Improving Forage Use Efficiency Cow/Calf Semi-Confinement Systems

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Introduction

Historical drought, escalating land values, and dramatic increases in most input costs have created a new paradigm in the cow/calf segment of the beef industry. Practices that were previously acceptable, even if wasteful, may be no longer tolerable if profitability is strong motivation. Therefore, our group has recently initiated a series of experiments to evaluate technologies or practices that appear to have promise in improving harvested forage use efficiency. Each of these technologies has been available in one form or another for many years, although adoption has remained low. Technologies evaluated to date and summarized here include hay feeder design, monensin supplementation, and these technologies combined with limiting access to forage and ammoniation.

Bale Feeder Design and Monensin Supplementation

Experiment 1

Fifty six crossbred beef cows (BW= 224.1 ± 22.7 lb; BCS= 5.2 ± 0.53) were used in a split-plot design with four periods. The whole plot included two supplement treatments, while the subplot included four hay feeder designs. Cows were weighed and allotted by BW to one of four previously grazed 2.03 ha paddocks equipped with a 12.2 x 7.6 m2 concrete feeding pad. Paddocks were randomly assigned to one of two supplement treatments which included a 36% CP cottonseed meal based pellet with 0 (**C**; control) or 200 mg/head of monensin (**M**; Rumensin 90®; Elanco Animal Health; Greenfield, IN), fed at a rate of 0.6 lb/head daily.

The four bale feeder designs used in the experiment can be seen in *Figure 1*. Each paddock was randomly assigned one of the four feeder designs which included: a conventional open bottomed steel ring (OBSR), a sheeted bottomed steel ring (RING), a polyethylene pipe ring (POLY), and a modified cone feeder (MODC).

The effects of supplement treatment and feeder treatment on hay waste are shown in *Table 1*. There were no supplement × feeder treatment interactions on hay waste. Supplement did not affect hay waste ($P = 0.77$). However, hay waste was significantly affected by feeder design ($P < 0.01$). The MODC feeder was the most efficient feeder treatment, saving 57.9 % more hay than the RING feeder which was next closest feeder. The RING feeder resulted in

Table 1. Effects of feeder design and supplement on hay waste

	Feeder[1]					Supplement[2]			*P*-value[3]	
Item	MODC	OBSR	POLY	RING	SEM	C	M	SEM	Feeder	Supplement
No.	7	7	7	7		14	14			
Dry waste, lb	63.3[a]	226.81[b]	239.4[b]	123.2[c]	22.64	165.3	161.0	24.9	< 0.01	0.90
Wet waste, lb	7.69	56.15	55.45	46.78	15.65	44.03	39.02	11.1	0.13	0.75
Total waste, lb	71.23[a]	283.3[b]	294.52[b]	169.8[c]	21.94	209.4	200.0	24.7	< 0.01	0.79
Orts weight, lb	226.9[a]	80.53[b]	66.03[b]	99.36[b]	23.79	138.1	98.24	22.07	< 0.01	0.22
Waste, % bale wt[4]	5.31[a]	20.54[b]	21.04[b]	12.6[c]	1.62	15.21	14.54	1.9	< 0.01	0.81

[1]MODC = modified cone feeder; OBSR = conventional open bottom steel ring feeder; POLY = polyethylene pipe ring feeder; RING = sheeted bottom steel ring feeder.
[2]C = 36% CP cottonseed meal based pellet with 0 mg/head of monensin; M = 36% CP cottonseed meal based pellet with 200 mg/head of monensin.
[3]Observed significance levels for main effects.
[4]Hay waste expressed as a percentage of mean bale wt.

Figure 1. Round bale feeder types: (a) modified cone feeder; MODC, (b), conventional open bottom steel ring feeder; OBSR, (c) polyethylene pipe ring feeder; POLY, and (d) sheeted bottom steel ring feeder; RING.

over twice the amount of waste as the MODC. However, the RING feeder wasted significantly less hay than both the OBSR and the POLY feeders ($P < 0.01$). Both the OBSR and the Poly feeder wasted 74.1 and 74.8 % more hay than the MODC feeder respectively ($P < 0.01$). However, no differences were found between the OBSR and POLY feeders ($P = 0.62$).

Neither supplement nor feeder type had an impact on DMI ($P = 0.47$). For this study DMI as a percent of cow BW was 1.70, 1.67, 1.72, and 1.78 % for MODC, OBSR, POLY, and RING respectively.

The effects of supplementing with monensin on cow performance are shown in *Table 2*. There were no supplement × feeder treatment interactions so they were removed from the model. Also, there were no effects of feeder treatment on performance since all cows in the experiment were exposed to all feeder designs ($P = 0.47$). There were no effects ($P > 0.28$) of supplementation on initial

Table 2. Effects of supplemental monensin on cow performance

	Supplement[1]			
Item	C	M	SEM	*P*-value[2]
No.	28	28		
Initial wt, lb	1082	1091	20.9	0.79
Initial BCS	5.15	5.21	0.10	0.70
Final wt, lb	1118	1155	23.4	0.28
Final BCS	5.28	5.81	0.14	0.01
Change in wt	35.5	65.3	10.1	0.04
Change in BCS	0.13	0.57	0.12	0.01
ADG, lb/d	0.62	1.12	0.18	0.04

[1]C = 36% CP cottonseed meal based pellet with 0 mg/head of monensin; M = 36% CP cottonseed meal based pellet with 200 mg/head of monensin.
[2]Observed significance levels for main effects.

Table 3. Effects of feeder design and supplement on apparent digestibility

	Feeder[1]					Supplement[2]			P-value[3]	
Item	MODC	OBSR	POLY	RING	SEM	C	M	SEM	Feeder	Supplement
NO.	7	7	7	7		24	24			
Apparent Digestibility, %										
DM	54.56	56.03	55.64	57.01	1.98	53.48	58.14	1.41	0.85	0.03
OM	57.00	58.68	58.20	59.28	1.91	56.06	60.52	1.36	0.86	0.03
NDF	57.93	58.01	57.92	60.18	1.72	55.70	61.32	1.22	0.74	< 0.01
ADF	45.09	47.44	47.08	49.03	2.48	43.83	50.49	1.76	0.74	0.01
CP	50.56	52.46	53.07	55.75	2.28	50.88	55.04	1.62	0.46	0.08

[1]MODC = modified cone feeder; O = conventional open bottom steel ring feeder; P = polyethylene pipe ring feeder; R = sheeted bottom steel ring feeder.
[2]C = 36% CP cottonseed meal based pellet with 0 mg/head of monensin; M = 36% CP cottonseed meal based pellet with 200 mg/head of monensin.
[3]Observed significance levels for main effects.

weight, initial BCS, or final weight. The final BCS of cows supplemented with C was statistically less than that of cows supplemented with monensin ($P = 0.01$). Change in weight, which was calculated as final weight less initial weight, was greater for cows supplemented with monensin ($P = 0.04$). Change in BCS was greater for cows supplemented with monensin than those that were not ($P < 0.01$). ADG during the 58 d feeding period was also significantly different for monensin supplemented cows than control supplemented cows ($P < 0.04$).

The effects of feeder design and supplementation of beef cows with monensin on digestibility is displayed in *Table 3*. There were no feeder × supplement interactions. Feeder design did not significantly affect digestibility ($P > 0.05$). Cows supplemented with monensin had greater DM, OM, NDF, and ADF total tract apparent digestibility ($P < 0.05$). There was a tendency for monensin supplemented cows to have greater total tract apparent CP digestibility ($P = 0.08$).

Differences in hay feeder design do not restrict DMI, but can significantly affect the amount of feed wasted and subsequently the amount of hay fed. Supplementing gestating cows with monensin may in increases in cow performance during the feeding period with no change in DMI.

Experiment 2

Spring calving Angus and Angus x Hereford cows and heifers (N = 84; initial BW = 1177 ± 150 lb; initial BCS = 5.27 ± 0.6; initial age = 4.8 ± 2.9 yr) were randomly allotted to one of two treatment combinations in a completely randomized design. Treatment supplements included 1) Cottonseed meal supplement with no monensin (**C**); 2) Monensin added to control to supply 200 mg·head-1·d-1 (**M;** Rumensin 90®; Elanco Animal Health; Greenfield, IN). Supplement was fed at a rate of 2 lb/head/d for duration of the study. Prior to, during, and after the treatment period, cows were managed as a contemporary group. Cows had ad libitum access to prairie hay (CP, 4.5%; TDN, 55%; crude fat, 2.8%; DM basis). The experiment was initiated on March 11, 2013 and terminated on May 11, 2013, resulting in a 60 d treatment period.

Cows were fed individually at 1200 daily in a barn containing 31 individual feeding stalls to ensure that each cow received the assigned amount of feed. Each d the cows were gathered from a small sacrifice pasture adjacent to the feeding barn and placed into a feeding stall, restrained, and allowed 20 min to consume their dietary supplement. Individual cow BW and body condition score (BCS; scale 1-9; Wagner et al., 1988) were determined at study initiation and conclusion. Milk production was measured through weigh-suckle-weigh procedure on April 19, 2013 and May 10, 2013. For this procedure, only calves 30 d of age or older were included. The cow-calf pairs included in the first collection were also included in the second collection.

There were no significant differences (P > 0.33) in cow BW or BCS at any time during the study. There were also no differences due to treatment (P > 0.19) in cow BW or BCS change from d 0 to calving, calving to d 60, or d 0-60. Calf birth BW was not affected by dam dietary treatment (P = 0.24; *Table 1*); however, calves from dams consuming monensin weighed significantly more at d 25 and 60 of the study. Calves from dams fed monensin also had greater (P = 0.04) ADG from birth to the end of the study. Milk production did not differ between cows on either of the treatments regardless of d postpartum (P > 0.26; *Table 2*).

Table 1. Effects of feeding monensin to beef cows on calf growth performance

	Treatment[1]			
Item	C	M	SEM	*P*-Value
No.	42	42		
Birth weight, lb	84.6	87.3	2.30	0.24
D45 weight, lb	132.1	142.4	4.39	0.02
D60 weight, lb	156.2	166.8	4.96	0.04
D0-60 ADG, lb	1.20	1.33	0.06	0.04

[1]Treatment supplements included 1) Cottonseed meal supplement with no monensin (C); 2) Monensin added to control to supply 200 mg·head^{-1}·d^{-1} (M). Supplements were fed at a rate of 2.00 lb·head^{-1}·d^{-1} for duration of the study.

Table 2. Effects of feeding monensin to beef cows on cow milk production

	Treatment[1]			
Item	C	M	SEM	*P*-Value
Group 1	42	42		
D postpartum: 28-38	84.6	87.3	2.30	0.24
No. of cows	13	19	4.39	0.02
Milk production, lb	31.1	33.1	2.7	0.47
D postpartum: 49-59	1.20	1.33	0.06	0.04
No. of cows	11	19		
Milk production, lb	17.97	20.75	2.4	0.26
Group 2				
D postpartum: 29-45				
No. of cows	24	31		
Milk production, lb	23.6	25.1	1.8	0.41

[1]Treatment supplements included 1) Cottonseed meal supplement with no monensin (C); 2) Monensin added to control to supply 200 mg·head^{-1}·d^{-1} (M). Supplements were fed at a rate of 2.00 lb·head^{-1}·d^{-1} for duration of the study.

In summary, cow performance was not impacted by monensin supplemented during late gestation and early lactation, nor was milk production significantly influenced. Nevertheless, early season calf performance was improved when dams received monensin supplementation during late gestation and early lactation.

Stacking Technologies in Semi-Confinement Forage Feeding Systems

Experiment 3

Seventy two gestating Angus and Angus x Hereford cows (1,172 ± 130 lb) were allotted by 12 h shrunk BW and assigned to one of two treatments. Treatment 1 (CONT; control) included 24 h access to an open bottom steel ring feeder containing low quality prairie hay (6.2% CP, 54% TDN) and 1.0 lb/d of a 38% CP cottonseed meal-based supplement. Treatment 2 (LIMIT; limited) included limited access to a modified cone feeder containing the same low quality prairie hay. A similar protein supplement (38% CP) containing monensin (Rumensin 90®; Elanco Animal Health; Greenfield, IN) was fed at the rate of 1.0 lb/d to deliver 200 mg of monensin daily. Wire panels were placed around the concrete pads to allow access for 7 h daily; starting at 0800 h. Cattle were assigned to one of six pens measuring three acres each with three replications (pens) per treatment and twelve cows per pen. Each pen was previously grazed to remove standing forage and four pens included a 40 x 25 ft2 concrete pad.

There was no difference between treatments for d 0-84 BW change ($P = 0.33$; *Table 1*), d 0-84 body condition score (BCS) ($P = 0.28$; data not shown) and off test BW ($P = 0.86$). These results suggest that both feeding systems provided nutrients close to the cows' requirements.

Table 1. The effect bale feeder type, monensin supplementation, and limit feeding on cow performance

	Treatment[1]			
Item, lb	CONT	LIMIT	SEM	P-value
BW				
Allotment	1,172	1,174	31.1	0.93
d0	1,208	1,203	31.4	0.87
d84	1,223	1,226	31.7	0.94
off test[2]	1,183	1,189	30.6	0.86
BW change				
d0-d84	10.0	22.9	13.0	0.33
d0-off test	-23.9	-14.1	11.8	0.41

[1]Control = 38% CP cottonseed meal based pellet with 0 mg/hd monensin, 24 h to prairie hay, open bottom steel ring feeder; Limit = 38% cottonseed meal based pellet with 200 mg/head of monensin, 7 h access to prairie hay, modified cone feeder.
[2] Off Test = Weight taken 7 d after completion of feeding to adjust for gut fill

Cattle receiving the CONT treatment had more ($P < 0.01$; *Table 2*) wet, dry waste, and total waste than cattle receiving the LIMIT treatment. Total hay waste was reduced by the LIMIT treatment by 181 lb per bale fed. Difference in percent of bale weight wasted was highly significant ($P \leq 0.01$) between treatments.

Table 2. The effect of bale feeder type, monensin supplementation, and limit feeding on hay waste

	Treatment[1]			
Item, lb	CONT	LIMIT	SEM	*P*-value
Hay fed	1,389	1,394	32.3	0.89
Orts	175	240	40.9	0.14
Wet waste	155	102	9.0	0.01
Dry waste	191	63	18.2	0.01
Total waste	346	165	15.9	0.01
Bale weight wasted, %	24.9	11.9	1.32	0.01

[1]Control = 38% CP cottonseed meal based pellet with 0 mg/hd monensin, 24 h access to prairie hay, open bottom steel ring feeder; Limit = 38% cottonseed meal based pellet with 200 mg/head of monensin, 7 h access to prairie hay, modified cone feeder.

Cattle receiving the CONT treatment wasted 24.9% of the original bale weight, while cattle receiving the CONT treatment wasted only 11.9% of bale weight. The combination of technologies in the LIMIT treatment is an effective method in reducing hay waste, resulting in a decrease in total waste of 52%.

Table 3. The Effect of bale feeder type, monensin supplementation and limit feeding on net disappearance

	Treatment[1]			
Item, lb	CONT	LIMIT	SEM[3]	*P*-value
Hay fed	28,131	24,527	1,971.9	0.14
Orts	1,371	2,391	709.2	0.22
Net disappearance[2]				
Per pen	26,760	22,136	1,369	0.03
Per cow	2,230	1,845	114.1	0.03
Per cow/d	26.6	22.0	1.36	0.03

[1]Control = 38% CP cottonseed meal based pellet with 0 mg/hd monensin, 24 h access to prairie hay, open bottom steel ring feeder; Limit = 38% cottonseed meal based pellet with 200 mg/head of monensin, 7 h access to prairie hay, modified cone feeder.
[2] Net disappearance is calculated by subtracting orts from hay fed.
[3]Limit = 38% cottonseed meal based pellet with 200 mg/head of monensin, 7 h access to prairie hay, modified cone feeder

Net disappearance per cow was 4.6 lb/d (*Table 3*) less for cattle receiving the LIMIT treatment. Total hay savings due to the combination of technologies in the LIMIT treatment for the entire experiment (87 d) per pen (n = 12) was 4,624 lb. Net disappearance is a function of both cow intake and hay waste, which makes it an effective indicator of hay feeding efficiency. The combination of modified cone feeder, limit feeding, and M supplementation in the LIMIT treatment was an effective method to reduce net disappearance, resulting in improved hay feeding efficiency.

Experiment 4

Sixty nine bales of prairie hay were ammoniated in September 2012. Anhydrous ammonia was injected into the covered hay stack at the rate of 2.5% of hay DM weight.

Thirty six lactating Angus and Angus x Hereford cows (1,164 ± 139 lb) were allotted by 12 h shrunk BW and assigned to one of two treatments. Treatment 1 (CONT; control) included 24 h access to an open bottom steel ring feeder containing round bales of prairie hay (5.5% CP, 50% TDN) and 2.5 lb/d of a 38% CP cottonseed meal-based supplement. Treatment 2 (LIMIT; limited) included limited access to a modified cone feeder containing ammoniated prairie hay (13.7% CP, 58% TDN) and 1.0 lb/d of a 20% CP wheat middlings and cottonseed meal based supplement with 200 mg/d per head inclusion of monensin (Rumensin 90®; Elanco Animal Health; Greenfield, IN).

Wire panels were placed around the concrete pads to allow access for 6 h daily; starting at 0800 h. Cattle were assigned to one of four pens measuring approximately three acres each with two pens per treatment. Each pen was previously grazed to remove standing forage and included a 40 x 25 ft^2 concrete pad.

Two waste collection periods were completed during the experiment. Prior to collection, cement pads were cleared of hay and debris, and all hay remaining within the feeders was removed, weighed, and sampled. A fresh round bale was weighed, core sampled, and placed in each feeder. Hay waste was measured at 1300 h daily for the time required for 85% of the hay within each feeder to be consumed. All hay outside of the feeders at the time of collection was considered waste. Waste was separated into wet and dry subgroups to account for differences in dry matter due to fecal and urine contamination.

Cattle were weighed and allotted based on allotment BW. The following d cattle were weighed again (d 0) and placed on treatment. A BW and body condition score (1 to 9 scale; Wagner et al., 1988) was recorded on all cattle on d 0, d 32, and d 62. BW was taken on calves on d 0, d 32, and d 62. Cattle and calves were removed from treatments on d 62 and were comingled on pasture until a final weight was taken 7 d later to adjust for differences in fill between cattle receiving either treatment.

Diets were designed to meet protein requirements, but weight loss in lactating beef cattle consuming ad libitum low quality hay was expected. Cattle receiving both treatments lost BW, -71.6 and -86.1 lb for CONT and LIMIT treatments, respectively. There was no difference between treatments for d 0-62 BCS change ($P = 0.17$; *Table 1*) and d 0-off test BW change ($P = 0.14$; *Table 1*). These results suggest that the LIMIT treatment maintained similar cow performance as the CONT treatment.

Table 1. Effect of bale feeder type, monensin supplementation, limit feeding, and hay ammoniation on cow performance, cow body condition score, and calf performance

	Treatment[1]			
Item	CONT	LIMIT	SEM	*P*-value
Cow BW change, lb				
d0-62	-5.2	-68.0	10.19	0.01
d0-off test[2]	-71.6	-86.1	9.70	0.14
Cow BCS change				
d0-62	-0.13	-0.41	0.20	0.17
Calf BW change, lb;				
d0-62	106.6	84.6	4.29	0.01
d0-off test	103.0	88.5	5.06	0.01

[1]Control = 38% CP cottonseed meal based pellet with 0 mg/hd monensin, ad libitum access to prairie hay, open bottom steel ring feeder; Limit = ammoniated hay, 20% cottonseed meal based pellet with 200 mg/head of monensin, 6 h access to prairie hay, modified cone feeder.
[2]Off Test = Weight taken 7 d after completion of feeding to adjust for gut fill.

Calf BW was not different between treatments on d 0 ($P = 0.96$) or off test ($P = 0.47$). Calves receiving the LIMIT treatment gained less BW between d 0-62 ($P = 0.01$; *Table 1*) and d 0-off test ($P = 0.01$). Calves receiving the LIMIT treatment gained 14.5 lb less than calves receiving the CONT treatment.

The LIMIT treatment resulted in less wet waste, dry waste and total waste ($P \leq 0.01$; *Table 2*). Total waste was decreased ($P < 0.01$) in the LIMIT treatment by 188 lb per bale fed. Total waste in the CONT treatment was 295 lb, compared to only 107 lb of waste in the LIMIT treatment. Cattle receiving the CONT treatment wasted 21.9% of bale weight while cattle receiving the LIMIT treatment wasted only 7.3% of bale weight.

Table 2. Effect of bale feeder type, monensin supplementation, limit feeding, and hay ammoniation on hay waste

	Treatment[1]			
Item, lb	CONT	LIMIT	SEM	*P*-value
Hay fed	1360	1480	62.1	0.10
Orts	124	288	49.4	0.02
Wet waste	152	66	20.7	0.01
Dry waste	143	41	17.4	0.01
Total waste	295	107	14.8	0.01
Bale weight wasted, %	21.86	7.25	1.85	0.01

[1]Control = 38% CP cottonseed meal based pellet with 0 mg/hd monensin, ad libitum access to prairie hay, open bottom steel ring feeder; Limit = 20% cottonseed meal based pellet with 200 mg/head of monensin, 6 h access to prairie hay, modified cone feeder.

There was a large decrease ($P < 0.01$; *Table 3*) in hay fed between treatments. The cattle receiving the LIMIT treatment were fed 5,279 lb less per pen than cows receiving the CONT treatment. Net disappearance was measured as hay fed minus orts. Net disappearance between treatments was highly significant ($P < 0.01$). The LIMIT treatment resulted in a decrease in net disappearance per d of 13.3 lb per cow. This resulted in a total hay savings of 6,584 lb per pen over the 62 d experiment.

Table 3. Effect of bale feeder type, monensin supplementation, limit feeding, and hay ammoniation on net disappearance

	Treatment[1]			
Item, kg	CONT	LIMIT	SEM	*P*-value
Hay fed	22,763	17,484	129.8	0.01
Orts	1,239	2,544	209.6	0.02
Net disappearance				
Per pen	21,524	14,940	147.7	0.01
Per cow	2,690	1,867	18.5	0.01
Per cow/d	43.4	30.1	0.30	0.01

[1]Control = 38% CP cottonseed meal based pellet with 0 mg/hd monensin, ad libitum access to prairie hay, open bottom steel ring feeder; Limit = 20% cottonseed meal based pellet with 200 mg/head of monensin, 6 h access to prairie hay, modified cone feeder.

Conclusion

A larger number of cow/calf operations may be able to take advantage of semi-confinement advantages if the efficiency of feeding harvested forages could be improved. These experiments suggest that there is substantial room for improvement in utilization of one of the nation's largest agricultural crops. Several technologies appear to have moderate to dramatic impacts on the amount of forage wasted, animal productivity, or both. Implementation of one or more of these underutilized technologies could greatly improve the efficiency of semi-confinement systems where management, facilities and other resources require the use of harvested forage.

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