Effect of Rumen-degradable and Undegradable Protein Sources in Barley-based Growing and Finishing Feedlot Diets

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Abstract

One hundred twenty-eight crossbred steers (878.8 ± 4.2 lbs.) were allotted by weight to one of four diets (4 pens per treatment, 8 head per pen) to determine the optimum source of supplemental protein (degradable and/or undegradable) for barley-based growing and finishing diets. Dry distillers grains (DDG) was used as a primary rumen-undegradable protein (RUP) source, urea was a highly-rumen degradable protein (RDP) source, and wet distillers grains (WDG) contributed both RUP and RDP. Diets were formulated to contain 13.5% CP (growing and finishing) and 53.0 (growing) and 57.5 (finishing) MCal NEg/cwt. Dried distillers, DDG + urea, WDG, and urea-supplemented growing diets contained 41.2, 32.4, 35.8, and 23.6% RUP, respectively. Growing diets were fed for 56 days, after which cattle were transitioned to the finishing diets. Dried distillers, DDG + urea, WDG, and urea-supplemented finishing diets contained 38.2, 33.1, 35.0, and 28.0% RUP, respectively. Steers were housed and fed at the Carrington Research Extension Center feedlot in open drylot pens and were slaughtered when body weight was estimated to be 1250 lbs. Gain did not differ among treatments ($P > 0.14$) during the growing phase. Weight at the end of the growing phase and dry matter intake during the growing phase did decrease linearly ($P < 0.03$) as proportion of RUP supplementation decreased. Average daily gain and dry matter intake decreased linearly during the finishing phase ($P < 0.08$ and $P < 0.02$, respectively) and overall ($P < 0.01$ and $P < 0.02$, respectively) as the proportion of RUP supplementation decreased. Feed efficiency did not differ among treatments during the finishing phase ($P > 0.81$), but when calculated for the entire trial, DDG + urea and urea-supplemented steers were the most efficient ($P < 0.06$). WDG-supplemented steers were the least efficient. Slaughter weights and hot carcass weights decreased linearly ($P < 0.01$) as RUP proportion of the protein decreased. Marbling score, fat thickness, ribeye area, and yield grade did not differ among treatments ($P > 0.51$). Despite barley rapidly fermenting in the rumen, and the potential need for RDP supplementation, the naturally high protein content (~ 13.2% CP) may provide adequate nitrogen for microbial populations to thrive. Results from this trial indicate that protein supplements with a higher proportion of rumen-undegradable protein (RUP) may be required to meet metabolizable protein needs of the animal when barley is fed.

Introduction

Barley is the predominant feed grain fed in Canada, Europe, and the northern United States. Feed barley is also an attractive alternative to corn when priced competitively. However, the optimum proportion of rumen-degradable vs. undegradable protein for barley-based growing and finishing diets has not been determined. Protein from barley is highly rumen degradable where protein in corn is less degraded in the rumen and digested in the lower gut. However, the higher protein content of barley as compared to corn (13.2 vs. 9.8% CP) may provide adequate nitrogen for ruminal microbial populations to thrive, indicating that supplemental rumen-undegradable protein (RUP) may be required to meet metabolizable protein needs. Ethanol industry co-products such as dried and wet distillers grains, which are relatively high in RUP, are the most economical choices for supplemental RUP, especially in the western corn belt where the ethanol industry is expanding. Feed barley is available in all of North Dakota, parts of Minnesota, and South Dakota, and ethanol co-products are available throughout the region.

Four protein supplementation strategies in both growing and finishing diets were investigated in this trial: 1) barley supplemented with RUP (dried distillers grains) 2) barley supplemented with RDP + RUP (urea + wet distillers grains); 3) barley supplemented with both RDP and RUP (urea + dried distillers grains); and 4) barley supplemented with RDP (urea).

Experimental Procedures

One hundred twenty-eight crossbred steers (878.8 ± 4.2 lbs.) purchased from a sale barn in Rugby, North Dakota, were allotted by weight to one of four diets (4 pens per treatment, 8 head per pen) to determine the optimum source of protein for dry-rolled, barley-based growing and finishing diets. Steers were housed and fed at the Carrington Research Extension Center feedlot in open drylot pens. Each pen was equipped with automatic waterers and fenceline bunks which allowed for two feet of bunk space per head. Feed was delivered as a totally-mixed ration once daily to appetite. The ionophore supplement was manufactured by the Northern Crops Institute, Fargo, ND, and contained appropriate amounts of minerals and vitamins. Growing diets were formulated to contain 13.5% CP and 53.0 MCal NEg/cwt. Rumen-undegradable protein content of the growing diets was 41.2, 32.4, 35.8, and 23.6% RUP for the dried distiller grains (DDG), DDG + urea, wet distillers grains (WDG), and urea-supplemented diets, respectively. Growing diets were fed for 56 days, after which cattle were transitioned to the finishing diet. Finishing diets were formulated to contain 13.5% CP and 57.5 MCal NEg/cwt. Rumen-undegradable protein content of the finishing diets was 38.2, 33.1, 35.0, and 28.0% RUP for the DDG, DDG + urea, WDG, and urea supplemented diets, respectively. Finishing diets were fed until cattle were slaughtered. Diet compositions are shown in tables 1 and 2. Feed samples were taken every week and composited for analysis of DM and CP.

Table 1. Growing diet composition (DM basis).

	High RUP	RDP + RUP		High RDP
Item	DDG	DDG + urea	WDG	Urea
Ingredients				
Barley	42.72	49.30	44.25	55.90
Urea		0.40		0.80
Dried distillers grains	14.00	7.00		
Wet distillers grains			12.50	
Corn silage	27.00	30.00	12.00	30.00
Native grass hay	13.00	10.00	28.00	10.00
Barley malt sprouts	1.39	1.39	1.39	1.39
Dicalcium phosphate	0.05	0.05	0.05	0.05
Limestone	1.46	1.48	1.43	1.48
Potassium chloride	0.20	0.20	0.20	0.20
Rumensin	0.02	0.02	0.02	0.02
Salt	0.12	0.12	0.12	0.12
Vitamin A, 30,000 IU/g	0.01	0.01	0.01	0.01
Vitamin D, 3,000 IU/g	0.01	0.01	0.01	0.01
Vitamin E, 44 IU/g	0.02	0.02	0.02	0.02
Diet specifications				
Crude protein, %	13.54	13.53	13.58	13.48
RUP, %	41.17	32.4	35.78	23.63
NEg, Mcal/cwt	52.60	53.00	52.80	52.60
Ca, %	0.66	0.66	0.65	0.66
P, %	0.40	0.41	0.38	0.41

Table 2. Finishing diet composition (DM basis).

Item	High RUP	RDP + RUP		High RDP
	DDG	DDG + urea	WDG	Urea
Ingredients				
Barley	73.52	77.27	73.52	81.00
Urea		0.25		0.50
Dried distillers grains	8.00	4.00		
Wet distillers grains			7.00	
Corn silage	5.00	5.00		5.00
Native grass hay	10.00	10.00	16.00	10.00
Barley malt sprouts	1.39	1.39	1.39	1.39
Dicalcium phosphate	0.05	0.05	0.05	0.05
Limestone	1.66	1.66	1.66	1.68
Potassium chloride	0.20	0.20	0.20	0.20
Rumensin	0.02	0.02	0.02	0.02
Salt	0.12	0.12	0.12	0.13
Zinc sulfate	0.003	0.003	0.003	0.003
Vitamin A, 30,000 IU/g	0.01	0.01	0.01	0.01
Vitamin D, 3000 IU/g	0.01	0.01	0.01	0.01
Vitamin E, 44 IU/g	0.02	0.02	0.02	0.02
Diet specifications				
Crude protein, %	13.58	13.61	13.56	13.63
RUP, %	38.21	33.09	34.95	28.00
NEg, Mcal/cwt	57.50	57.20	58.00	57.00
Ca, %	0.68	0.68	0.69	0.68
P, %	0.42	0.43	0.42	0.43

Four weeks prior to initiation of the trial, cattle were vaccinated for protection against IBR, BVD, BRSV, PI3 (Bovishield-4; Pfizer, Exton, PA), and clostridia (7-way + somnus; Pfizer, Exton, PA). Health status of the cattle was monitored daily. Rectal temperatures were measured in animals that were visibly anorexic or had severe nasal mucous drainage and rapid or labored breathing. Sick animals were treated with one of two antibiotics according to label instructions (Micotil, Elanco, Indianapolis, IN; A180, Pfizer, Exton, PA). Micotil was used on first and second pulls, followed by A180 if cattle were unresponsive. Antibiotic treatment continued until animals appeared healthy. Research protocols regarding animal care followed guidelines recommended in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1998).

All steers were implanted with Synovex-Choice (100 mg trenbolone acetate, 14 mg estradiol) at the initiation of the trial.

Cattle were slaughtered at Tyson Foods (Dakota City, NE) when body weight for the entire group was estimated to be 1250 lbs. Hot carcass weight, fat thickness, percentage kidney, pelvic and heart fat, longissimus muscle area, and USDA quality and yield grades were determined by qualified personnel 48 hours after slaughter.

Data were subjected to a one-way analysis of variance as a completely randomized design using the GLM procedures of SAS (Version 8.0; SAS Inst. Inc., Cary, NC). Pen was the experimental unit.

Results and Discussion

Cattle gained well during the growing phase (4.23 lbs. /d for all treatments) which may to some degree be accredited to compensatory effect. Gains did not differ among treatments (P > 0.14) during that 56-day period (Table 3).

Table 3. Effect of supplemental RUP[a] and RDP[b] in barley-based diets on cattle performance.

	High RUP[a]	RUP[a] + RDP[b]		High RDP[b]		
	DDG[c]	DDG[c] + Urea	WDG[d]	Urea	St Error	P value
Weight, lbs.						
May 28, 2004	882.8	880.4	876.4	875.5	4.2	0.58
June 18, 2004[g]	969.6[e]	976.3[e]	961.3[ef]	951.2[f]	4.5	0.01
July 8, 2004[g]	1067.1[e]	1055.5[ef]	1044.2[f]	1040.6[f]	5.6	0.03
August 6, 2004[g]	1152.1[e]	1150.3[e]	1134.7[e]	1108.8[f]	7.7	0.01
September 9, 2004[g]	1264.2[e]	1259.6[e]	1244.2[e]	1218.4[f]	7.3	0.01
Average daily gain, lbs./d						
Period 1	4.13	4.57	4.05	3.56	0.27	0.13
Period 2	4.88	3.96	4.15	4.57	0.34	0.28
Growing phase	4.49	4.27	4.10	4.03	0.14	0.14
Period 3[h]	2.93[ef]	3.27[e]	3.12[e]	2.29[f]	0.22	0.05
Period 4	3.30	3.21	3.22	3.38	0.17	0.9
Finishing phase[gh]	3.13[e]	3.24[e]	3.18[e]	2.82[f]	0.11	0.08
Overall[g]	3.67[e]	3.65[e]	3.54[e]	3.30[f]	0.07	0.01
Dry matter intake, lbs./d						
Period 1	24.6	23.1	24.4	22.8	0.8	0.31
Period 2[g]	30.0[e]	27.2[ef]	28.4[e]	24.8[f]	1.0	0.02
Growing phase[g]	27.2[e]	25.1[ef]	26.3[e]	23.7[f]	0.8	0.07
Period 3[g]	27.6[e]	27.1[e]	27.3[e]	24.3[f]	0.8	0.05
Period 4[gh]	27.6[e]	28.0[e]	28.8[e]	24.6[f]	0.7	0.01
Finishing phase[gh]	27.6[e]	27.6[e]	28.1[e]	24.5[f]	0.7	0.02
Overall[g]	27.4[e]	26.5[e]	27.4[e]	24.2[f]	0.7	0.02
Feed efficiency, lbs./lb.						
Period 1	6.0	5.1	6.1	6.6	0.4	0.13
Period 2	6.3	6.9	7.0	5.6	0.5	0.20
Growing phase	6.1	5.9	6.4	5.9	0.2	0.37
Period 3[h]	9.6[ef]	8.3[e]	9.1[e]	10.7[f]	0.7	0.09
Period 4[h]	8.5[ef]	8.7[e]	9.0[e]	7.3[f]	0.5	0.10
Finishing phase	8.8	8.5	8.9	8.7	0.3	0.81
Overall	7.5[ef]	7.3[e]	7.7[f]	7.3[e]	0.1	0.06

[a]Rumen-undegradable protein; [b]Rumen-degradable protein; [c]Dried distillers grains; [d]Wet distillers grains; [ef]Means within a row with different superscripts differ; [g]Linear effect; [h] Quadratic effect

Table 4. Effect of supplemental RUP[a] and RDP[b] in barley-based diets on carcass characteristics.

	High RUP[a]	RUP[a] + RDP[b]		High RDP[b]		
	DDG[c]	DDG[c] + Urea	WDG[d]	Urea	St Error	P Value
Hot carcass weight, lbs.[gh]	731.2[e]	730.1[e]	724.0[e]	697.7[f]	5.5	0.01
Dressing, percent	57.8	58.0	58.2	57.3	0.3	0.27
Marbling score	374.0	365.8	375.6	362.1	9.1	0.68
Yield grade	2.40	2.40	2.50	2.30	0.10	0.72
Fat thickness, in.	0.37	0.38	0.40	0.36	0.03	0.76
Ribeye area, sq. in.	13.2	13.2	12.7	12.7	0.3	0.51
Kidney, pelvic, heart fat, %	1.85	1.93	1.83	1.82	0.04	0.25
Choice, %	48.3	46.0	44.0	41.3	10.3	0.97

[a]Rumen-undegradable protein; [b]Rumen-degradable protein; [c]Dried distillers grains; [d]Wet distillers grains; [ef]Means within a row with different superscripts differ; [g]Linear effect; [h] Quadratic effect

Despite similar gains, however, DDG-supplemented steers were the heaviest ($P < 0.03$) at the end of the growing phase, followed by DDG + urea-supplemented steers. Cattle supplemented with urea were the lightest ($P < 0.03$) at the end of the growing phase. Steers supplemented with DDG consumed the greatest dry matter ($P < 0.07$) during the growing phase and steers supplemented with urea consumed the least dry matter during the growing phase. On average, cattle gained 3.09 and 3.54 lbs. /d during the finishing phase and overall, respectively. Average daily gain and dry matter intake decreased linearly during the finishing phase ($P < 0.08$ and $P < 0.02$, respectively) and overall ($P < 0.01$ and $P < 0.02$, respectively) as the level of RUP supplementation decreased. Feed efficiency did not differ among treatments during the finishing phase ($P > 0.81$), but when calculated for the entire trial, DDG + urea- and urea-supplemented steers were the most efficient ($P < 0.06$) and WDG-supplemented steers were the least efficient.

Slaughter weight and hot carcass weight decreased linearly ($P < 0.01$) as RUP supplementation decreased. Carcasses from urea-supplemented steers were 4.2 percent lighter than the average carcass weight of DDG-, DDG + urea-, and WDG-supplemented steers. Marbling score, fat thickness, ribeye area, and yield grade did not differ among treatments ($P > 0.51$).

Researchers at North Dakota State University (Pamp et al., 2004) observed that barley-based control diets (13.7% CP) supplemented with RUP (blood meal and feather meal, 14.7% CP), or a combination of RDP and RUP (15.5% CP) improved gain, ribeye level increased in barley-based diets (0.0, 0.4, 0.8, 1.2 %), gain and intake increased linearly, leveling off at 0.8 percent, indicating that supplemental RDP is advantageous. However, it is important to note that diets fed by both Zinn et al. (2003) and Pamp et al. (2004) did not contain equal amounts of crude protein.

Success of the barley-based diets supplemented with RUP indicates that the protein content of barley may provide adequate nitrogen for microbial populations to thrive, thus meeting metabolizable protein needs of the animal. Despite the high level of rumen degradability of feed barley, supplemental RDP may not be required to meet metabolizable protein needs of the animal (DDG + urea had same gain as just DDG). Cattle fed barley-based diets supplemented with any form of distillers grains consumed more dry matter than cattle fed barley-based diets supplemented with urea, indicating that distillers grains made the diet more palatable or that adding a less ruminally-degradable feed improved overall digestive function. More work is justified to explore the maximum amount of distillers grains that can be fed in barley-based feedlot diets.

References

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