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INFLUENCE OF ADDING AMMONIA WITH OR WITHOUT MOLASSES TO CORN STALKLAGE ON PERFORMANCE OF DAIRY COWS AND ON STALKLAGE FERMENTATION

By

Antonio Hargreaves

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ABSTRACT

INFLUENCE OF ADDING AMMONIA WITH OR WITHOUT MOLASSES TO CORN STALKLAGE ON PERFORMANCE OF DAIRY COWS AND ON STALKLAGE FERMENTATION

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Upgrading of corn stalklage with ammonia mixtures was investigated and compared to the following treatments: 1) corn silage (control); 2) untreated stalklage; 3) stalklage treated with 2% ammonia, and 4) same as 3 plus 2% molasses. Stalklage was fed as 25% of the complete ration to 6 cows per group in mid- to late-lactation. Cows produced an average of 19.29 kg FCM/day. Treatments 1 and 2 (20.77 and 17.16 kg FCM/day) were significantly higher in milk yield than 3 and 4 (14.71 and 15.44 kg FCM/day) ($P<.05$). In additional experiment, stalklage (in treatment 4) was compared with corn silage at 10 and 20% of the ration dry matter and no depression in milk yield was observed. Fermentation patterns were characterized by ensiling stalklages in experimental bag silos and sampling at 0, 3, 7, 19 and 50 days. Dry matter did not differ significantly. Lactic acid increased with ammonia-molasses and time; pH for all treatments decreased with time and then stabilized. After ammoniation all fiber components decreased, but IVDMD increased ($P<.01$).

DEDICATION

To My Mother,

Mrs. Graciela B. de Hargreaves

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TABLE OF CONTENTS

LIST OF TABLES

Table		Page

1. INTRODUCTION

During the last few years the amount of crop residues such as cereal straws, corn stalks, corn cobs and husks fed to ruminant animals has increased to reduce feeding costs and because of somewhat inadequate supplies of conventional roughages. Current reports estimate that around 80% of the corn crop is harvested for grain which means that more than 150 million metric tons of corn residue are produced in the United States each year (Klopfenstein, 1978). Approximately 50% of the corn plant dry matter remains in the field after grain harvest (Berger et al., 1979). This residue consists of 54% stalks, 12% leaves, 21% cobs and 13% husks (Klopfenstein and Owen, 1981). Based on these estimates, nearly 81 million metric tons correspond to corn stalks and leaves which offer good potential sources of energy for ruminants. Although this material could be grazed directly, one may reduce field losses and obtain higher palatability through ensiling.

Corn stalks are characterized by low crude protein, high lignin and neutral detergent fiber, and a dry matter digestibility of no more than 55% (Klopfenstein, 1981). When harvested as mature corn, degree of lignification of the plant is at its maximum. Ruminants are able to digest polysaccharides that are contained in both the hemicellulose and cellulose, but these fractions are poorly utilized because of high lignin and silica which impede microbial digestion.

Animal performance is limited by the low digestibility and poor intake. Researchers have been attempting to upgrade these low-quality roughages by physical or chemical treatments, or both. This research is justified not only because of low digestibility, but also because of environmental pollution by burning residues.

Nitrogen and phosphorus are limiting nutrients in corn stalks. Considerable improvements on corn stalk nutritive value have been obtained by chemical treatment with ammonia (Oji et al., 1977; Saenger et al., 1982). Ammonia increases energy availability and nitrogen content of corn stalks, thereby improving the efficiency of utilization. However, supplementation with sugar might be advantageous for an improved silage fermentation.

Corn stalk consists of the stem or main axis of the plant and its leaves. Corn stalks stored as silage is called corn stalklage. Most of the studies on ammonia-treated or untreated corn stalklage have been with beef cattle and sheep with promising results. Studies with lactating dairy cows are limited.

The lactating dairy cow is an efficient food producer. Ammonia addition to corn stalklage may enhance nutritive value so that it may substitute for a portion of the forage in dairy cow rations.

The objectives of this study were as follows:

1. To evaluate corn stalklages treated with ammonia or ammonia plus molasses as forage sources for lactating cows.
2. To characterize fermentation patterns of treated and untreated corn stalklage.

2. LITERATURE REVIEW

Crop residues have received considerable attention during the last few years. They are considered low quality forages inefficiently utilized by ruminants because of their high content of poorly digestible fiber. This poor digestibility is due to the high lignin and cell wall contents of these forages (Klopfenstein, 1973).

Van Soest and Wine (1967) divided forages by extraction with a neutral detergent solution into two groups. These are: 1) soluble cell contents comprised of sugars, organic acids, starch, lipids, protein, nucleic acids and most of the inorganic constituents; and 2) the insoluble residue or cell walls containing hemicellulose, cellulose, cutin and lignin. The proportion of cell walls in forages and the proportion of lignin in the cell walls increases with: 1) advancing maturity; 2) with the elevation of evapotranspiration rates and ambient temperatures, and 3) with declining day length under which the plants are grown (Osbourn, 1978; Deinum et al., 1968). Digestion of the cell wall fraction is entirely dependent upon the enzymes secreted by the microorganisms in the rumen and/or large intestine, and is reduced as the forage plant matures and lignification increases (Anderson, 1978; Osbourn, 1978; Van Soest and Marcus, 1964).

Several crop residues have been studied with the goal of increasing their availability for livestock. Corn residue, for example, has been widely tested as a ration component for cattle and sheep.

2.1 Chemical Composition of Corn Stalklage

The quality of corn residues varies with location, water availability and maturity at harvest (Klopfenstein, 1981). Corn stalk decreases in digestibility and content of cell solubles with time after physiological maturity of the corn plant (Van Soest and Marcus, 1964; Ward, 1978; Berger et al., 1979; Klopfenstein and Owen, 1981). Both in vitro dry matter digestibility and carbohydrate content of the stalks decrease with maturity throughout the harvest season and are related to rainfall (Cummins, 1970; McDonnell and Klopfenstein, 1980).

After corn grain harvest, the remaining stover is usually high in dry matter (Holloway et al., 1977) and the crude protein is low (Klopfenstein and Owen, 1981). Chemical composition of corn stalks and stalklage is summarized from several authors (Table 1).

TABLE 1. Chemical composition of corn stalks, % of dry matter

Item	Crude protein	Nuetral detergent fiber	Acid detergent fiber	Acid detergent lignin	Source
	%	%	%	%	
Corn stalks	5.06	85.70	53.30	9.1	Saenger et al. 1982
Corn stalks	4.00	75.00	-	7.0	Klopfenstein and Owen, 1981
Corn stalklage	5.16	91.65	71.28	10.05	Holloway et al. 1977
Corn stalklage	8.20	64.90	42.50	7.90	Colenbrander et al., 1971
Average	5.61	79.31	55.69	8.51	

Protein content of corn stalks is quite low (Boehlje and Vetter, 1979). Diets containing mostly stalks might be deficient in protein for the gestating cow, but in both protein and energy for the lactating cow (Ward, 1978). Calf diets containing corn stalks required supplemental protein and energy (Orcasberro et al., 1978). Furthermore, corn residues are deficient in most minerals, particularly phosphorus; and very low in vitamin A (Kendall, 1977; Ward, 1978). It is therefore necessary to supplement these nutrients to prevent deficiencies. Also, supplemental magnesium was critical for beef cows fed corn stover (Vona et al., 1980).

Corn stalks vary in digestibility depending upon moisture, variety, temperature and maturity (McDonnell and Klopfenstein, 1980; Klopfenstein and Owen, 1981). Dry matter digestibility values of 38% to 65% have been reported with an average of 43% (Klopfenstein and Owen, 1981). In vitro dry matter disappearance of the stalks decreased linearly with time (Kamstra et al., 1958; Cummins, 1970; Berger et al., 1979; Paterson et al., 1981; Klopfenstein, 1981).

Time between grain harvest and corn stalk harvest markedly affects dry matter digestibility, soluble carbohydrate content and cellulose digestibility (Johnson and McClure, 1968; Cummins, 1970; Ward, 1978), as well as animal gains (Paterson et al., 1981). Berger et al. (1979) reported that steers fed corn stalklage harvested within 72 hours of grain harvest gained significantly more than steers fed stalklage harvested one month later, when moisture content dropped to 30% (Table 2). Hence, manipulation of harvest time offers the opportunity to obtain higher quality forage at no extra expense (Klopfenstein and Owen, 1981).

TABLE 2. Effect of corn stalk harvest date on calf performance[a]

Item	Corn silage	Early harvest corn stalklage[b]	Late harvest corn stalklage[c]
Number of steers	79	43	43
Initial weight, kg	252.3	251.8	251.4
Daily gain, kg	0.95	0.65	0.48
Daily feed intake, kg D.M.			
Corn silage	7.04	----	----
Corn stalks	----	5.4	4.8
Supplement	0.78	1.07	0.95
Total	7.82	6.47	5.75
Feed efficiency (kg/kg)			
Corn silage	3.38	----	----
Corn stalks	----	3.78	4.55
Supplement	0.38	0.75	0.90
Total	3.76	4.53	5.45

[a]Average of 2 years.
[b]Stalklage harvested same day as 25% moisture corn grain.
[c]Stalklage harvested 3 to 4 weeks after 25% moisture corn grain.
From Klopfenstein, T. 1981. In Upgrading Residues and Byproducts for Animals. John T. Huber (Ed.), p. 43.

The decrease in in vitro dry matter digestibility as the plant matured was attributed to decreased cell solubles, increased structural carbohydrates, and greater lignification (Berger et al., 1979).

Lamm and Ward (1977) have found that corn stalks which remained in the field during winter decreased in crude protein from 6.6% (as percentage of organic matter) to 5.8%, and that in vitro organic matter digestibility decreased from 62.1% to 48.8%, compared to fall-harvested

corn stalks. A negative correlation was shown between in vitro dry matter digestibility and neutral detergent fiber, and a positive relationship between loss of solubles with time and IVDMD (Berger et al., 1979). Van Soest (1968) pointed out that chemical composition of forages (and feeds in general) determines the availability of nutrients and true digestibility. Additional factors which contribute to apparent digestibility, metabolizable energy and net energy of feeds arise mostly from the digestive physiology of the animal.

Cell solubles can be separated from cell wall constituents by a neutral detergent solution (Deinum, 1973; Theander and Aman, 1980) which provides a clear differentiation in availability of forage dry matter (Van Soest, 1968) and is highly related to animal intake. Cell contents of a forage are almost completely digested, and is independent of the lignin, hemicellulose and cellulose content.

Lignin is primarily responsible for the incomplete digestibility of cellulose and hemicellulose. Such action occurs through its direct linkage to the structural carbohydrates (Van Soest, 1964; Van Soest, 1968; Falen et al., 1968; Deinum, 1973; Johnson and Pezo, 1975; Fahey et al., 1979; Fahey et al., 1980). Plant cell wall content is the most important factor that affects organic matter digestibility of roughages for ruminants. It represents the portion of the plant over which lignin exerts its influence and determines the space-occupying capacity of a feed. Hence, it is not surprising that high cell wall content is associated with low intakes (Van Soest, 1968; Deinum, 1973; Thomson and Beever, 1973). Furthermore, characteristics of forages which determine digestibility also affect intake and explain the close relationship between digestibility

and intake (Blaxter et al., 1961; Demarquilly, 1965; Demarquilly and Jarrige, 1971).

Growing lambs fed different levels of corn stover with corn silage (Keys, 1980) efficiently utilized corn stover at about 25% of the dry matter, but gains and efficiency decreased when stover was increased to 50%. Similar trends have been reported by others (Oh et al., 1971; Meno et al., 1972; Colenbrander et al., 1973; McDonnell et al., 1979).

TABLE 3. Effect of corn stover level in corn silage based rations on intakes by sheep

Level in the diet			Dry Matter	Cell wall	Intake	Average
Corn silage	Corn stover	Soybean meal	digestibility	content		daily gain
-------% of DM---------			%	%	g DM/kg $BW^{.75}$	g
0	90.4	9.6	68.6	47.0	58.1	150
25	64.6	10.4	68.9	64.1	58.7	138
50	38.7	11.3	59.1	63.9	46.2	74
75	12.8	12.2	57.7	75.1	45.2	62

Source: Keys, J.E. 1980. 75th Ann. Meet. ADSA, Virginia, 153.

Through plant breeding, lignin content has been decreased in experimental corn; therefore, better utilization of corn stover might be obtained. Colenbrander et al. (1973) fed Holstein heifers two corn stalklages, one from the brown midrib 3 mutant gene for low lignin and the other from a commercial hybrid (normal). Silage from the mutant stover was significantly lower in lignin, cell wall content, acid detergent fiber and higher in crude protein. Average daily gain, efficiency

of gains, intake and digestibilities of dry matter, cell walls, acid detergent fiber, hemicellulose and cellulose were higher for heifers fed the mutant stover (Colenbrander et al., 1973).

The importance of both intake and digestibility in utilization of poor quality roughages has been reported by many investigators (Campling et al., 1962; Oh et al., 1971; Ellis, 1978; Lippke, 1980). There is a strong relationship between ration composition and food intake (Conrad et al., 1964; Bines, 1976). For diets of low digestibility, intake is regulated by rumen capacity, rate of passage and dry matter digestibility; whereas, metabolic size, production and digestibility become the controlling factors on intake of rations higher in digestibility (Conrad et al., 1964; Oh et al., 1969; Jones, 1973; Bines, 1976; Journet and Remond, 1976; Ellis, 1978). There is also a relationship between intake by sheep of low-protein roughage and their nitrogen status (Egan 1965a; Oh et al., 1969). When nitrogen status of sheep was gradually improved by infusing nitrogen supplements (casein or urea) into the duodenum, daily digestible energy intake increased. When urea was added to the ration, voluntary feed consumption, microbial activity, dry matter digestibility, concentration of rumen volatile fatty acids and microbial protein, and blood urea were increased (Egan, 1965b; Oh et al., 1969) when steers were fed oaten chaff ad libitum. Intake was 23% higher with N supplementation (urea or casein) than without (Redman et al., 1980). Huber and Thomas (1971) reported that intakes of corn silage by lactating cows and total dry matter were directly related to the protein content of the ration between 8.5 and 12.5% crude protein equivalent.

2.2 Influence of Ammonia on the Chemical Composition and Dry Matter Digestibility of Roughages

Ammonia is a ubiquitous constitutent of the soil, the atmosphere and the waters of the earth. It is a colorless gas under standard conditions, whose pungent odor is easily discernible at concentrations above 50 ppm. It represents the 3 valence state of nitrogen, and can exist in a number of additional valence states (N.R.C., 1979). Ammonia is a polar substance and exhibits strong hydrogen-bonding characteristics.

A promising method to treat low-quality roughages is with ammonia. Anhydrous ammonia (NH_3, gaseous) and solutions of ammonia in water (NH_4OH, aqueous) have both shown positive effects in improving the nutritive value of low-quality roughage (Sundstol et al., 1978).

Lignin is bound tightly to the plant polysaccharides at several sites to give a strong structure which, as was discussed before, decreases digestibility of the plant fiber by rumen or caecum microorganisms. The attachment to lignin prevents swelling of the plant fiber in an aqueous media to a condition suitable for penetration by microbial polysaccharidases (Harkin, 1973). Also, non-glycosidic crosslinks inhibit digestion of cellulose derivatives because cellulases normally cannot approach closer than 2-3 sugars away from the crosslink (Harkin, 1973).

Ammonia treatment does not affect the particle size of the material but it does increase swelling of cell walls. During swelling there is a marked increase in the water-holding capacity (fiber saturation point) of the cell walls (Tarkow and Feist, 1969; Chandra and Jackson, 1971; Harkin, 1973; Oji, 1979) due to the cleavage of uronic ester crosslinks.

Also, ensiling anaerobically produces organic acids (lactic and acetic) that lower the pH and cleave acid-labile lignin-carbohydrate bonds (Harkin, 1973).

Oji (1979) reported that alkali reduces the strength of intermolecular hydrogen bonds which bind cellulose, thus causing swelling. Alkali causes intracrystalline, as opposed to intercrystalline swelling of cellulose which enhances rumen microbial accessibility and greater digestibility of roughages (Oji, 1979).

Addition of 3 g NH_3 per 100 g tall fescue hay resulted in ammonolysis of ester bonds and acetyl groups attached to xylan chains present in lignocellulosic materials (Buettner, 1978; Oji, 1979; Kuhl, 1982). The acetyl groups increase with the maturity of the grass, and accompany a fall in the digestibility, particularly of the pentosan fraction. They may be as high as 2.7% of the dry matter (Bacon et al., 1975). Morris and Bacon (1977) found that the removal of acetyl groups, using sodium ethoxide, leaving sugars and lignin unchanged, increased the digestibility of cell walls. Ammonolysis readily changes acetyl groups to acetic acid (Oji et al., 1977). Ammonia also increases solubilization of hemicellulose (Klopfenstein, 1978; Holloway et al., 1977; Itoh et al., 1975; Solaiman et al., 1978; Kuhl, 1982) of different roughages.

Ammonia often does not reduce the lignin content of treated roughages (Garret et al., 1974; Waller, 1976; Klopfenstein, 1978; Garret et al., 1979; Streeter and Horn, 1981). However, lignin in cereal straw was reduced after treatment with ammonia (Horton, 1981; Harbers et al., 1982) and in corn stover after treatment with ammonium polyphosphate (Colenbrander et al., 1971). Furthermore, alkali treatment of barley straw decreased the content of cis-p-coumaric, cis-ferulic and diferulic acids, which are phenolic components of plant cell walls, causing cell wall digestibility to increase (Hartley and Jones, 1978).

In general, crop residues do not contain more than 5% crude protein (dry matter basis); and, as it was discussed earlier, corn stalklage was about 5.6%. One of the most important advantages of using ammonia is the value of the residual nitrogen as nonprotein nitrogen (Klopfenstein and Owen, 1981). Ammonia treatment increases crude protein content of low-quality roughages (Martynov, 1972; Lawlor and O'Shea, 1979; Breaux et al., 1981; Harpster et al., 1981; Johanning et al., 1981; Males, 1981; Oji and Mowat, 1981; Saenger et al., 1981).

Ammonia-treated corn silages increased in water insoluble nitrogen (Henderson and Bergen, 1972; Huber et al., 1973; Huber et al., 1979a; Huber et al., 1979b; Foldager and Huber, 1979), due to a combination of decreased breakdown of original plant protein; increased synthesis of silage microbial protein; and binding of ammonia by silage particles (Huber et al., 1979b; Bergen et al., 1974). With ^{15}N labelled ammonia, Huber et al. (1979b) found that 41% of the increase in water insoluble nitrogen was due to indirect action of ammonia on plant material. They (Huber et al., 1979b) proposed a reduction in proteolysis by plant enzymes during the early stages of fermentation as suggested by Bergen et al. (1974), and subsequently established by Johnson et al. (1982).

Ammonia addition to corn silage also delays decreases in pH and increases lactic acid (Britt and Huber, 1975; Huber et al., 1973;

Huber et al., 1979b). This greater buffering capacity caused a higher lactate content (Huber et al., 1973). Factors which affect response to ammoniation are moisture, plant species, treatment time, level of ammonia, temperature and pressure (Oji, 1979).

a) Moisture

In an experiment by Solaiman et al. (1978), chopped wheat straws of five dry matter levels (10,20,30,40 and 50%) were sprayed with NH_4OH at 3.3% of DM and then sealed. Water content had significant linear effects on in vitro dry matter digestibility and total nitrogen content. High moisture material resulted in distribution problems when anhydrous ammonia was injected; so if straw is dried, this should be done before rather than after ammonia treatment (Sundstol et al., 1978). Higher digestibility with higher moisture was demonstrated by Borhami and Sundstol (1982).

b) Plant Species

Response of low quality roughages to alkali treatment is fairly specific. Variation between and within species influences the effectiveness of NH_3 treatment. Kiangi et al. (1981) compared different sources of ammonia for treatment of corn stover, rice and wheat straws at rates of 0, 25 and 50 g NH_3/kg DM. They found that anhydrous ammonia was the most effective reagent for improving IVDMD and in vitro organic matter digestibility (IVOMD) of corn stover; that aqueous ammonia was the most active in increasing IVDMD and IVOMD of wheat straw; and the two forms of ammonia were similarly effective on rice straw.

Kernan et al. (1981) found different responses within the same

crop and among cultivars and locations. They concluded that crop residues of annual grass families responded more to ammonia treatment than did those of annual legume families. Legumes generally have a higher lignin content than grasses and the chemical bonds between lignin and polysaccharides differ. In grasses, ester links occur between lignin acid and a xylan chain (hemicellulose), whereas in legumes they are mainly glycosidic bonds (Harkin, 1973; Oji, 1979). Response to alkali treatment is smaller in legume straws due to the resistance of glycosidic bonds to alkaline hydrolytic cleavage (Kernan et al., 1981).

Initial quality of roughage has been suggested as influencing response to ammoniation. The improvement obtained with ammonia is more pronounced for roughages with low initial digestibility (Waiss et al., 1972; Oji, 1979; Sundstol et al., 1978).

c) Treatment Time

Time of treatment is an important factor influencing the effect of ammoniation. Chandra and Jackson (1971) concluded that there is a slight decrease with time in the amount of residual alkali present in sprayed straw which indicates that alkali continues to react with straw at a slow rate (Jackson, 1977). There is an interaction between time and temperature during ammoniation of low-quality forages. For low-quality roughages treated with 3 to 4% ammonia at different ambient temperatures, the following treatment times were recommended (Sundstol et al., 1978).

Temperature ^{o}C	Length of Treatment weeks
<5	>8
5-15	4-8
15-30	1-4
>30	<1

Time of treatment is more critical at low than at high temperatures. Ammonia reaction time may be up to 20 days longer than sodium hydroxide (Klopfenstein and Owen, 1981).

d) Level of Ammonia

Sundstol et al. (1978) proposed that the optimum level of ammonia is 3-4%, since no further improvement in digestibility is obtained with higher concentrations. Similar observations were reported by Felix and Diarra (1982) and Felix et al. (1982). However, Sundstol et al. (1979) found that the nitrogen content and enzyme solubility increased with increasing NH_3 level up to 7.0%. On the other hand, maximum digestibility was at 2.6% NH_3, 62^{o}C and 4 days incubation, or 5.9% NH_3, 30^{o}C and 3-7 days incubation (Waagepetersen and Thomsen, 1977). These data suggest that besides the time-temperature interaction, there is a dosage-time-temperature interaction influencing the effect of ammoniation.

e) Temperature and Pressure

At moderate temperatures, ammonia reacts slowly with coarse roughage (Oji, 1979), but the reaction is extremely slow below 5^{o}C (Sundstol et al., 1978). Ammoniation at elevated temperatures and/or

pressure will bring the greatest improvements in digestibility (Oji and Mowat, 1979; Oji, 1979; Oji et al., 1979). Oji (1979) concluded that smaller concentrations of ammonia are required when treating at high than at low temperatures.

High temperatures and pressures have been reported to yield products low in digestibility and nitrogen utilization (Oji, 1979). Nonetheless, greatest increases in nutritive value are achieved when the roughages are pressure-cooked with alkali solutions (Ololade et al., 1970).

2.3 Influence of Ammonia on the Preservation, Digestibility of Dry Matter Components and Intake of Roughages

Antifungal effects constitute another advantage of ammonia. Spoilage and decomposition from microbial action is inhibited after treating forages with ammonia, especially those of high moisture content (Huber, 1981; Kuhl, 1982). These effects were observed in rice straw (Waiss et al., 1972); in corn silage (Huber et al., 1979a); in whole high moisture shelled corn (Mowat et al., 1981); and in alfalfa hay (Knapp et al., 1974; Knapp et al., 1975).

Several researchers have demonstrated that both in vitro and in vivo digestibilities of dry matter are increased after treatment with ammonia (Anderson and Ralston, 1973; Horton, 1978b; Bales et al., 1979; Kernan et al., 1979; Buettner et al., 1982; Paterson et al., 1982; Owen et al., 1982). Mechanisms for improvement of digestibility have been discussed earlier.

Nevertheless, the effect of ammoniation on nitrogen utilization is somewhat controversial. Some reports have shown that the apparent nitrogen digestibility decreases after treatment with ammonia (Garret et al., 1974; Garret et al., 1979; Oji et al., 1977; Oji and Mowat, 1979), whereas others have shown an increase (Laguta, 1962; Dokukin and Tracenko, 1967; Sundstol et al., 1978; Horton and Steacy, 1979). Waiss et al. (1972) mentioned that the production of toxic 4-methyl-imidazole has been observed in the ammoniation of molasses, but they were unable to demonstrate its presence in ammonia-treated rice straw.

The cause of the reduced nitrogen digestibility has not been clarified. Oji (1979) reported a color change in ammoniated materials due to oxidation of phenols. Presumably, some nitrogen bound to phenolic compounds could partially account for the decreased nitrogen digestibility. However, the addition of supplements to ammoniated straws improved the utilization of the nitrogen bound through ammoniation (Horton and Holmes, 1976; Horton, 1978a).

The digestibility of other organic components generally increases after ammoniation. The effect of anhydrous ammonia treatment of corn stalks upon apparent digestibility of fiber components is presented in Table 4.

After treating with ammonia, apparent digestibilities of NDF, ADF, hemicellulose and cellulose increased 19.6, 13.7, 34.4 and 16.2%, respectively ($P<.05$). These results suggest that a major effect of ammonia on corn stalks is increasing digestibility of the hemicellulose fraction of fiber (Saenger et al., 1982).

TABLE 4. Effects of anhydrous ammonia treatment of corn stalks upon apparent digestibility of fiber components

Treatment	Apparent Digestibility of				
	NDF	ADF	Hemicellulose	Cellulose	Lignin
	%				
1) NH_3-stover + corn supplement	66.0	58.4	78.7	72.3	22.8
2) Stover + soybean meal	56.3	52.4	59.1	62.8	19.4
3) Stover + urea	56.0	52.3	57.4	62.5	24.5
4) Stover + corn supplement	53.3	49.4	59.1	61.3	24.7
% change (1 vs. 4)	19.6	13.7	34.4	16.2	0

Source: Saenger et al., 1982. J. Animal Sci. 54(2):419-425.

Some authors have shown decreased consumption of ammonia-treated roughages (Rounds et al., 1976; Davis, 1981; Males and Falen, 1982). In contrast, several groups demonstrated that treatment with ammonia improved voluntary intake of roughages (Horton and Steacy, 1979; Saenger et al., 1980; Nelson and Klopfenstein, 1980; Herrera-Saldana et al., 1982; Nelson et al., 1982a; Pace et al., 1982). Feeding the ammoniated material with fermented feed (50:50), cottonseed meal, or other supplement also improved intakes and rates of gain.

2.4 Molasses Addition to Ammonia-Treated Roughages

Molasses is an inexpensive source of carbohydrate for ruminants and has been used in ruminant rations for many years to increase palatability, improve pelleting characteristics, avoid dustiness in conventional dry-mixed rations (Karalazos and Swan, 1976), and increase rumen microbial activity (Bently et al., 1954).

a) Chemical Composition and Nutritive Value of Molasses

Table 5 shows the chemical composition of molasses from three different sources. The level of potassium is rather high. However, the ruminant is able to rapidly excrete an excess of dietary potassium.

TABLE 5. Chemical composition of molasses

Dry Matter	Sugar	Crude Protein	Ash	Potassium	Source
%	%	N x 6.25, %	%	%	
78.0	50.0	1.3	11.0	4	Karalazos and Swan, 1976
77.6	55.5	1.9	10.5	-	Lofgreen and Otagaki,1960
44.0	86.2	3.0	10.8	-	Sharma et al., 1972
66.5	63.9	2.1	10.8	4	Average

Net energy content of molasses for dairy cows is about 75% that of corn grain (Karalazos and Swan, 1976). When Lofgreen and Otagaki (1960) fed molasses at a level of 10% and 30% of the total ration for lactating dairy cows, the net energy of molasses for lactation was 68.1 and 23.1 Mcal per 100 lb, respectively, compared to 54.2 Mcal for the basal ration. They concluded from this very large energy loss, together with a significant decrease in percentage of butterfat and solids-not-fat in the milk that 30% molasses in the entire ration is too high for lactating dairy cows because it changes volatile fatty acids in the rumen. As the level of molasses in the diet increases, microorganisms of high butyrate and low propionate fermentation patterns increase (Sutton, 1979).

A depression in the digestibility of crude fiber was reported when molasses was added to the diet, which was greater than that caused by equivalent carbohydrate as starch (Elias and Preston, 1969). The decrease in dry matter digestibility was not statistically significant when 10 or 20% of the barley dry matter was replaced by molasses or condensed molasses solubles (CMS) (Karalazos and Swan, 1977).

Potter et al. (1971) reported improved dietary nitrogen utilization by steers fed 2.5% molasses (dry matter basis) in a diet containing either urea or soybean meal. No further improvements were found when molasses was increased to 10%. The authors suggested that the addition of molasses to the urea ration provided an essential factor for maximum growth and synthesis of protein from nonprotein nitrogen of microorganisms.

Large decreases in dry matter intake observed with animals fed high levels of molasses (Komkris et al., 1965; Sharma et al., 1972) were improved by the addition of forage (Karalazos and Swan, 1976). At low forage, digestibility was not limiting capacity but food intake fell rapidly. This may be explained by a physiological change due to the physical characteristics of molasses (Karalazos and Swan, 1976). They also proposed the low rate of rumen turnover on molasses-based diets a main reason for poor voluntary intakes.

The effect of adding molasses and ammonia to silage has been studied by several authors. Soper and Owen (1977) treated chopped whole corn plant (32% dry matter) with an ammonia-molasses-mineral solution and found a lower loss of dry matter and increased preservation of crude protein. Based on quality measurements such as lactic acid content, titratable acidity, freedom from observable mold, dry matter preservation, and temperature stability, the treated silage was higher in quality than untreated, after both had been exposed to air for 48 hours.

In another experiment, Heidker et al. (1982) treated high moisture sorghum grain with inoculum (.1% Silabac), molasses (1.0%), and a combination of the two. The grain treated with molasses had higher final lactic acid and the fastest decline in water soluble carbohydrates. The slowest decline was noted for grain treated only with the inoculum.

ProSil (liquid suspension of anhydrous ammonia, minerals and molasses) treatment of corn silage has been studied in a series of trials by Henderson et al. (1971) and Beattie et al. (1971) at Michigan State University. Crude protein content of 35% dry matter silage was increased 90% by the addition of 27 kg of ProSil per ton. Forty percent of the increase was organic protein, 55% ammonia salts and 5% unidentified nitrogen (Henderson et al., 1971). ProSil significantly increased lactic acid, but changes in acetic acid and butyric acid were small and nonsignificant.

2.5 Ammonia-Treated Roughages and Animal Production

a) Beef Cattle and Sheep

When ammoniated feeds are used in production experiments, rate of gain and feed efficiency increase for sheep (Rounds et al., 1976;

Al-Rabbat and Heaney, 1978; Klopfenstein and Owen, 1981) and for beef cattle (Horton et al., 1979; Paterson et al., 1981; Nelson et al., 1982b; Saenger et al., 1982). Klopfenstein and Owen (1981) reported that at ad libitum intake, dry matter digestibility of corn stalks was increased from 36.8% for sheep fed untreated stalks to 47.0% for sheep fed stalks treated with 2 g ammonia/100 g dry matter.

Saenger et al. (1982) fed four forms of corn stover to mature, pregnant beef cows during 70 days. Results showed a marked decrease in body weight loss of cows on ammonia-treated stover compared to control (Table 6). Holloway et al. (1977) fed mature, dry, pregnant beef cows with: dry corn stover, ammonia-treated stover, corn stalklage, and corn silage. Cows fed corn silage lost considerably less weight and less condition than those fed the other forages. Cows fed dry corn stover, ammonia-treated stover, and corn stalklage lost similar amounts of weight and condition, although ammonia-treated stover tended to maintain better condition.

TABLE 6. Cow weight change and condition score change with four corn stover treatments

Treatment	Cow Weight Change	Condition Score[a]
	%	
NH_3 stover + corn supplement	7.6	.00
Stover + soybean meal	-20.7	-.14
Stover + urea	-27.1	-.57
Stover + corn supplement	-44.0	-.64

[a]Visual condition score: 1=very thin; 3=average flesh; 5=very fat.
Source: Saenger et al., 1982. J. Animal Sci. 54(2):419-425.

b) Ammoniated Forages for Dairy Cows

Ammoniated feeds have been used in dairy rations although not extensively. Sundstol et al. (1978) summarized experiments on dairy cows. Animals receiving ammoniated straw (only a small part of the ration) produced an average 19.7 kg FCM, whereas the controls produced 19.9 kg. They concluded that dairy cows showed poor response when ammoniated feeds formed a small amount of the ration. Similar results were obtained by Heinrichs and Conrad (1982) and Greenhalgh et al. (1976). Huber (1981) reported milk yields of cows fed different ammonium salts were similar to controls fed soybean meal. However, fat-corrected-milk was higher when either urea or ammonium salts were added to the diet, suggesting that milk fat production was increased with NPN. Huber et al. (1980) fed lactating dairy cows corn silage, corn stalklage, ammonia-treated corn stalklage, ammonia-mineral-molasses treated corn stalklage (14% CP), and ammonia-mineral-molasses treated corn stalklage (16.8% CP). At 25% of the ration dry matter results presented in Table 7 show that dry matter intake was significantly higher for corn silage than other treatments and milk yields were higher for corn silage and AMS-stalklage (16.8% CP). The better response of cows on AMS-stalklage (16.8% CP) than other stalklages may be due to increased digestibility. They concluded that treatment of corn stalklage with an ammonia-mineral-molasses suspension improves its usefulness for lactating dairy cows.

Based on available evidence, one can reasonably conclude that ammoniation increases the energy availability of low quality roughages equal to that of medium-quality hay primarily through improved fiber digestion.

TABLE 7. Ammonia and ammonia-mineral molasses corn stalklage for lactating dairy cows

Item	Dry Matter Intake	Milk Yield
	kg/day	kg/day
Corn silage	20.0	26.6
Corn stalklage	16.9	24.2
Ammonia stalklage	16.7	23.7
AMS-stalklage (14% CP)	16.5	23.9
AMS-stalklage (16.8% CP)	16.3	25.7

Source: Huber et al., 1980. 75th Ann. Meet. ADSA, p. 152.

Ammoniation of corn stalklage improves dry matter digestibility and increases nitrogen content. However, the effect of ammoniation on nitrogen utilization of low quality forages is controversial.

Effect of ammoniation on intake of forages has been controversial, but one can conclude that 25% or more of the ration dry matter as corn stalklage fed to dairy cows, depresses intake regardless of type of ammonia treatment.

The variation in results suggest that more research is needed to improve the effectiveness of ammoniation on corn stalklage. Changes on the nitrogen fractions and energy fractions and digestibility after treatment with ammonia need to be elucidated, as well as fermentation patterns after ensiling. It is also desirable to determine the usefulness of varying levels of ammoniated corn stalklage in diets for dairy cows in terms of effects on milk yield and efficiency of feed utilization.

3. MATERIALS AND METHODS

3.1 Stalklage Management

Stalks were harvested 2 weeks after high moisture corn harvest from an area of 7.1 hectares at Michigan State University Experimental Station located South of campus from October 15 to 30, 1981. The average yield of corn stalklage was 8.5 tons per hectare with a 42% dry matter content. Therefore, around 3.4 tons of dry matter were produced per hectare. The total 60.2 tons of stalklage was finely chopped and placed in three concrete upright silos (3x12 m). Each silo contained around 20 tons of material.

Silo 1 contained untreated corn stalklage and therefore constituted a control treatment. Stalklage in Silo 2 was treated with 2.1% (of DM) aqueous ammonia (28% NH_3) as it passed through the blower to be elevated into the silo. The correct amount of ammonia to add to each was determined and was delivered with a pump calibrated according to unloading rates of wagons.

In Silo 3, a 50:50 mixture of aqueous ammonia and molasses (mixed before ensiling) was added. The amount of ammonia was similar to that added to Silo 2, and as indicated, molasses level was also 2.1% (of DM).

At ensiling samples of treated and untreated material were taken for subsequent analysis of dry matter, of nitrogen and fiber fractions and of in vitro dry matter digestibility. Stalklages remained in the

silos at least 60 days before they were opened for use in feeding trials.

3.2 Feeding Trial 1

Twenty four Holstein lactating dairy cows in mid- to late-lactation were fed a standard ration (Table 8) for 14 days before the experiment began. During this period, milk yields were recorded and used as the primary factor for assigning to treatment. Cows were allotted in a randomized block design to four treatments balanced for age, stage of lactation and breeding group. Treatments were as follows:

A. Corn silage (Control (CS).

B. Untreated corn stalklage (US).

C. Corn stalklage treated with 2% aqueous ammonia (AS).

D. Corn stalklage treated with 2% ammonia plus 2% molasses (AMS).

The experimental period was 60 days.

TABLE 8. Pre-experimental period ration for lactating dairy cows

	Dry matter	Amount in diet	Amount in diet	Crude protein
	%	% of DM	as is	%
Alfalfa haylage	44	17.00	38.64	2.42
Alfalfa hay	88	11.00	12.50	1.71
Corn silage	28	28.00	102.71	2.44
High moisture corn	68	25.08	36.88	2.26
Supplement	90	11.92	13.24	5.24
Minerals and salt	100	6.24	0.24	----
Total		100.00	204.21	14.07

Corn stalklage was added to experimental rations to supply 25% of the total ration dry matter (Table 9). Supplement contained 44% crude protein and varied in amount so as to obtain approximately 14% CP in each ration. Average body weight of the cows was 613 kg and the initial milk yield was 19.30 kg/day.

Cows were weighed for two consecutive days at the beginning and at the end of the experiment. Milk yields and weighbacks for the complete ration were recorded daily. A composite sample from two consecutive milkings was taken each week and analyzed for total solids, butterfat, and protein content at the DHIA Laboratory.

TABLE 9. Experimental rations for feeding trial 1 (% of dry matter)

	A (CS)	B (US)	C (AS)	D (AMS)
Ground hay	10	10	10	10
Corn silage	50	25	25	25
Corn stalklage	0	25	25	25
High moisture corn	30	27	33	33
Supplement*	10	13	6	6

*The composition of the supplement is in Table 10.

Feed was sampled twice weekly. Dry matter (DM), crude protein (CP), and in vitro dry matter digestibility (IVDMD) were determined on the complete ration mixtures, and on components of the ration. Additionally, stalklages were analyzed for insoluble (IN) and soluble nitrogen (SN), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose

(HC), cellulose (C), acid detergent lignin (ADL), ash (A) and lactic acid (LA).

TABLE 10. Composition of the supplement

Item	Percentage of the DM
Crude protein	44.0*
Crude fat	1.6
Crude fiber	8.0
Calcium	3.0
Phosphorus	1.6
Salt (NaCl)	2.0
Vitamin A (USP units/lb)	15,000.0
Vitamin D_3 (USP units/lb)	3,000.0
Zinc (ppm)	250.0
Copper (ppm)	50.0
Manganese (ppm)	100.0
Magnesium (%)	0.5

*This includes not more than 4.4% equivalent crude protein from non-protein nitrogen.

Determination of DM was by drying a weighed sample at 60°C for 48 hr. Crude protein (Nx6.25) was by the Kjeldahl procedure (AOAC,1965) IN and SN by Bergen et al. (1974) and IVDMD by the modified Terry-Tilly procedure (Goering and Van Soest, 1970). Fiber fractionation (NDF, ADF, HC, C, and ADL) was according to Goering and Van Soest (1970) and LA by the procedure of Barker and Summerson (1941). Ash was determined by

burning off all organic material in a muffle furnace at 600°C for 5 hr. Ash remains in the crucible.

3.3 Feeding Trial 2

Fifteen lactating Holsteins in early lactation were fed a standard ration as in Trial 1 (Table 8) for 10 days and allotted to three treatments (5 cows per treatment) in a randomized block design. Treatments were again balanced for age, stage of lactation, and breeding group, and the trial was for 30 days. Rations (listed in Table 11) were as follows:

A. Corn silage - Control (CS_2).

B. 10% of the ration dry matter as AMS (10 S).

C. 20% of the ration dry matter as AMS (20 S).

Average body weight of cows was 554 kg and initial milk yield was 26.7 kg/day. Milk weights and composition and feed samples were managed as in Trial 1.

TABLE 11. Experimental rations for feeding trial 2 (% of dry matter)

	A (CS_2)	B (10 S)	C (10 S)
Ground hay	10	10	10
Corn silage	50	40	30
Corn stalklage	0	10	20
High moisture corn	30	31	33
Supplement*	10	8	6

*See Table 10.

3.4 Corn Stalklage Fermentation Study

Double plastic bags of 30 kg capacity were used as experimental silos for stalklage harvested 19 days after high moisture corn harvest. Corn plant material was finely chopped with a silage harvestor, weighed into 17-20 kg lots, and placed in bags. Bags were evacuated with a heavy duty vacuum, sealed, and stored at room temperature until opened for processing. The following treatments were compared:

1. Untreated stalklage (US)
2. Corn stalklage treated with 2% (of dry matter) aqueous ammonia (AS)
3. Corn stalklage treated with 2% ammonia and 2% molasses (of dry matter) (AMS)
4. Corn stalklage treated with bacterial inoculum (*Lactobacillus brevis*, *L. plantarum* and *Pedoecocos acidilactici* applied at .5 g/kg (IS)

Duplicate bags for each treatment were opened and samples processed on days 0, 3, 7, 19 and 50 of fermentation. Samples were analyzed for the same components as in Trial 1, using the following scheme.

Duplicate sample (40 g) was cut with a laboratory chopper and used for DM determination (60°C oven for 48 hr). Part of this sample was used for total nitrogen (TN) determinations. Another (15 g) was mixed with 100 ml distilled water on which pH was immediately measured using a lab pH meter (Digital Ionolyzer Model 801A). The mixture was then homogenized with a lab Omni Mixer in an ice bath for 2 min, filtered through a double layer of cheesecloth and centrifuged at 15,000 rpm

for 15 min. The residue was discarded and the supernatant retained for determining soluble nitrogen and lactic acid. Insoluble nitrogen was calculated by difference between TN and SN.

A third sample was air dried and ground through the Wiley Mill to a 1 mm particle size for determination of IVDMD (Goering and Van Soest, 1970) and fiber analysis (NDF, ADF, HC, C and ADL) (Goering and Van Soest, 1970) and ash. Results were corrected for dry matter content.

3.5 Statistical Analysis

3.5.1 For Feeding Trials 1 and 2

a) The effect of treatments on milk yield was analyzed by analysis of variance using initial milk yield (4% fat corrected) and initial body weight as covariates, according to the following model:

$$Y = \mu + COV_1 + COV_2 + T + \text{error}$$

where: Y = milk yield

μ = overall mean

COV_1 = initial milk yield

COV_2 = initial body weight

T = effect of treatment

The analysis and the program are presented in Appendix Table 1.

b) The effect of treatment and time on dry matter intake was analyzed using a split-plot, repeated measurement design. The following statistical model was used:

$$Y_1 = \mu + T + A/T + t + T \cdot t + \Sigma$$

where: Y_1 = dry matter intake

μ = overall mean

T = effect of treatment

A/T = effect of animal within treatment or error a, used to test treatment effects

t = effect of time

$T \cdot t$ = effect of the interaction treatment x time

Σ = residual error (includes the animal within treatment over time), or error b, used to test the time effect and treatment x time

The analysis and program are presented in Appendix Table 2.

c) Scheffe's test as described by Gill (1978) was used to compare the means between treatments for the Feeding Trial 1.

3.5.2 Fermentation Study

This experiment was analyzed as a factorial 4 x 5 with two replicates, four treatments and five times. The statistical model was:

$$Y = \mu + T + t + T \cdot t + \text{error}$$

where: Y = dry matter, pH, total nitrogen, soluble nitrogen, insoluble nitrogen, neutral detergent fiber, acid detergent fiber, hemicellulose, cellulose, acid detergent lignin, lactic acid, in vitro dry matter digestibility

μ = overall mean

T = effect of treatment

t = effect of time

$T \cdot t$ = effect of interaction between treatment and time

Error = residual error

In those cases where the interaction treatment x time was significant, Dunnett's test as described by Gill (1978), was used to compare the means against the control (Appendix Table 3).

4. RESULTS AND DISCUSSION

4.1 Feeding Trial 1

4.1.1 Chemical Analysis of Corn Stalklages

Compared to the untreated stalklage (US), dry matter was slightly higher when ammonia (AS) and ammonia plus molasses (AMS) were added (2.41% and 5.28%, respectively), but differences were not significant (Table 12). Ammonia and ammonia-molasses treatments significantly increased total ($P<.01$), insoluble ($P<.01$) and soluble ($P<.05$) nitrogen. The higher insoluble nitrogen obtained after treatment with ammonia was partially due to a reduction in proteolysis by plant enzymes during the early stages of fermentation (Bergen et al., 1974; Huber et al., 1979; Johnson et al., 1982) and to linkage of ammonia with insoluble components of plant tissue (Huber et al., 1979).

Neutral detergent fiber, acid detergent fiber, hemicellulose and cellulose did not differ between US, AS and AMS, even though they showed a slight decrease with ammonia treatments. Lignin was significantly decreased ($P<.05$) in AMS. Horton (1981) also found a consistent trend of lower lignin and hemicellulose in ammonia-treated cereal straws, but the differences were not significant. Harbers et al. (1982) reported decreased lignin in wheat stems following treatment with 3.2% NH_4OH, as suggested by less dense staining under light microscopy. Furthermore, they reported less dense, but more diffuse, staining

TABLE 12. Effect of ammoniation and ammonia-molasses treatment on the composition of corn stalklage composites[a]

	US[b]	AS[b]	Change	AMS[b]	Change	Effect
			%		%	
Dry matter (%)	35.20	36.05	+ 2.41	37.06	+ 5.28	N.S.
Total nitrogen (%)	0.957	2.022	+111.29	1.827	+ 90.91	P<.01
Insoluble N (%)	0.664	1.506	+126.81	1.389	+109.19	P<.01
Soluble N (%)	0.293	0.516	+ 76.11	0.438	+ 49.49	P<.05
Fiber components (%)						
NDF	75.40	73.30	- 2.79	72.60	- 3.71	N.S.
ADF	41.68	40.79	- 2.14	41.03	- 1.56	N.S.
Hemicellulose	33.72	32.51	- 3.59	31.57	- 6.38	N.S.
Cellulose	31.03	29.89	- 3.67	30.15	- 2.84	N.S.
Lignin	9.46	8.28	- 12.47	7.96	- 15.86	P<.05
Ash	17.81	17.96	+ 0.84	17.31	- 2.81	N.S.
Lactic acid(% DM)	3.10	3.03	- 2.56	3.17	+ 2.26	N.S.
pH	4.51	4.63	+ 2.66	4.46	- 1.11	N.S.
IVOMD (%)[c]	46.60	54.12	+ 13.90	54.78	+ 14.93	P<.01

[a]Samples were taken twice a week from upright silos.
[b]Stalklage designations were: US, untreated; AS, ammonia added (2.1% of DM); AMS, ammonia and molasses added (2.1% of DM) for each.
[c]DMD was corrected by OMD by subtracting ash content from 100.

throughout cell walls indicating loosening of the lignin-polysaccharide binding. We conclude, therefore, that ammonia solubilized part of the hemicellulose and lignin in our corn stalklages, but cellulose was not affected. In contrast, Colenbrander et al. (1971) found no differences in cell wall components after treatment of corn stover silages with ammonium polyphosphate.

Lactic acid was lowered in AS, but increased in AMS, probably due to more soluble carbohydrates available for growth of microorganisms. However, differences were not significant. Addition of ammonium

polyphosphate did not change lactic acid production, but when urea was added, a linear increase in lactic acid was obtained (Colenbrander et al., 1971). Huber et al. (1979b) reported decreased lactic acid when 1.92% anhydrous ammonia was added to corn silage.

The pH did not differ among corn stalklages, but AS was slightly higher and AMS slightly lower than US. This may be associated with higher lactic acid in AMS. Both AS and AMS were higher in in vitro dry matter digestibility (IVDMD) ($P<.01$). These findings agree with several other authors (Oji and Mowat, 1979; Oji et al., 1979; Saenger et al., 1982).

Total ash was not different between silos but values are somewhat high, even though within the normal range for corn stalklage.

4.1.2 Animal Performance

Analysis of composites of samples taken twice weekly for dry matter, crude protein and IVDMD of the experimental rations are in Table 13. As expected, dry matter and crude protein of rations were not different, but IVDMD of stalklages treated with ammonia was significantly lower ($P<.01$) than the control corn silage.

Dry matter intakes of the complete ration (Table 14) are weekly averages of daily observations statistically analyzed as repeated measurements in a split-plot design (Gill, 1978). There were no significant differences between treatments, even though intakes tended to be lower for cows fed treated stalklages (AS and AMS) than controls (UC and US), compared to corn silage controls. Huber et al. (1980)

TABLE 13. Composition of ration composites for cows. Feeding trial 1[a]

	CS	US	AS	AMS	Effect
Dry matter (%)	40.4	41.0	40.3	41.2	N.S.
Crude protein (%)	13.82	13.89	13.86	13.93	N.S.
IVDMD (%)[b]	61.69[c]	56.14[d]	55.31[d]	52.32[e]	P<.01

[a]See Table 9.
[b]In vitro dry matter digestibility.
[cde]Means within a row without a common superscript are different (P<.01). Dunnett's test (Gill, 1978).

reported a depression in intakes when lactating cows were fed untreated, ammonia-treated and ammonia-mineral-molasses-treated stalklages at 25% of the ration dry matter. The lower digestibilities (P<.05) of AS and AMS rations than CS and US may in part explain the lower intakes. Also, a negative effect of ammonia on palatability may have affected the intake, similar to the observations of Rounds et al. (1976), Davis (1981) and Males and Falen (1982). Huber et al. (1979a) also reported depressed intakes by dairy cattle fed corn silage treated with .375% gaseous ammonia (82% N) but the effect was not consistent. Furthermore, the estimated net energy for lactation (Table 14) was lower for AS and AMS.

In our study, there was a high variation in DM intakes within groups as denoted by the large coefficient of variation (CV = 28%). Even though the trends we noted were similar to those reported by others, treatments did not differ significantly.

All cows averaged about 19.3 kg fat-corrected milk per day (Table 15) with those fed AS and AMS significantly lower than those fed CS or US

TABLE 14. Treatment and time effect on the dry matter intake (kg DM/cow/day). Feeding trial 1[a]

Trt.	1	2	3	4	5	6	7	8	Trt. Means[b]	% B.W.	NE_1[c] (Mcal)
CS	18.36	16.70	17.16	17.79	17.40	17.75	17.49	17.86	17.56±2.48	2.86	30.12
US	19.37	17.05	17.64	18.38	18.46	18.16	17.06	17.27	17.92±2.52	3.02	29.34
AS	15.51	15.11	15.54	15.98	16.33	15.61	15.29	15.20	15.57±2.20	2.50	25.36
AMS	15.36	14.56	15.39	15.52	15.47	15.33	14.90	15.49	15.25±2.20	2.64	24.85
Time Means[d]	17.22	15.89	16.47	16.96	16.94	16.76	16.22	16.51			

[a]Six cows per treatment for 60 days.
[b]Treatment effect on DM intake was not significant (P<.05).
[c]Estimated net energy lactation (NE_1).
[d]Significant time effect (P<.05).

(P<.01). In a previous experiment (Huber et al., 1980), cows fed rations with 25% of the dry matter as ammonia or ammonia-mineral-molasses treated stalklage (AMMS, 14% CP) produced significantly less milk than those fed a control (corn silage) ration or one containing stalklage treated at a high level of AMMS (16.8% CP). Cows fed untreated stalklage were intermediate between two groups. The higher milk production obtained with untreated stalklages than those treated with ammonia may have been due to the higher digestibility of ration dry matter, probably because of the addition of more natural protein supplement and, also, the higher values of NE_1 for those rations. This may also explain the higher, though not significantly, dry matter intakes.

Milk components were all within normal ranges, and did not differ significantly between groups (Table 15). However, milk protein tended

TABLE 15. Milk production, milk composition, feed efficiency and changes in body weight. Feeding trial 1.

	Treatments			
	CS	US	AS	AMS
Initial milk yield (kg FCM/cow/day)[c]	19.46	19.71	18.85	19.12
Milk yield (kg FCM/cow/day)[e]	20.77[a]	17.16[ab]	14.71[b]	15.44[b]
Predicted milk yield[f] (kg/day)	24.00	22.80	17.57	16.82
Milk composition				
Protein (%)	3.64± .10	3.56± .13	3.37± .11	3.54± .10
Fat (%)	3.86± .09	3.80± .10	3.99± .07	4.10± .09
Feed efficiency[d]	1.18	0.96	1.06	0.99
Changes in body weight (kg)	13.86±5.55	3.73±5.55	9.05±6.09	5.55±5.55

[ab]Means within a row with an uncommon superscript are different. Scheffe's Interval (Gill, 1978) ($P<.05$).
[c]Initial fat-corrected-milk used as covariate.
[d]Calculated as total milk yield/total dry matter intake.
[e]Covariate adjusted production.
[f]Calculated by estimated net energy lactation.

to be lower and milk fat higher when stalklage was fed. This effect might be explained by the higher fiber and/or lower milk production. Efficiency of conversion of feed to milk was not significantly different between treatments; however, cows fed stalklage had slightly lower efficiency.

All groups gained weight which might be expected for cows in mid- to late-lactation, and treatments did not affect weight changes.

4.2 Feeding Trial 2

4.2.1 Animal Performance

Corn stalklage used for this experiment was the same as the AMS in treatment in feeding trial 1 (Table 12). Dry matter content, crude protein and in vitro dry matter digestibility of rations are in Table 16. As in feeding trial 1, analyses were from composites taken twice weekly. Dry matter, crude protein and IVDMD did not differ between treatments, even though the ration with 20% AMS (20 AMS) was slightly higher than others in IVDMD.

TABLE 16. Composition of ration composites for cows fed varying amounts of stalklage treated with ammonia and molasses (AMS). Feeding trial 2[a]

	Ration[b]			
	Corn silage	10 AMS	20 AMS	Effect
Dry matter (%)	39.2	41.2	40.9	N.S.
Crude protein (%)	13.92	14.01	13.99	N.S.
IVDMD (%)[b]	62.26	62.00	64.49	N.S.

[a]See Table 11.
[b]In vitro dry matter digestibility

No significant treatment effects were found for dry matter intakes (Table 17), although a slight depression was observed on 20 AMS, probably because of the lower levels of NE_1 in this ration. However, when dry matter consumption was expressed as percent body weight, values were similar to experiment 1 with stalklage rations lower than the corn silage.

TABLE 17. Effect of treatment and time on the dry matter intakes of cows fed varying amounts of stalklage treated with ammonia and molasses (AMS) (kg DM/cow/day). Feeding trial 2[a]

Ration	Week 1	Week 2	Week 3	Week 4	Treatment means[b]	% B.W.	NE_1[c] (Mcal)
Corn silage	15.62	15.61	15.52	16.25	15.75$\pm$.17	2.95	27.01
10 AMS	13.84	15.39	15.45	16.14	15.21$\pm$.49	2.69	24.79
20 AMS	13.62	14.56	14.95	15.08	14.55$\pm$.33	2.63	23.91
Time means	14.36	15.18	15.30	15.83			

[a]Five cows per treatment for 30 days.
[b]Differences were not significant (P<.10).
[c]Estimated net energy lactation.

TABLE 18. Milk production, milk composition, feed efficiency, and changes in body weight of cows fed varying amounts of stalklage treated with ammonia and molasses (AMS). Feeding trial 2.

	Treatments[b] Corn silage	10 AMS	20 AMS
Initial milk yield (kg FCM/cow/day)[a]	22.85	22.39	23.24
Milk yield (kg FCM/ cow/day)	25.50	25.30	28.10
Predicted milk (kg/day)[d]	20.98	17.97	16.79
Milk composition			
Protein (%)	2.75$\pm$.25	2.65$\pm$.25	2.64$\pm$.25
Fat (%)	3.18$\pm$.12	3.37$\pm$.12	3.32$\pm$.12
Feed efficiency[c]	1.62	1.66	1.93
Changes in body weight (kg)	13.45$\pm$10.1	-7.05$\pm$10.1	16.05$\pm$10.1

[a]Initial fat corrected milk used as covariate.
[b]None of the differences between treatments were significant (P<.10).
[c]Calculated as total milk yield/total dry matter intake.
[d]Calculated by estimated net energy lactation.

Initial FCM yields of cows averaged about 22.83 kg/day (Table 18). The main objective of this experiment was to determine whether treated stalklage (AMS) at lower levels than experiment 1 (20% or 10% of dry matter) would maintain as high milk yields as the corn silage control. The data show that AMS could be added at up to 20% of the ration dry matter without a decrease in milk production. Predicted milk yield is lower than the observed productions. This situation leads to the conclusion that corn stalklage can be fed during short periods of time with no detrimental effects. The slightly higher milk yields for treatment 20 AMS may be related to the higher, although not significant, IVDMD of the complete ration.

Milk fat was within the normal range, but milk protein was lower than standard for all treatments. A possible explanation might be a consistent error in protein determination. As in experiment 1, stalklage treatments were slightly higher than the corn silage control in percent milk fat, lower in percent milk protein, but similar in feed efficiency and body weight changes.

4.3 Corn Stalklage Fermentation Study

4.3.1 Dry Matter

Initial dry matter of stalklages was not significantly altered by treatments or time of ensiling (Table 19). This result is consistent with other studies (Huber et al., 1979b; Johnson, 1981). However, dry matter of treated stalklages decreased slightly as fermentation progressed, possibly due to a loss of volatile organic

acids during oven drying, coupled with the evolution of CO_2 and the production of water during fermentation (Johnson, 1981).

TABLE 19. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on dry matter content (%) in corn stalklage[a]

Treatment	Days of Ensiling					Treatment
	0	3	7	19	50	mean
	---------% of dry matter---------					
US[b]	38.81	42.67	41.70	40.15	40.08	40.68
AS[b]	42.88	42.41	40.23	40.70	39.89	41.22
AMS[b]	41.42	37.54	42.55	39.06	39.39	39.99
IS[b]	42.08	42.68	37.55	41.41	40.80	40.90
Time mean	41.30	41.33	40.51	40.33	40.04	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.
Treatment x time interaction is significant ($P<.05$).

4.3.2 pH

Values for pH are presented in Table 20. Initially (days 0 and 3) treatments with ammonia resulted in a much higher pH than the control and inoculum-treated stalklages ($P<.05$). All stalklages decreased with time, but on days 19 and 50 AS and AMS were still somewhat higher than US and IS. Similar results have been obtained in other studies (Britt and Huber, 1975; Johnson, 1981; Boman, 1980) with corn silage treated with ammonia.

TABLE 20. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on pH in corn stalklage[a]

Treatment	Days of Ensiling					Treatment
	0	3	7	19	50	mean[b]
US[h]	7.13	4.45	4.38	4.38	4.49	4.96[g]
AS[h]	8.87[d]	6.20[d]	5.44[d]	4.85	4.87	6.04[c]
AMS[h]	8.76[d]	6.13[d]	4.93	4.82	4.75	5.88[c]
IS[h]	7.13	4.49	4.51	4.45	4.42	4.99
Time mean[f]	7.97	5.31[e]	4.81[e]	4.62[e]	4.63[e]	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect (P<.01).
[c]Significantly higher than the control (P<.05).
[d]Significantly higher than the control (P<.05).
[e]Significantly lower than day 0 (P<.01).
[f]Standard error of any time mean is $\pm .0401$.
[g]Standard error of any treatment combination mean is $\pm .0359$.
Treatment x time interaction is significant (P<.01).
[h]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

4.3.3 Lactic Acid

Lactic acid values in corn stalklage are shown in Table 21. There were significant treatment and time of ensiling effects (P<.01). As can be observed, AS and IS were initially lower in lactic acid than US and AMS. Because of the extra sugar provided for microbial growth, lactate in AMS was highest at the end of fermentation. Ammoniation delayed lactic acid production, but values were similar to the control by 50 days of fermentation. Oji et al. (1977) reported negligible levels of lactic acid in ammonia-treated stover suggesting

TABLE 21. Effect of ammonia, ammonia-mola-ses, inoculum, and time of ensiling on lactic acid in corn stalklage[a]

Treatment	Days of ensiling					Treatment mean[b]
	0	3	7	19	50	
	----------% of dry matter---------					
US[i]	1.22	3.43	3.89	4.59	4.00	3.42[g]
AS[i]	1.49	1.53[e]	2.32[e]	3.77	3.83	2.59[e]
AMS[i]	2.17[d]	1.99[e]	4.68[d]	4.74	5.85[d]	3.88
IS[i]	2.52[d]	2.28	3.89	3.82	3.34	3.17
Time mean[c]	1.85[h]	2.31	3.69[f]	4.23[f]	4.25[f]	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect ($P<.01$).
[c]Significant time effect ($P<.01$).
[d]Significantly higher than control ($P<.05$).
[e]Significantly lower than control ($P<.05$).
[f]Significantly higher than day 0 ($P<.01$).
[g]Standard error of any treatment combination mean is $\pm.0875$.
[h]Standard error of any time mean is $\pm.0979$.
Treatment x time interaction is significant ($P<.01$).
[i]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

an absence of fermentation during storage. Boman (1980) and Beattie (1970) reported the highest values of lactic acid in corn silage treated with an ammonia-mineral-molasses suspension. Furthermore, there was a trend for increased lactic acid with time of ensiling (Boman, 1980) which is consistent with results of this experiment. The delayed increase in lactic acid on ammonia treatments is attributable to an increased buffering, thus requiring more lactic acid to reduce pH to 4.5 or below (Johnson, 1981). Stalklage treated with IS was slightly lower in lactic acid than the control, but differences were not significant. The values of LA by day 0 of ensiling were rather high maybe because stalklage laid in the field for at least 5 hr after being chopped.

These are some of the first studies where fermentation of corn stalklage has been characterized at different times after ensiling. The decrease in pH to about 4.5 and increase in lactic acid to 3 to 5% (of DM) suggests that a substantial lactic acid type of fermentation occurs in stalklage, which is enhanced with addition of ammonia and molasses.

4.3.4 Nitrogen Fraction

The effect of treatment and time of ensiling on total, insoluble and soluble nitrogen are in Tables 22, 23 and 24. Ammonia, and ammonia plus molasses significantly increased total, insoluble and soluble N ($P<.01$). Time of ensiling did not affect any nitrogen fraction of stalklages. Similar observations have been observed with corn silages (Huber et al., 1979a,b; Johnson, 1981) and corn stalklages (Saenger et al., 1982; Oji, 1979) treated with ammonia. Huber et al. (1973) observed a sparing effect of the original plant protein when ammonia was added to corn silage resulting in higher insoluble N. Bergen et al. (1974) and McDonald (1979) reported that much of the corn plant protein breakdown during ensiling is due to plant enzymes and that proteolysis is greatly diminished in ammonia-treated corn silages. Also, the higher insoluble N in ammonia-treated corn materials is partly due to a binding of ammonia by insoluble compounds in plant tissues (Huber et al., 1980).

TABLE 22. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on total nitrogen in corn stalklage[a]

Treatment	Days of Ensiling					Treatment
	0	3	7	19	50	mean[b]
	---------% of dry matter----------					
US[h]	0.879	0.888	1.006	0.819	0.941	0.906[cf]
AS[h]	1.575[e]	1.441[e]	1.732[e]	1.895[e]	1.895[e]	1.708[d]
AMS[h]	1.908[e]	1.944[e]	1.980[e]	1.771[e]	1.705[e]	1.862[d]
IS[h]	1.149	0.834	1.069	0.912	0.986	0.990[c]
Time mean[g]	1.378	1.277	1.447	1.349	1.383	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect (P<.01).
[cd]Means within a column without a common superscript are different (P<.01).
[e]Significantly higher than control (P<.01).
[f]Standard error of any treatment combination mean is $\pm$.054.
[g]Standard error of any time mean is $\pm$.0604.
Treatment x time interaction is significant (P<.05).
[h]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

The higher values of water soluble nitrogen (WSN) in stalklage after ammonia treatment was due to addition of nitrogen as soluble ammonia. Similar results were observed by Johnson (1981).

4.3.5 Fiber Fractionation

Effects of treatments and time of ensiling on neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HC), cellulose (CL) and acid detergent lignin (ADL) are in Tables 25, 26, 27, 28 and 29. Fractions of NDF, ADF, and ADL were decreased after ammonia

TABLE 23. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on insoluble nitrogen in corn stalklage[a]

Treatment	Days of ensiling					Treatment
	0	3	7	19	50	mean[b]
	----------% of dry matter---------					
US[i]	0.620	0.641	0.727	0.548	0.692	0.646[cg]
AS[i]	0.937	0.649	0.996[e]	1.201[e]	1.292[e]	1.015[d]
AMS[i]	0.938[e]	1.236[e]	1.279[e]	1.131[e]	1.191[e]	1.155[d]
IS[i]	0.849	0.475[f]	0.796	0.634	0.758	0.702[c]
Time mean[h]	0.836	0.750	0.950	0.879	0.983	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect (P<.01).
[cd]Means within a column without a common superscript are different(P<.05).
[e]Significantly higher than control (P<.01).
[f]Significantly lower than control (P<.05).
[g]Standard error for any treatment combination mean is $\pm$.0601.
[h]Standard error for any time mean is $\pm$.0672.
Treatment x time interaction is significant (P<.05).
[i]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

TABLE 24. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on soluble nitrogen in corn stalklage[a]

Treatment	Days of ensiling					Treatment
	0	3	7	19	50	mean[b]
	----------% of dry matter---------					
US[h]	0.260	0.247	0.279	0.271	0.249	0.261[cf]
AS[h]	0.638[e]	0.792[e]	0.736[e]	0.694[e]	0.603[e]	0.693[d]
AMS[h]	0.970[e]	0.708[e]	0.701[e]	0.640[e]	0.514[e]	0.707[d]
IS[h]	0.300	0.359	0.273	0.278	0.228	0.288[c]
Time mean[g]	0.542	0.526	0.497	0.471	0.400	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect (P<.01).
[cd]Means within a column without a common superscript are different(P<.01).
[e]Significantly higher than control (P<.01).
[f]Standard error for any treatment combination mean is $\pm$.0361.
[g]Standard error for any time mean is $\pm$.0403.
Treatment x time interaction is not significant.
[h]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

treatment (P<.01). Hemicellulose was also decreased (P<.05) (Table 26), but CL was least affected. The AMS treatment decreased CL (P<.05) (P<.05) but AS and IS did not. Similar results have been reported for ammoniated corn stover by Kiangi et al. (1981) and Saenger et al. (1982) and for stalklage treated with ammonia polyphosphate (Colenbrander et al., 1971). In tall fescue hay (Buettner et al., 1982), NDF, HC and lignin were decreased by ammoniation, but the ADF and CL were not. Lignin was also decreased by ammoniating wheat straw (Streeter and Horn, 1981). One can reasonably conclude from the present study that ammoniation increased solubilization of HC, ADL and silica although the values for lignin are higher than reported in the literature. Cellulose solubility was not greatly altered. Similar conclusions were reached by Jackson (1977) and a review article. Time of ensiling affected NDF and ADF (P<.01) (Table 24, 25) but not HC, CL and ADL. Ash values are presented in Table 30. Ash content was used to correct by organic matter.

4.3.6 In Vitro Organic Matter Digestibility

Values of IVDMD were corrected by OM because of the high values of ash. Effects of treatment and time of ensiling on in vivo organic matter digestibility (IVOMD) are presented in Table 31. Ammoniation and time of ensiling increased IVOMD (P<.01). Several studies have also demonstrated increased IVOMD in corn stalklage treated with ammonia (Oji and Mowat, 1979; Paterson et al., 1981; Saenger et al., 1982) and have associated this effect with a reduction of the fiber components after ammoniation. The significant effect of time of ensiling on IVOMD

TABLE 25. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on neutral detergent fiber in corn stalklage[a]

Treatment	Days of ensiling					Treatment mean[b]
	0	3	7	19	50	
	----------% of dry matter---------					
US[h]	73.72	73.20	71.20	70.85	70.52	71.90[f]
AS[h]	70.84	68.36[d]	67.98[d]	67.28[d]	67.10[d]	68.31[c]
AMS[h]	71.47	67.71[d]	68.27[d]	66.08[d]	66.37[d]	67.98[c]
IS[h]	70.50	70.51	69.63	68.86	69.40	69.78
Time mean[g]	71.63	69.94	69.27	68.27[e]	68.35[e]	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect ($P<.01$).
[c]Significantly lower than control ($P_{<}.05$).
[d]Significantly lower than control ($P_{<}.05$).
[e]Significantly lower than time 0 ($P<.05$).
[f]Standard error for any treatment combination mean is $\pm.597$.
[g]Standard error for any time mean is $\pm.667$.
Treatment x time interaction is not significant.
[h]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

TABLE 26. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on acid detergent fiber in corn stalklage[a]

Treatment	Days of Ensiling					Treatment mean[b]
	0	3	7	19	50	
	----------% of dry matter---------					
US[g]	44.27	44.63	43.49	43.06	43.25	43.74[e]
AS[g]	43.98	42.38[c]	40.76[c]	40.45[c]	40.08[c]	41.53[c]
AMS[g]	42.59[c]	41.94[c]	41.72[c]	40.77[c]	40.64[c]	41.53[c]
IS[g]	40.87[c]	41.99[c]	41.91[c]	41.60[c]	41.97[c]	41.67[c]
Time mean[f]	42.93	42.73	41.97	41.47[d]	41.48[d]	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect ($P<.01$).
[c]Significantly lower than the control ($P<.05$).
[d]Significantly lower than day 0 ($P<.05$).
[e]Standard error for any treatment combination is $\pm.2676$.
[f]Standard error for any time mean is $\pm.2992$.
Treatment x time interaction is significant ($P<.05$).
[g]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

TABLE 27. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on hemicellulose in corn stalklage[a]

Treatment	Days of Ensiling					Treatment mean[b]
	0	3	7	19	50	
	----------% of dry matter----------					
US[f]	29.45	28.57	27.72	27.79	27.26	28.16[d]
AS[f]	26.86[c]	25.98[c]	27.22	26.84	27.03	26.78[c]
AMS[f]	28.87	25.77[c]	26.55	25.31[c]	25.74[c]	26.45[c]
IS[f]	30.18	28.52	27.73	27.26	27.43	28.23
Time mean[e]	28.84	27.21	27.31	26.80	26.86	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect (P<.05).
[c]Significantly lower than control (P<.05).
[d]Standard error for any treatment combination mean is $\pm.680$.
[e]Standard error for any time mean is $\pm.761$
Treatment x time interaction is not significant.
[f]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

TABLE 28. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on cellulose in corn stalklage[a]

Treatment	Days of Ensiling					Treatment mean[b]
	0	3	7	19	50	
	---------% of dry matter---------					
US[f]	30.97	30.61	30.92	30.93	31.11	30.91[d]
AS[f]	30.46	30.09	30.20	29.29	29.39[c]	29.89
AMS[f]	31.04	29.26	28.96[c]	28.91[c]	28.87[c]	29.41[c]
IS[f]	29.91	30.03	29.81	29.89	29.62	29.85
Time mean[e]	30.60	30.00	29.98	29.76	29.75	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant effect of treatment (P<.05).
[c]Significantly lower than control (P<.05).
[d]Standard error for any treatment combination mean is $\pm.464$.
[e]Standard error for any time mean is $\pm.518$.
Treatment x time interaction is not significant.
[f]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

TABLE 29. Effect of ammonia, ammonia-molasses, inoculum and time of ensiling on acid detergent lignin in corn stalklage[a]

Treatment	Days of Ensiling					Treatment mean[b]
	0	3	7	19	50	
	----------% of dry matter--------					
US[f]	12.83	13.30	12.73	12.58	12.60	12.81[d]
AS[f]	11.40	10.59[c]	10.26[c]	10.26[c]	9.01[c]	10.31[c]
AMS[f]	10.62[c]	10.49[c]	10.87[c]	9.99[c]	9.56[c]	10.30[c]
IS[f]	11.18	11.09[c]	11.13	11.22	11.22	11.17
Time mean[e]	11.51	11.37	11.24	11.01	10.60	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect (P<.01).
[c]Significantly lower than control (P<.05).
[d]Standard error for any treatment combination mean is $\pm$.749.
[e]Standard error for any time mean is $\pm$.837.
Treatment x time interaction is not significant.
[f]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

TABLE 30. Total ash of corn stalklage

Treatment[a]	Days of Ensiling					Treatment mean
	0	3	7	19	50	
	----------------%-----------------					
US[a]	13.32	11.88	10.90	16.72	13.54	13.27
AS[a]	14.83	12.76	13.70	13.20	13.85	13.67
AMS[a]	13.36	13.33	13.17	13.15	14.76	13.55
IS[a]	15.66	13.05	14.52	14.49	15.89	14.72
Time mean	14.29	12.75	13.07	14.39	14.51	

[a]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.

might be explained by the possible cleavage of acid-labile lignin-carbohydrate bonds (both benzyl ethers and esters) by the lower pH caused by the production of organic acids after anaerobic fermentation in the silo (Harkin, 1973).

TABLE 31. Effect of ammonia, ammonia-molasses, inoculum, and time of ensiling on in vitro organic matter digestibility[j] in corn stalklage[a]

Treatment	Days of Ensiling					Treatment
	0	3	7	19	50	mean[b]
	-------% of organic matter-------					
US[i]	43.15	42.16	41.35	44.61	45.05	43.45[g]
AS[i]	44.73	45.39	46.81[d]	47.12[d]	47.82[d]	46.38[d]
AMS[i]	40.69	42.63	45.38[d]	45.94	46.40	44.20
IS[i]	39.90[e]	39.28[e]	40.54	40.52[e]	44.76	40.98
Time mean[c]	42.12[h]	42.36	43.52	44.56[f]	46.02[f]	

[a]Values are averages from two experimental silos with two determinations per silo.
[b]Significant treatment effect ($P<.01$).
[c]Significant time effect ($P<.01$).
[d]Significantly higher than control ($P<.05$).
[e]Significantly lower than control ($P<.05$).
[f]Significantly higher than day 0 ($P<.05$).
[g]Standard error of any treatment combination mean is $\pm.539$.
[h]Standard error of any time mean is $\pm.603$.
Treatment x time interaction is not significant.
[i]Stalklages designated as follows: US, untreated; AS, treated with 2% ammonia; AMS, treated with 2% ammonia and 2% molasses; IS, treated with bacterial inoculum.
[j]Dry matter digestibility was corrected by organic matter as follows:
1) 100 - ash = OM
2) (DMD/OM) x 100 = OMD (%)

5. SUMMARY AND CONCLUSIONS

The value of anhydrous ammonia and molasses, as an additive to corn stalklage at ensiling was studied in two feeding trials with lactating dairy cows and in a fermentation study with experimental bag silos. When ammonia treated and ammonia-molasses treated corn stalklage were fed at 25% of the ration dry matter to lactating dairy cows, milk production was significantly ($P<.05$) depressed and tended to decline the dry matter intake. This is consistent with a previous experiment (Huber et al., 1980). Cows fed stalklage showed a slight increase in milk fat and a decrease in milk protein probably as a result of the increase of dietary fiber. At lower stalklage intake levels (10% or 20% of DM) cows fed stalklage treated with ammonia-molasses maintained milk yields with no depression in dry matter intake.

The present study is one of the first to characterize fermentation of corn stalklage at different times after ensiling. We conclude that corn stalklage underwent a normal fermentation pattern with lactic acid lower and pH higher than corn silage of similar dry matter. A decrease in pH to about 4.5 and increase in lactic acid to 3 to 5% of dry matter suggest that a substantial lactic acid-type of fermentation occurs in corn stalklage, which is enhanced with addition of ammonia and molasses. Microbial inoculum and ammonia alone had little effect on corn stalklage fermentation.

Total and soluble nitrogen were increased by ammoniation. This increase was proportional to the ammonia additions. Insoluble nitrogen was also increased by ammoniation as shown by others (Huber et al., 1979a,b) for corn silage, and by Saenger et al. (1982) and Oji (1979) for corn stalklage.

Ammoniation decreased neutral detergent fiber, acid detergent fiber and lignin (P<.01). Hemicellulose and cellulose were also reduced (P<.05) but cellulose was least affected. Similar conclusions were reached by Jackson (1977) in a review article. Ammoniation and a longer time of ensiling had a beneficial effect on in vitro dry matter digestibility.

In summary, the beneficial effect of ammoniation upon nutritive value of low quality forages if fairly clear. Energy derived from the digestion of structural carbohydrates makes an important contribution to the energy supply of the ruminant. Increases in the content of structural carbohydrates in forage are associated with declining digestibility and reduced intake. Lignin and hemicellulose restrict the digestion of cellulose; therefore, removing lignin or lignin linkages with polysacchardies by ammoniation increased the amount of plant cell-wall polysaccharides digested by bacterial cellulases. This finding has special relevance when low-quality roughages are fed in productive rations for ruminants.

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