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Abstract

Three trials were conducted to compare silage and hay yields and feeding values of winter cereal foraged harvested in the boot and dough stages of maturity. Included were triticale; common rye; Kanby barley; and Centurk, Arkan, and Bounty 205 wheats. As expected, forage dry matter (DM) yields were higher at the dough stage then boot stage, and silage yields tended to be higher than those for hay. In Trials 2 and 3 (1986-87), barley and rye forage yields were lower than wheat yields. In all three years, wet weather conditions made hay-making difficult. In Trial 1, cattle performance from dough stage wheat (Centurk) and triticale, both silages and hays, was very poor, with daily gains from .9 to 1.2 lb and DM intakes below 2.0% of body weight. Triticale and Centurk wheat forages were high in fiber, and their dough silages had low intakes and digestibilities. Digestion trial results indicated that Arkan and Bounty wheats, Kanby barley, and rye generally had higher feeding values at the boot stage than at the dough stage, and that how well the silage or hay was preserved was a major factor influencing final feeding values.

Keywords

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Yield, Chemical Composition, and Feeding Value of Winter Cereal Silages and Hays: A 3 Year Study[1]

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Summary

Three trials were conducted to compare silage and hay yields and feeding values of winter cereal forages harvested in the boot and dough stages of maturity. Included were triticale; common rye; Kanby barley; and Centurk, Arkan, and Bounty 205 wheats. As expected, forage dry matter (DM) yields were higher at the dough stage than boot stage, and silage yields tended to be higher than those for hay. In Trials 1 (1983-84) and 2 (1985-86), wheat and triticale had similar forage yields, and in Trials 2 and 3 (1986-87), barley and rye forage yields were lower than wheat yields. In all three years, wet weather conditions made hay-making difficult.

In Trial 1, cattle performance from dough stage wheat (Centurk) and triticale, both silages and hays, was very poor, with daily gains from .9 to 1.2 lb and DM intakes below 2.0% of body weight. Triticale and Centurk wheat forages were high in fiber, and their dough silages had low intakes and digestibilities. Digestion trial results indicated that Arkan and Bounty wheats, Kanby barley, and rye generally had higher feeding values at the boot stage than at the dough stage, and that how well the silage or hay was preserved was a major factor influencing final feeding values.

Introduction

In the 1970's, our research showed the potential and possible limitations of whole-plant wheat, barley, and oat silages for growing cattle (KAES, Bulletin 613R). In the fall of 1983, a series of studies was begun to further document the effect of stage of maturity on yield and nutritive value of winter cereals. At that point,we introduced triticale and common rye into the comparisons, and included both silage and hay as methods of forage conservation.

Experimental Procedures

Trial 1: 1983-84. Triticale (Jenkins) and hard red winter wheat (Centurk 78) were sown in the fall of 1983 (approximately 15 acres per crop). Each crop was harvested from a single plot for both silage and hay in the boot and soft-dough stages of maturity, except that rainy weather prevented the successful baling of the triticale boot hay.

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[1]Triticale for Trials 1 and 2, and partial financial assistance were provided by Arco Seed Company, Woodland, California.

[2]Visiting researcher from the Agriculture University, Beijing, Peoples Republic of China.

The boot forages were field-wilted to about 65 to 70% moisture prior to ensiling; the soft-dough forages were direct-cut at about 65% moisture. All silages were made in 55-gallon capacity, plastic lined, pilot silos; the dough silages were also made in 10 x 50 ft concrete stave silos and in large round bales (balage: 1,200 lb avg. wt.). All hays were baled in conventional (60 to 80 lb) and large round (700 to 800 lb) bales, except the triticale hay, which was made in round bales only. Dry matter yield was determined for each crop at each harvest.

The control, whole-plant, irrigated corn (Pioneer 3183), was harvested in the early-dent stage and contained about 67% moisture. It was ensiled in a 10 x 50 ft concrete stave silo.

The stave silos were opened on November 15, 1984 and emptied at a uniform rate over a 13-week period. Samples of silages and hay were taken twice weekly and all bale silages were core-sampled prior to feeding.

Twenty-four crossbred wether lambs (avg. wt., 101 lb) were allotted by weight to the following six hays and silages in a two-period, voluntary intake and digestion study: wheat boot stage hay (1) and silage (2); wheat dough stage hay (3) and silage (4); triticale boot stage silage (5); and triticale dough stage silage (6). The wheat hays were in conventional bales and were ground prior to feeding. The silages were from the pilot silos. There were four lambs per forage in each period, which consisted of 10-day forage adaptation, 5-day voluntary intake, 2-day forage intake adjustment, and 7-day fecal collection phases. During the intake adjustment and collection phases, all lamb received 90% of their previously established ad libitum intake. At the end of period one, all lambs were weighed and randomly reassigned to the six forages. All rations were 82.5% of the appropriate forage, 2.5% cane molasses, and 15% supplement on a dry matter (DM) basis. Liquid molasses was mixed with the hays prior to feeding and dry molasses was added to the supplements for the silage rations. All rations were formulated to 11.5% crude protein (CP); .5% calcium; .35 phosphorus; and supplied equal amounts of trace minerals, vitamins (A, D, and E), and aureomycin (20 mg/per/lamb day).

The stave silo wheat and triticale dough silages, large round bale wheat and triticale dough hays, balage, and corn silage were each fed to steer and heifer calves (472 lb initial wt.) in four pens for four calves per forage. The 84-day growing trial began on November 16, 1984. Silages and hays were full-fed and all calves received 2.0 lb of supplement daily. Rations were formulated to provide 12.25% crude protein (DM basis); 200 mg of Rumensin® per calf daily; and required amounts of calcium, phosphorus, and vitanins A, D, and E. Supplements were top-dressed and partially mixed with the silage or hay in the bunk. Supplement for the calves fed balage was premixed twice daily with 8.0 lb of wheat silage per pen prior to feeding.

Balage was fed free-choice and the bales were cut in half before they were placed in the feed bunks. The hays were stored outside and tub-ground prior to feeding. Feed offered was recorded daily for each pen, and the quantity of forage fed was adjusted daily to assure that fresh feed was always available. Feed not consumed was removed, weighed, and discarded every 7 days or as necessary. All calves were weighed individually on 2 consecutive days at the start and at the end of the trial. Intermediate weights were taken at 28 and 56 days. Because the balage was in short supply, it was fed for the first 56 days only.

Trial 2: 1985-86. Winter cereals compared were hard red winter wheats (Arkan and Cargill Bounty 205), Kanby barley, and triticale (Trical®). The cereals were all seeded in three replicated plots, which strengthened the yield data over that collected in Trial 1. Silages and hays were harvested by procedures similar to those in Trial 1, but rainy weather in May made baling the boot stage hays impossible and harvesting of the silages at the intended DM content (30 to 35%) difficult. None of the dough stage hays received more than .25 inches of rainfall between cutting and baling.

Thirty-six wether lambs were allotted by weight to the 12 forages in a two-period, voluntary intake and digestion study. All rations were 90% forage and 10% supplement on a DM basis and formulated to a minimum of 11% crude protein; all supplied NRC required amounts of minerals and vitamins. All other procedures were similar to those described in the digestion study in Trial 1.

Trial 3: 1986-87. Winter cereals compared were Arkan and Bounty 205 wheats, Kanby barley, and common rye. The cereals were all seeded in four replicated plots. Silages and hays were harvested by procedures similar to those in Trial 1, but rainy weather in late May and early June made baling the Arkan and Kanby hays impossible. Forty-two wether lambs were used in a two-period, voluntary intake and digestion study with the 14 forages fed in 90% forage and 10% supplement rations. All other procedures were similar to those described in the digestion study in Trial 1.

Results and Discussion

Trial 1: Cattle Growing Study. Performance by cattle fed the six rations in Trial 1 are presented in Table 46.1. All five winter cereals resulted in very poor performance throughout the feeding period. Cattle fed corn silage made excellent gains overall (2.29 lb/day) and significantly out-performed those fed wheat or triticale. In general, there was little difference in feeding value among the five winter cereals. Wheat silage and balage supported similar gains for the first 56 days. The poorer efficiency of cattle fed balage reflects higher feed refusals, since only 71% of each bale was consumed, on average. Overall DM intakes were extremely low, ranging from 1.75% of body wt. for cattle fed wheat and triticale silages to 2.0% for those fed wheat hay.

Chemical analyses of the six silages and hays fed in the cattle study are shown in Table 46.2. All five winter cereals had very high acid detergent fiber (ADF) contents and low crude protein (CP) values. The triticale had very poor grain development, and the kernels never reached full size. As a result, the triticale might have been a few days beyond the "dough stage" when swathed for silage and hay. The wheat kernels developed normally and the crop did not appear to be past the mid-dough stage when swathed. These poor results, particularly with the Centurk wheat, were completely unexpected, since our research in the 1970's indicated much higher feeding values for dough silages (KAES, Bulletin 613R).

Trial 1: Lamb Digestion Study. Summarized in Table 46.3 are results of the digestion study in Trial 1. Boot stage silages and hays had higher ($P<.05$) voluntary intakes (about 24%) and higher ($P<.05$) digestibility for all nutrients (except protein) when compared with the dough stage forages. Triticale forages yielded feeding values similar to wheat, and silage had feeding values similar to hay. Forage DM yields for the boot stage silages were somewhat lower than expected for both triticale and wheat. Yields for dough stage silages were acceptable; the equivalent of 9 to 10 tons of 67% moisture silage per acre.

All four silages in the digestion study were well preserved and had lactic and acetic acid, ethanol, and ammonia-nitrogen contents within a normal range. The wheat hays had slightly lower CP and higher ADF values than their silage counterparts.

Trial 2. Summarized in Table 46.4. are results from Trial 2. Forage DM yield for all four cereals was lower at the boot than dough stage, and at the dough stage, yields were higher for the silages than for hays. Triticale had the highest boot stage yield; and barley had the lowest. Arkan and Bounty 205 wheats had the highest dough stage yields.

In the digestion study, boot stage triticale and Bounty 205 silages supported higher intakes than dough silages, and intakes of dough stage hays were lower than those of dough silages for all four cereals. The DM digestibilities for triticale and the two wheats were highest for the boot stage silages, but DM digestibility of the barley silages was not affected by stage of maturity. Dough stage hays tended to have lower DM and CP digestibilities than their silage counterparts, except for Arkan. Triticale consistently had lower DM, CP, and NDF digestibilities than the two wheats or barley.

As expected, all dough stage silages and hays had lower CP values than boot stage silages. Triticale forages had the highest ADF content, and Arkan wheat and barley forages had slightly lower ADF values than Bounty 205. Silage fermentation results showed that the dough stage silages were more efficiently preserved than their boot stage counterparts, with dough silages having lower pH, ethanol, and ammonia-nitrogen values and higher lactic acid contents. All four boot stage silages had a high pH (ranging from 4.7 to 5.5) and a very high ammonia-nitrogen content (ranging from 22 to 38% of the total nitrogen).

Trial 3. Summarized in Table 46.5 are results from Trial 3. Forage DM yield for all four cereals was lower at the boot stage vs. the dough, and boot stage hay had a lower yield than boot stage silage, except for the barley. Rye and Bounty 205 dough stage silages had higher DM yields than their counterpart hays. Bounty 205 had the highest DM yields at both maturities; rye had the lowest yields.

In the digestion study, lambs fed rye boot stage hay had a DM intake that was 38 to 60% higher than those fed the other boot hays, but intake of the rye dough stage hay was 32% lower then that of the Bounty 205 dough hay. The DM digestibilities did not show a consistent trend when compared by winter cereal, stage of maturity, or method of harvest. Digestibilities of the three barley forages were similar; digestibilities of the boot and dough silages of Bounty 205 were higher than those of the two hays. Arkan boot silage digestibility was higher than its boot hay or dough silage. The rye boot hay had the highest digestibility of the 14 forages, but the rye dough hay and silages had the lowest digestibilities.

Chemical analyses of the 14 forages showed that all boot stage silages and hays had higher CP values than the dough stage material. The ADF and NDF values for rye boot forage were lower than for rye dough forages, but fiber values for the other forages were not affected by maturity or method of harvest. Preliminary silage fermentation results indicate that all silages were well preserved, except the barley boot silage, which had extensive clostridial activity as evidenced by a pH of 7.5. Both DM intake and digestibility of the barley boot silage were lower when compared to the other three boot silages.

Table 46.1. Performance of Steers and Heifers Fed the Six Silage and Hay Rations in Trial 1 (56 Days: November 16, 1984 to January 11, 1985 and 84 Days: to February 8, 1985)

	Corn	Triticale		Wheat		
Item	silage	Hay	Silage	Hay	Silage	Balage
No. of Cattle	16	16	16	16	16	16
Initial Wt., lb	471	473	473	469	472	476
	0 to 56 Days					
56-day Wt., lb	609	525	543	552	543	535
Avg. Daily Gain, lb	2.46^{a}	$.93^{c}$	1.25^{bc}	1.48^{b}	1.27^{bc}	1.04^{c}
Daily Feed Intake, lb[1]	13.86^{a}	10.29^{bc}	9.79^{c}	11.80^{b}	10.28^{bc}	10.31^{bc}
Silage	12.06	8.49	7.99	10.00	8.48	8.51[2]
Supplement	1.80	1.80	1.80	1.80	1.80	1.80
Feed/lb of Gain, lb[1]	5.71^{a}	11.43^{c}	7.78^{b}	7.85^{b}	8.14^{b}	10.18^{c}
	0 to 84 Days					
84-day Wt., lb	664	548	559	571	555	---
Avg. Daily Gain, lb	2.29^{a}	$.89^{c}$	1.03^{bc}	1.21^{b}	1.00^{bc}	---
Daily Feed Intake, lb[1]	14.67^{a}	10.89^{c}	10.51^{c}	12.44^{b}	10.47^{bc}	---
Silage	12.87	9.09	8.79	10.64	8.67	---
Supplement	1.80	1.80	1.80	1.80	1.80	---
Feed/lb of Gain, lb[1]	6.43	12.23^{c}	10.27^{b}	10.30^{b}	10.53^{b}	---

[abc]Values in the same row with different superscripts differ ($P<.05$).
[1]100% dry matter basis.
[2]The 8.51 lb of silage DM intake included 6.45 lb of balage and 2.06 lb of wheat silage from the stave silo.

Table 46.2. Harvest Date, Yield, and Chemical Composition of the 12 Triticale, Wheat, and Corn Silages and Hays in Trial 1

	Lamb Digestion Study						Cattle Growing Study					
	Triticale Silage		Wheat Silage		Wheat Hay		Triticale		Wheat		Wheat	Corn
Item	Boot	Dough	Boot	Dough	Boot	Dough	Silage	Hay	Silage	Hay	Balage	Silage
Harvest Date, 1984	May 24	June 18	May 21	June 12	May 24	June 14	June 19	June 22	June 12	June 14	June 12	Aug 25
Dry Matter Yield, Ton/Acres	2.12	3.33	2.34	2.91	2.24	2.83	---	---	---	---	---	5.95
Dry Matter, %	38.4	42.1	37.0	37.4	91.5	91.3	38.6	86.2	38.1	87.3	43.2	32.0
pH	4.76	4.20	4.75	3.99	---	---	4.40	---	4.12	---	---	3.73
	-----% of the Forage DM-----											
Lactic Acid	10.1	5.6	6.8	5.2	---	---	4.4	---	4.3	---	3.9	6.5
Acetic Acid	1.7	1.6	2.3	1.7	---	---	3.1	---	2.3	---	2.4	2.9
Ethanol	.83	.60	.93	.98	---	---	.95	---	.92	---	1.02	1.53
Ammonia-N	.30	.14	.28	.14	---	---	.23	---	.22	---	.28	.11
Crude Protein	11.4	8.3	11.4	7.6	11.0	6.2	7.5	7.8	7.4	8.3	7.9	8.1
Neutral Detergent Fiber	64.2	68.3	58.9	63.6	68.2	69.8	67.5	72.7	62.2	72.4	63.8	40.4
Acid Detergent Fiber	40.8	45.2	39.0	41.6	43.6	46.0	46.0	52.0	41.0	46.8	41.6	22.3
Lignin	4.5	6.6	4.7	6.5	5.5	6.4	6.8	7.2	6.3	6.8	6.5	4.9
Ash	10.2	7.5	9.8	7.5	10.2	7.6	7.9	9.5	7.4	8.5	7.2	5.3

Table 46.3. Voluntary Intake and Nutrient Digestibilities of the Six Triticale and Wheat Forage Rations in Trial 1

Forage	VI[1]	Digestibility, %[1]			
	lb DM/Day	DM	CP	ADF	NDF
Triticale Silages					
Boot	2.49^{a}	63^{a}	70^{a}	59^{ab}	60^{a}
Dough	1.74^{bc}	56^{c}	69^{a}	46^{c}	42^{b}
Wheat Silages					
Boot	1.83^{bc}	65^{a}	68^{ab}	59^{cd}	56^{ab}
Dough	2.03^{b}	56^{c}	64^{b}	42^{c}	40^{c}
Wheat Hays					
Boot	2.38^{a}	62^{ab}	34^{c}	56^{a}	64^{a}
Dough	1.56^{c}	59^{bc}	64^{b}	56^{b}	50^{b}

[1] VI = Voluntary intake, DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

[abcd] Values in the same column with different superscripts differ ($P<.05$).

Table 46.4. Harvest Date, Forage and Grain Yields, Chemical Composition, and Voluntary Intake and Digestibility of the Triticale, Wheat, and Barley Forages in Trial 2

Forage[1]	Harvest Date	Forage DM Yield	Chemical Composition[2]								VI[2]	Digestibility, %			
			DM	LA	NH_3-N	ETOH	CP	NDF	ADF	pH	lb DM/Day	DM	CP	NDF	ADF
	1986	Tons/ Acre	%	---------% of the DM------------											
Triticale															
Boot Silage	May 22	2.84	25.1	2.1	.78	.20	14.7	56.2	40.1	5.2	1.67^{bc}	54.7^{c}	65.9^{b}	55.0^{cd}	55.8^{c}
Dough Silage	June 13	4.23	36.3	7.1	.26	.03	11.0	59.5	40.5	4.1	1.21^{cd}	52.2^{c}	56.6^{cd}	52.3^{d}	49.3^{d}
Dough Hay	June 16	3.70	76.5	---	---	---	10.9	63.0	41.2	---	$.97^{d}$	48.5^{d}	52.4^{de}	50.2^{d}	45.8^{de}
Arkan Wheat (64)															
Boot Silage	May 6	2.42	32.1	4.6	.57	.15	16.4	59.4	33.8	4.7	1.72^{bc}	65.9^{a}	74.1^{a}	69.0^{a}	65.9^{a}
Dough Silage	June 2	4.71	39.8	7.6	.20	.27	11.0	53.3	33.2	3.9	1.81^{ab}	53.9^{c}	56.4^{cd}	53.1^{d}	47.2^{d}
Dough Hay	June 4	4.22	82.5	---	---	---	10.4	58.8	31.5	---	1.39^{c}	55.4^{c}	61.2^{bc}	59.2^{bc}	41.3^{e}
Bounty 205 Wheat (59)															
Boot Silage	May 12	2.48	22.0	5.0	.95	.22	15.6	54.4	36.9	5.0	2.03^{a}	59.8^{b}	66.4^{b}	60.4^{b}	60.3^{b}
Dough Silage	June 6	4.69	37.2	7.2	.19	.08	11.1	53.1	34.3	4.0	1.56^{c}	53.8^{c}	56.9^{cd}	48.4^{e}	42.7^{e}
Dough Hay	June 8	4.55	81.0	---	---	---	10.5	57.9	33.0	---	1.21^{cd}	52.9^{c}	50.9^{e}	52.3^{d}	43.3^{e}
Barley (56)															
Boot Silage	May 5	2.22	29.8	3.7	.89	.15	16.6	56.9	33.8	5.5	1.98^{a}	62.6^{ab}	68.8^{ab}	63.7^{ab}	65.0^{a}
Dough Silage	May 30	3.64	28.7	9.9	.20	.15	11.9	57.5	32.0	3.9	2.00^{a}	61.0^{b}	63.1^{bc}	63.2^{ab}	54.2^{c}
Dough Hay	June 4	3.06	77.5	---	---	---	12.4	61.4	30.0	---	1.90^{ab}	54.8^{c}	60.2^{c}	55.9^{cd}	43.1^{e}

[1] Grain yield in bushels per acre (adjusted to 12.5% moisture) is shown in parenthesis. Extensive lodging made it impossible to harvest the triticale grain.

[2] VI = voluntary intake, DM = dry matter, LA = lactic acid, ETOH = ethanol, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

[abcde] Values in the same column with different superscripts differ ($P < .05$).

Table 46.5. Harvest Date, Forage and Grain Yields, Chemical Composition, and Voluntary Intake and Digestibility of the Rye, Wheat, and Barley Forages in Trial 3

Forage	Harvest Date	Forage DM Yield	Chemical Composition[1]				VI[1]	DM Digestibility
			DM	CP	NDF	ADF	lb DM/Day	
	1987	Tons/ Acre	%	--% of the DM----				%
Common Rye								
Boot Silage	Apr 25	2.10	25.1	22.1	51.3	26.8	2.18	62.9
Boot Hay	Apr 28	1.83	84.0	21.2	56.3	30.9	2.58	70.9
Dough Silage	May 16	2.64	36.3	12.1	60.9	37.4	1.10	53.4
Dough Hay	May 19	2.40	76.5	11.5	63.3	38.4	.86	54.2
Arkan Wheat								
Boot Silage	May 9	2.40	36.8	15.5	60.4	33.6	2.12	66.5
Boot Hay	May 11	2.15	71.1	15.5	60.2	31.9	1.61	56.5
Dough Silage	June 2	3.56	35.7	10.7	58.3	31.5	.99	57.3
Dough Hay[2]		---	---	---	---	---	---	---
Bounty 205 Wheat								
Boot Silage	May 8	2.55	29.5	17.8	58.4	33.2	2.07	65.5
Boot Hay	May 11	2.36	67.2	16.5	60.9	34.1	1.67	57.3
Dough Silage	May 29	3.75	34.5	12.0	59.1	34.4	.82	64.3
Dough Hay	June 1	3.43	73.6	11.5	65.6	37.6	1.26	58.4
Barley								
Boot Silage	May 3	2.25	26.1	14.9	63.4	35.8	1.54	57.9
Boot Hay	May 5	2.30	83.1	15.7	66.5	35.4	1.87	57.3
Dough Silage	May 30	3.38	31.1	10.3	68.3	36.3	1.81	59.3
Dough Hay[2]		---	---	---	---	---	---	---

[1] VI = voluntary intake, DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

[2] Not baled due to rainy weather.