which has been implicated with feed intake problems. Thus until more is known about intake and efficiency of utilization, definite recommendations as to moisture level and particle size can not be made. However, a recommendation which applies to all types of ensiled material can certainly be made. Rapid and continued exclusion of oxygen will aid in producing a better quality material regardless of moisture or particle size.

Fermentation and Digestion of Formaldehyde Treated Ensiled High Moisture Corn Grain

J. H. Thornton, F. N. Owens, D. E. Williams and E. C. Prigge

Story in Brief

Formaldehyde application of 0.2, 0.3, and 0.5 percent effectively reduced solubilization of ensiled ground high moisture corn protein. In general, these levels of formaldehyde increased intestinal, but decreased ruminal and total digestion of dry matter, starch, and nitrogen. Microbial protein synthesis per unit of dry matter digested in the rumen was unchanged, however, the total daily quantity of microbial nitrogen was reduced by all three formaldehyde treatment levels. In addition to decreased microbial nitrogen, formaldehyde treatments increased the supply of dietary nitrogen and increased total nitrogen to the true stomach or abomasum. Because corn protein quality is poorer than microbial protein, these formaldehyde treatments would reduce the quality of protein reaching the abomasum.

Formaldehyde treatment of ground high moisture corn grain offers potential for reducing protein solubilization, which may in turn alleviate feed intake problems. However, the depression in total dry matter and starch digestion observed at these levels of formaldehyde treatments indicate that improvement in feed intake could be offset by decreased nutrient utilization. Levels above 0.2 percent are useless. If lower levels of formaldehyde will prevent protein solubilization without decreasing total nutrient utilization, such

treatment may prove useful, but this remains to be demonstrated before its use could be recommended.

Introduction

Several economic factors have advanced the practice of harvesting grain at moisture levels too high for storage without drying or preserving. Of the methods for preserving high moisture grain, ensiling is both economical and acceptable for grain destined to be fed to livestock. One problem associated with feeding ensiled feeds, depressed feed consumption, appears related to the high levels of soluble nitrogen often formed in ensiled feedstuffs. Characterization of ensiled ground high moisture corn grain from large horizontal silos located in feedlots on the High Plains Region of Oklahoma and Kansas has revealed soluble nitrogen levels as high as 70 percent of total nitrogen (Thornton *et al.*, 1976).

Since formaldehyde insolubilizes protein, treating high moisture grains with formaldehyde could reduce soluble nitrogen levels, and in turn improve feed consumption. However, formaldehyde treatment would also inhibit digestion; thus benefits of such treatment would depend upon ruminal and total nitrogen and energy utilization.

The objectives of this study were to determine the effects of formaldehyde treatment of ensiled high moisture corn grain on: 1) solubilization of corn nitrogen during fermentation, 2) site and extent of dry matter, starch and nitrogen digestion, and nitrogen retention in steers, and 3) quantity of microbial protein synthesis.

Materials and Methods

A formyl solution, containing 40 percent formaldehyde, was applied to ground high moisture corn grain to supply 0.2, 0.3 and 0.5 percent formaldehyde on a wet basis. This material, plus untreated material, was packed in 55 gallon metal drums lined with plastic bags, sealed, and stored four months before feeding to allow fermentation and solubilization of the corn protein. The ensiled corn grain was fed to four ruminally and abomasally fistulated steers in an arrangement of treatments so that each steer received each treatment. The rations (Table 1) provided 11.6 percent crude protein, and were fed hourly with mechanized feeders at a level of 9.25 pounds ration dry matter daily. Polyethylene glycol (PEG) and chromic oxide were included as nondigestible markers and used for calculating ruminal digestion.

Following a ten-day adjustment period, total urine and feces were collected for four days followed by a two-day (two samples/day) rumen and abomasal sample collection. Ensiled corn was analyzed for dry matter, total, and soluble nitrogen. Rations were analyzed for dry matter, starch, total nitrogen, lignin, and PEG. Rumen samples were analyzed for ammonia.

Table 1. Ration composition, dry matter basis

Ingredient	Percent
Ensiled HMC Grain	80
Cottonseed hulls	12
Soybean meal	3.6
Dry corn	2.3
Urea	0.6
Calcium carbonate	.8
Dicalcium phosphate	.35
Trace mineral salt	.35
Potassium chloride	.25
Polyethylene glycol	1.25
Chromic oxide	0.5

Abomasal samples were analyzed for dry matter, starch, total nitrogen, ribonucleic acids (RNA), lignin, and PEG. Urine nitrogen and fecal dry matter, starch, and nitrogen analyses were made.

Results and Discussion

Soluble nitrogen was reduced from 16.2 percent to 4, 3, and 2 percent by 0.2, 0.3, and 0.5 percent formaldehyde treatments. The soluble nitrogen of the control corn (16.2 percent) was unusually low for material containing 27 percent moisture. Based upon samples from large horizontal silos (page 56 this publication) soluble nitrogen in the range of 30 to 50 percent is typical of ensiled ground corn of this moisture level. Whether silo size, packing, storage time or other factors caused this discrepancy is not certain. Nevertheless, all formaldehyde treatments reduced protein solubilization.

All three formaldehyde treatments reduced ruminal dry matter disappearance (lower line, Figure 1), and total dry matter disappearance (upper line). Dry matter disappearance postruminally (the difference between the two curves) was increased at a level of 0.3 percent formaldehyde.

Ruminal starch digestion (Figure 1) was significantly reduced by 0.2 and 0.3 percent formaldehyde, and post-ruminal digestion was increased by 0.3 percent formaldehyde. Approximately five times more starch was recovered in

Table 2. Ensiled ground high moisture corn grain analysis

Item	Formaldehyde level, percent			
	0	0.2	0.3	0.5
Dry matter, %	72.9	72.3	73.5	73.0
Crude protein, %	9.2	9.4	9.1	9.1
Sol. N, % of total	16.2	4.0	3.0	2.0

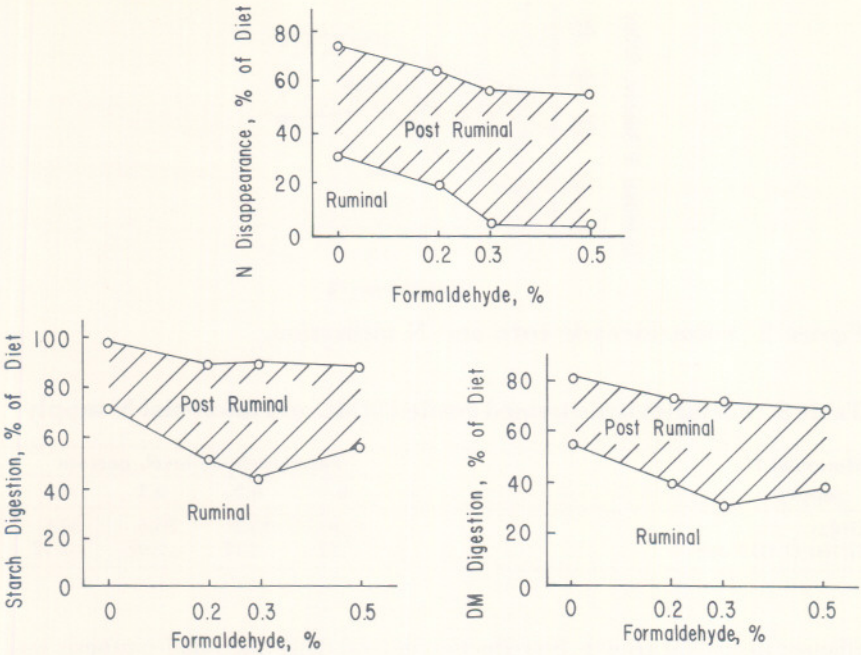

Figure 1. Effect of formaldehyde treated ensiled corn grain on disappearance of dry matter, starch and nitrogen at the abomasum (ruminal) and at feces (total) in steer metabolism studies.

feces from steers fed the formaldehyde treated grain (2.3, 11, 10, and 12 percent of dietary starch for 0, 0.2, 0.3, and .5 percent formaldehyde).

Nitrogen disappearance (Figure 1) was reduced ruminally by 0.3 percent and 0.5 percent formaldehyde, but unchanged post-ruminally. Total tract (upper line) nitrogen disappearance was less with all three formaldehyde treatments. The decreased nitrogen disappearance corresponds to the increased fecal losses (Figure 2). Urinary losses were less with 0.3 percent formaldehyde, however nitrogen retention did not differ greatly between treatments.

Estimates of microbial protein synthesis in the rumen (Table 3) were calculated from microbial protein concentration in abomasal digesta (calculated from RNA), and abomasal passage rate (calculated from PEG). Total microbial nitrogen reaching the abomasum daily was reduced from 43.6 to 25.6 gm./day by formaldehyde treatment. However, microbial nitrogen produced per 100 gm. dry matter digested in the rumen (1.97 to 2.17 gm./100 DM digested) were similar for all treatment levels. Rumen ammonia levels (13, 10, 8, and 7 mg./100 ml. rumen fluid) should have provided adequate nitrogen for

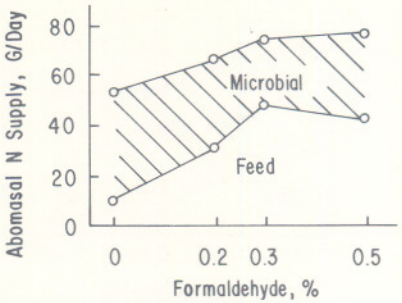

Figure 2. Formaldehyde corn and N utilization.

Table 3. Formaldehyde treated ensiled HMC and microbial N supply

Microbial N supply	Formaldehyde level, percent			
	0	0.2	0.3	0.5
G/day	43.6	35.3	25.6	33.6
G/100 G DM dig.	1.97	2.17	2.02	2.12

efficient microbial growth. So reduction in total daily microbial synthesis was a result of the depression in ruminal dry matter or starch digestion, not reduced efficiency of bacterial growth.

The protein needs of ruminant animals are met from two sources, microbial protein synthesized during rumen fermentation, and feed protein escaping rumen degradation. Figure 3 depicts the relative contributions of microbial nitrogen and total nitrogen at the abomasum. Reduction in microbial nitrogen supply was more than offset by increased bypass of dietary nitrogen following formaldehyde treatment. Unfortunately, such a trade-off would lower the quality of protein available to the animal, since for animals the value

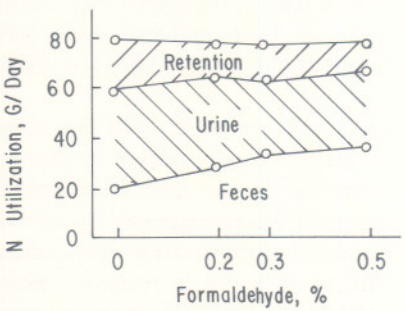

Figure 3. Formaldehyde corn and abomasal N supply.

of microbial protein is higher than corn protein. Consequently such formaldehyde treated corn would prove most useful in rations for animals where quality of protein is less important.

References:

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Ensiled Corn Grain Moisture Level and Supplement Protein Source Effects on Feed Intake

J. H. Thornton, F. N. Owens, D. E. Williams, R. P. Lake and R. W. Fent

Story in Brief

Ensiled ground high moisture corn of two moisture levels, 24 and 30 percent and containing 24 and 49 percent of nitrogen in a soluble form was fed with either urea or soybean meal supplements to sixteen 500 pound steers to estimate voluntary intake. Consumption of dry matter from the higher moisture - higher soluble nitrogen grain was 12 percent less than the drier - lower soluble nitrogen grain. Urea reduced intake only slightly (5 percent reduction). This study would indicate that: (1) urea can be satisfactorily fed with ensiled corn rations, and (2) grain intake may be increased by ensiling drier grain, although improvement in animal performance may not correspond to increased intake.

Introduction

Livestockmen feeding ensiled high moisture corn voice two concerns: 1) problems with feed intake, and 2) complications associated with non-protein nitrogen supplements. These two concerns may be inter-related in that a portion of ensiled corn protein is degraded to non-protein nitrogen during storage. Intake depressions in feedlots have been related to high moisture and