gain in condition whereas the other two groups remained essentially the same in condition as they were in the fall. This can be best explained by observing the weight losses.

TABLE 10. LEAST SQUARE MEANS OF COW AND CALF PERFORMANCE DATA, EXPERIMENT II

Item	Control Silage	Soybean Residue	Cotton Gin Trash	Approximate Standard Error
Number of Cows	14	10	9	--
Cow Initial Weight, kg ^c	464	464	469	13.139
Cow Weight Change, kg ^d	-6 ^a	-58 ^b	-53 ^b	6.868
Cow Body Weight Change as % of Initial Weight, % ^e	-1.3 ^a	-12.3 ^b	-11.4 ^b	.018
Cow Initial Condition ^f	7.2	7.6	7.9	.389
Cow Condition Change ^g	+1.3	+0.1	+0.2	.362
Amount of Forage Offered kg/cow/day	15.9	14.5	12.5	--
Calf Birth Weights, kg	27	26	28	1.204
Adjusted Average Daily Gain to 220 Days, kg	.81	.77	.78	.032

^{ab}Means superscripted with different letters are significantly different ($P < .05$) by Student Newman-Keuls' Multiple Range Test.

^cTo obtain least square values a model was fitted which included replication within treatment, cow age and initial condition.

^dTo obtain least square values a model was fitted which included replication within treatment, days on treatment, cow age, birth weight of calf, initial weight of cow and initial condition of cow.

^eTo obtain least square values a model was fitted which included replication within treatment, days on treatment, cow age, birth weight of calf, initial condition and initial weight of cow.

^fTo obtain least square values a model was fitted which included replication within treatment, cow age and initial weight.

TABLE 10 CONTINUED

⁹To obtain least square values a model was fitted which included replication within treatment, days on treatment, cow age, birth weight of calf, initial weight of cow and initial condition of cow.

The control group lost only 6 kg as compared to a loss of 58 and 53 kg respectively for the soybean residue and cotton gin trash groups. Since cows usually lose roughly 50-60 kg at calving, there should have been no actual body finish change for the soybean residue and cotton gin trash cattle and the control silage group should have gained slightly in condition.

The fact that slight increases were noted is probably a reflection of individual animals as well as the fact that the grading system is based on whole numbers without fractions. These factors along with the subjectiveness of the measure could easily explain the condition changes noted. There were no significant differences ($P > .1$) among treatments for either calf birth weight or adjusted 220 day average daily gain.

Two cows being fed the soybean residue died of veterinary diagnosed mycotoxin poisoning. Mycotoxin poisoning has been reported to be a problem in the Southeast where feedstuffs are contaminated in the field and if not stored in dry conditions the toxin-producing organism can flourish (Ciegler, 1976). Since the soybean residue was harvested from the ground after grain harvest and stored outside this possibility seems likely.

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