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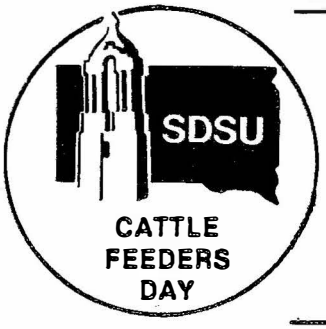

EFFECTS OF BACTERIAL INOCULATION OF CORN SILAGE ON FEEDLOT PERFORMANCE, NUTRIENT UTILIZATION, PRESERVATION AND AEROBIC FEEDBUNK LIFE

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CATTLE 84-2

Summary

A total of 168 steer calves of Angus and Angus x Hereford breeding averaging 581 lb were used in a 103-day feeding trial. Two silage and six protein supplement treatments with two replications per silage-supplement combination were used. Two 18 x 50 ft concrete stave silos were used to store the untreated silage and the silage inoculated with 100 billion colony forming units of Lactobacillus plantarum per ton of wet forage. The moisture content of forage at storage was 61%. The control supplement contained 8.2% crude protein, while the remaining supplements contained 31 to 34% crude protein. Average daily gain, dry matter consumption and feed required per unit gain for steers fed the untreated silage were 2.59 lb., 17.06 lb. and 659 lb., respectively. The values for steers fed the inoculated silage were 2.57 lb., 17.00 lb. and 665 lb.

Digestibility and nitrogen retention were measured in two 5-day total collection studies using six steers per silage treatment. Percent dry matter and crude protein digestibility for the untreated silage were 65.65 and 58.94 (trial I) and 67.74 and 58.77 (trial II). Values for the inoculated silage were 68.55 and 59.85 (trial I) and 71.14 and 63.34 (trial II). Nitrogen retained as a percentage of consumed was 36.0 and 35.1 and 34.2 and 43.5 for the untreated and treated silage in trials I and II, respectively.

Preservation of dry matter was about the same for untreated and inoculated silage. Recovery of feedable silage averaged about 88% for the two silages.

Results of determinations made on samples taken during the feeding period show a range of variability in pH, titratable acidity, ammonia nitrogen and lactic acid levels. An average of all samples showed only small differences in the various measurements for the untreated and the inoculated silage.

Aerobic (feed bunk life) studies gave an inconsistent dry matter loss response relative to Lactobacillus plantarum inoculation of corn silage through 15 days of exposure to air. Losses at 15 days ranged from 25 to 34% of the initial dry

matter. Temperatures recorded for the two experimental silages were similar in trial I. However, in trial II the peak response was quite different. Peak temperatures of 120 to 126 F were observed at 4 to 5 days exposure to air with both the untreated or inoculated silage.

Introduction

The making of quality silage is largely dependent upon the fermentation process as carried out by microorganisms present in the forage during ensiling. Research has shown that the number of these organisms can vary considerably in the corn forage. Inoculation of the forage with microorganisms favorable to fermentation such as Lactobacillus species is a means of reducing variation due to kind and number of fermentative organisms. Previous research at SDSU has shown there is very little difference in feedable corn silage quality with microbial inoculation, but that the fermentation process can be accelerated as indicated by higher lactic and organic acid formation. Lower fermentation temperatures were also observed with inoculated silage than untreated silage. The purpose of this experiment was to determine if a highly concentrated silage inoculant containing Lactobacillus plantarum[a] would improve silage quality and preservation when compared to untreated silage. Response to inoculation was compared with uninoculated silage in terms of feedlot performance of beef cattle, nutrient digestibility and nitrogen retention by steers, chemical quality and aerobic stability.

Procedures

Corn forage from the 1982 corn crop was harvested at approximately 57% moisture with a conventional forage chopper. Loads of forage were stored alternately between two concrete stave silos (18 x 50 ft). The blower for one silo was equipped with a sprinkler head attached to a flow meter and connected to a 55-gallon steel barrel containing the liquid silage inoculant. The solution was prepared by dissolving 1 lb of the inoculant in 45 gallons of nonchlorinated water. The flow rate was adjusted to dispense 1 gallon of solution per ton of forage. This was equivalent to 10 grams (10 billion colony-forming units per gram) of product per ton. Each silo was filled rapidly to the level of the unloader and then leveled. A sample was collected from each load of chopped forage and frozen for chemical analysis.

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[a] Biomax, SI, Chr. Hansen's Laboratory, Inc., Milwaukee, WI.

Feeding Trial

A total of 168 head of Angus and Angus x Hereford steers averaging 581 lb were used in the study. The steers were allotted to 24 pens with 7 steers per pen. A shrunk weight was taken following an 18-hour stand without feed and water at the beginning of the test period and at each 28 day interval during the 103-day study.

The two pens of cattle fed each silage treatment received one of six protein supplements. The supplement portion of this study was part of a research project dealing with sources of protein for beef cattle and sheep (see CATTLE 84-4). A control supplement (designated A) without a high protein ingredient contained 8.2% crude protein. The five remaining supplements (designated B, C, D, E and F) included ingredients rich in protein or protein equivalent and ranged from 31 to 34% crude protein. All supplements were fortified with macro and micro minerals and vitamin A. Lasalocid sodium (Bovatec-68[a]) was added to the diets to provide 30 grams of drug per ton of dry diet.

The cattle were fed once a day and the silage and supplement were mixed on an individual pen basis. The cattle were fed according to appetite and diet composition was maintained at 90% dry matter as silage and 10% as supplement. Samples of silage were collected twice weekly and supplements once a week. A moisture determination was made on all samples so that the silage and supplement could be maintained at the desired ratio.

Digestion-Nitrogen Balance Trials

Two total collection (5-day) digestion and nitrogen balance trials were conducted with 12 steers averaging 539 lb (trial I) and 618 lb (trial II). The corn silage for these studies was from the silos used in the feeding trial. Digestion trial I utilized silage from the upper 1/3 of the silo, while digestion trial II utilized silage from the lower 1/3 of the silo. Six steers were allotted to each silage treatment and placed in metabolism crates for the study. A 7-day adjustment period was allowed for the steers to adapt to the conditions of the metabolism crate. During the 5-day collection period that followed, the steers were fed twice daily. Silage was fed to appetite and a protein supplement was top-dressed on the silage at a rate of 1.14 lb per head daily. The supplement consisted of 58% soybean meal (44% protein), 28.7% ground corn, 2.0% ground limestone, 6.3% dicalcium phosphate, 5.0% trace mineral salt and vitamin A (10,000 IU/lb). Collection and handling of feed refusals, feces and urine followed conventional procedures. Digestion coefficients for dry matter, crude protein and organic matter were calculated. Fecal and urinary nitrogen losses were determined and retention of nitrogen available for productive purposes reported as a percentage of nitrogen consumed.

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[a] Hoffman-LaRoche Inc., Nutley, NJ

TABLE 1. UNTREATED AND MICROBIAL-INOCULATED CORN SILAGE FOR FEEDLOT STEERS
(March 1 to June 12, 1983, 103 Days)

	Supplement Groups						
	A	B	C	D	E	F	Average
Untreated Silage							
No. animals	14	14	14	14	14	14	84
Initial wt, lb	583.0	582.5	578.5	584.0	580.0	578.5	581.1
Final wt, lb	810.5	855.0	835.0	853.5	867.0	866.0	847.8
Avg daily gain, lb	2.21	2.65	2.49	2.62	2.79	2.79	2.59
Avg daily ration, lb[a]	15.62	17.60	17.10	17.22	17.30	17.52	17.06
Feed/100 lb gain, lb[a]	707	664	687	657	620	628	659
Microbial-Inoculated Silage[b]							
No. animals	14	13[c]	14	14	14	14	83
Initial wt, lb	580.5	579.5	582.5	579.5	583.0	580.0	580.8
Final wt, lb	803.5	852.4	852.5	865.0	856.0	840.5	845.0
Avg daily gain, lb	2.17	2.65	2.62	2.77	2.65	2.53	2.57
Avg daily ration, lb[a]	15.75	17.18	17.38	17.08	17.46	17.17	17.00
Feed/100 lb gain, lb[a]	726	648	663	617	659	676	665

[a] Dry matter basis.

[b] *Lactobacillus plantarum* fermentation product applied at 10 g per ton of forage.

[c] One steer died of causes unrelated to either silage or supplement treatments.

Preservation, Chemical Characteristics and Aerobic Stability Studies

The preservation of corn forage/silage was calculated on total pounds ensiled versus total pounds removed based on dry matter content of the samples of forage going into the silo and samples of silage removed. The surface layer of spoiled or waste material from each silo was removed, weighed and adjusted to a dry basis.

A routine chemical quality profile was completed in the laboratory on all silage samples. Moisture content of the forage going into the silo was determined by drying in a forced-air oven. The toluene distillation method with acid correction was used to determine the dry matter of the silage removed from the silo. A water extract was prepared from ground silage and analyzed for pH, titratable acidity, ammonia nitrogen and lactic acid.

Two aerobic feedbunk stability studies were conducted utilizing each silage. The procedure was to place 6.6 lb of silage in plastic pans exposed to the atmosphere at temperatures of 24 to 26 C for 15 days. Three replication samples per silage treatment were removed at 0, 3, 6, 9, 12 and 15 days. The replicates were combined and dry matter content determined by toluene distillation procedures. Temperature was continuously monitored by thermocouples inserted into each pan of silage and connected to a chart recorder.

Results and Discussion

Feeding Trial

The results of the 103-day feeding trial summarized by supplemental protein treatments are presented in table 1. Average daily gains were low for both silage treatments and supplement group A which received no additional protein. Groups B through F responded to supplementation, but there was no consistent trend in gains between silage treatments and no apparent interaction of silage treatment and supplement group. Overall daily gains averaged 2.59 lb per steer for steers fed untreated corn silage and 2.57 lb for steers fed the inoculated silage. Dry matter intake averaged about 17 lb per steer for both silage treatments. Feed requirements per hundred pounds of gain were about the same, 659 vs 665 lb. for untreated and treated silage, respectively.

Digestion-Nitrogen Balance Trials

Results of digestion and nitrogen balance studies with beef steers are presented in table 2. In each trial digestibility of dry matter crude protein and organic matter was higher with the inoculated silage than with untreated silage. Digestibility appeared to be slightly higher for silage from the lower third of the silo (trial II) than from the upper third of the silo (trial I).

Nitrogen balance data for trial I showed no important differences in fecal, urinary or retained nitrogen between the silage treatments. However, in trial II, nitrogen intake was slightly higher (18 g per day) for steers fed the inoculated silage than for steers fed the untreated silage. Nitrogen retained for productive purposes as a percentage of nitrogen consumed was higher, 43.5% vs 35.1, for the inoculated corn silage than for the untreated silage.

The improvement in nutrient digestibility observed here did not parallel the performance results obtained in the feeding trial. Reasons for this discrepancy are not apparent.

TABLE 2. DIGESTIBILITY AND NITROGEN UTILIZATION WITH STEERS FED UNTREATED AND MICROBIAL-INOCULATED CORN SILAGE

	Trial I		Trial II	
	Untreated	Inoculated[a]	Untreated	Inoculated[a]
No. of animals	6	6	6	6
Avg weight, lb	519.5	558.0	625.7	609.3
Dry matter intake, lb	12.7	13.1	13.5	15.2
Digestibility, %				
Dry matter	65.65	68.55	67.74	71.14
Crude protein	58.94	59.85	58.77	63.64
Organic matter	66.95	70.07	69.02	72.35
Nitrogen (N) balance, g/day				
Nitrogen intake	92.0	90.7	95.2	112.9
Fecal N	37.1	37.2	39.3	41.1
Urinary N	21.8	22.5	22.5	22.7
N retained	33.1	31.0	33.4	49.1
Retained of consumed, %	36.0	34.2	35.1	43.5

[a] *Lactobacillus plantarum* fermentation product applied at 10 g per ton of wet forage.

Preservation, Chemical Characteristics and Aerobic Stability Studies

Table 3 shows dry matter recovery and dry matter loss during storage of the two silages. Average dry matter content of forage at ensiling and silage at feeding was essentially the same for each silage. The recovery of dry matter for feeding was 88.31% for untreated silage and 88.14% for the microbial-inoculated silage. Losses of dry matter as spoilage and as nonrecoverable dry matter were also about the same for the two silages.

TABLE 3. DRY MATTER (DM) RECOVERY OF UNTREATED AND MICROBIAL-INOCULATED CORN SILAGE

Item	Untreated	Inoculated[a]
Avg forage DM, %	39.40	39.64
Total dry matter ensiled, lb	166,969	169,245
Avg silage DM, %	42.23	43.07
Dry matter available for feeding	147,450	149,172
Percent of ensiled, %	88.31	88.14
Spoilage losses, lb	457	533
Percent of ensiled, %	0.27	0.31
Non recoverable losses, lb	19,062	19,540
Percent of ensiled, %	11.42	11.55

[a] *Lactobacillus plantarum* fermentation product applied at 10 g/ton wet forage.

The results of chemical quality analyses of samples collected after the silos were opened for feeding (135 days after ensiling) are presented in table 4. The rather wide range in values for the different measurements appeared to be due to the variability of samples taken from the upper third of the silo. Average values show very little effect of silage treatment on any of the quality parameters. The variations observed in sampling this quantity of silage are of the magnitude that would be expected with a tower-type silo structure.

The results of two aerobic stability studies are presented in table 5. Dry matter losses on days 3 and 6 were higher for the treated silage in trial I but were lower for the same silage treatment in trial II. Losses after 6 days varied among trials and treatments. In trial I after 15 days of exposure to air, treated silage lost 28% of the original dry matter as compared to 25% for untreated silage. In trial II, dry matter losses were 32% for treated silage and 34% for untreated silage. It is unlikely that silage placed in the feed bunk would be exposed to air for this length of time before being consumed. Even 3 days

TABLE 4. CHEMICAL PROFILES OF CORN SILAGE FOR FEEDING AS AFFECTED BY MICROBIAL INOCULATION OF THE FORAGE AT STORAGE

	Untreated silage		Inoculated silage[a]	
	Range	Average	Range	Average
No. of samples	--	19	--	20
Dry matter,[b] %	37.74 -- 55.18	43.07	37.11 -- 50.10	42.23
pH	3.57 -- 4.47	3.91	3.67 -- 4.50	3.85
Titratable acidity[c]	4.63 -- 14.60	9.52	5.54 -- 12.71	10.06
Crude protein[d]	7.27 -- 9.58	8.45	6.69 -- 10.18	8.27
Ammonia nitrogen[e]	0.040 -- 0.304	0.127	0.074 -- 0.390	0.160
Lactic acid[d]	1.68 -- 7.48	4.40	2.20 -- 6.03	4.29

a
Lactobacillus plantarum fermentation product applied at 10 g/ton wet forage.
b
Toluene distillation with acid correction.
c
Milliliters of .1N KOH to bring pH to 7.
d
Percent of dry matter.
e
Percent of total nitrogen.

TABLE 5. DRY MATTER LOSSES OF UNTREATED AND TREATED[a] SILAGE DURING EXPOSURE TO AIR

	Dry matter loss, %[b]			
	Trial 1		Trial 2	
Day	Untreated	Treated	Untreated	Treated
3	7.91	10.69	19.52	8.53
6	10.94	18.31	26.50	21.91
9	17.09	24.14	28.89	28.31
12	22.02	21.57	33.04	31.49
15	25.12	28.41	33.72	31.56

a
Lactobacillus plantarum fermentation product applied at 10 g/ton of wet forage.
b
Dry matter determined by toluene distillation. Loss for each day is based on the average difference of triplicate samples from day 0.

would be longer than silage should remain in the bunk. Nevertheless, when stored silage is prepared for feeding the effects of exposure to air may influence the dry matter available for feeding.

The temperature profiles of untreated and inoculated silage exposed to the atmosphere in the stability studies are presented in figures 1 and 2. The curves shown in the graphs are based upon the average temperature of three replications of hourly intervals. Ambient temperature was rather consistent during the study at 25 C (77 F).

In figure 1 (trial I), two peaks are shown for each silage. With untreated silage these occurred at 50 hours (2 days) and 125 hours (5 days) and temperatures of 37 C (98 F) and 49 C (120 F), respectively. Peaks for the inoculated silage were similar and appeared at 40 hours (1.7 days) and 110 hours (4.6 days) and correspond to temperatures of 38 C (100 F) and 50 C (122 F), respectively.

Results of aerobic stability trial II are shown in figure 2. Upon exposure to the atmosphere, temperatures in untreated silage increased rather steadily, reaching a peak at 72 hours (3 days) and a temperature of 45 C (113 F). Temperatures declined steadily and equilibrated with room temperature at 135 hours (5.6 days). The response of treated silage to the atmosphere differed greatly from untreated silage. Several high temperatures were observed. They occurred at 38 hours (1.6 days) with 35 C (95 F); 53 hours (2.2 days) with 38 C (100 F) and 96 hours (4 days) with 52 C (126 F).

The temperature phenomena observed in these studies is not fully understood. Heat production appears to be associated with aerobic growth of yeasts, molds and other bacteria and with the degradation of dry matter under these conditions. Further research is planned to clarify these results.

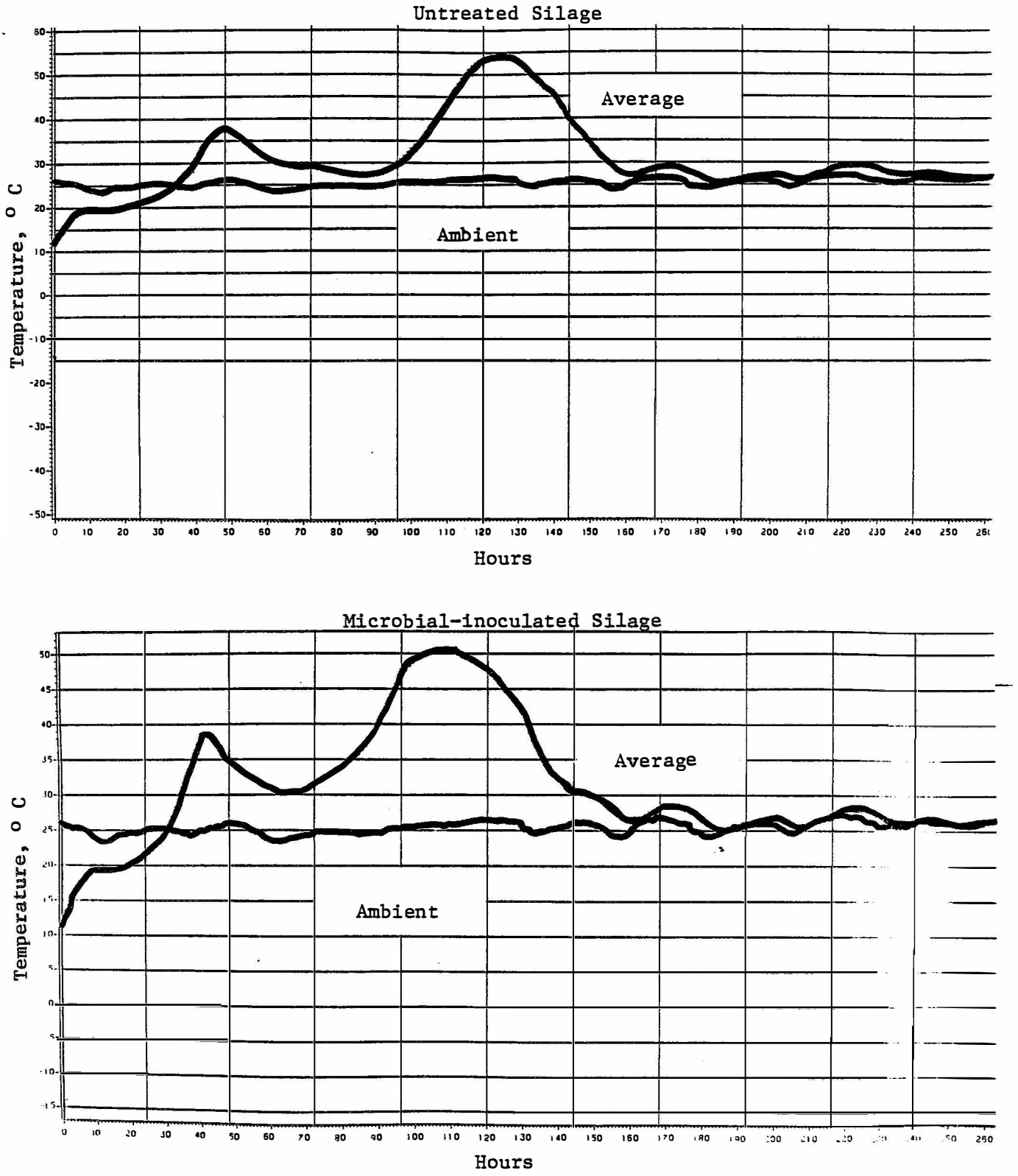

Figure 1. Aerobic stability temperature profile of untreated and inoculated silage (Trial I).

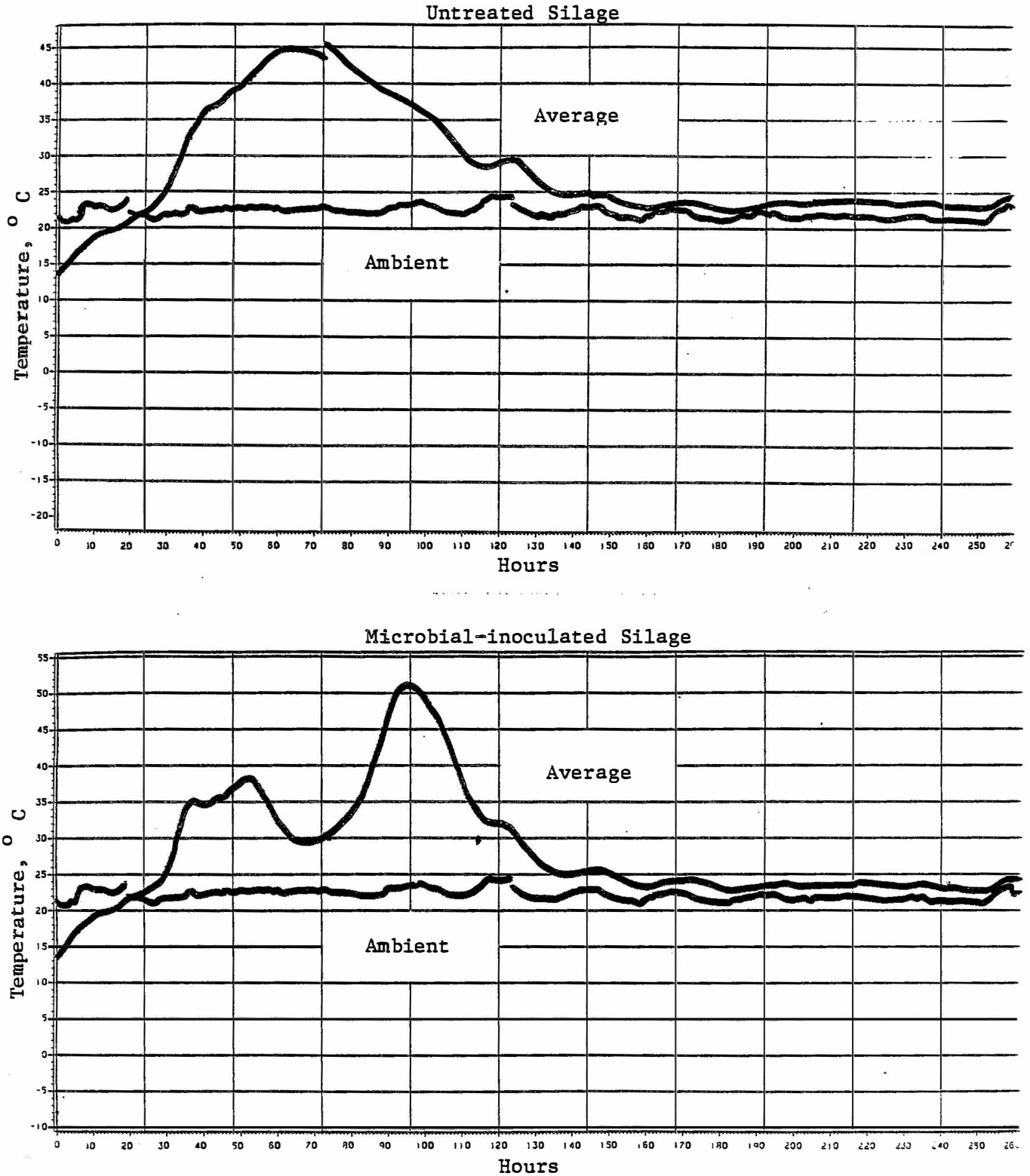

Figure 2. Aerobic stability temperature profile of untreated and inoculated silage (Trial II).