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Summary

Feedlot cattle are now capable of growth rates that greatly exceed our descriptions for established nutrient requirements. We must now redefined the impact of sources and levels of dietary CP on growth rate and efficiency. Pursuing this question, yearling steers (n = 360 $\bar{x}$ BW = 790 ± 10) were fed various levels and sources of supplement crude protein during a 120 day finishing period. Diets were formulated to contain 12 or 13% CP. Supplemental CP was provided in the forms of urea, soybean meal, bloodmeal, and feather meal. Actual dietary CP levels of 11.8% and 12.6% were lower than formulations but still allowed for level comparisons. Higher CP levels improved feed/gain (P<.05) during the initial 42 days on feed in only one set of diet contrasts. CP level did not affect cumulative performance by steers. In one set of contrasts SBM supported higher (P<.05) ADG and a trend (P<.15) toward improved feed/gain over urea based supplements. In a second set of contrasts SBM tended to support higher ADG (P<.15) and higher DMI (P<.10) than urea plus escape protein liquid supplements. There were no interactions between sources and levels of supplemental CP. The apparent CP requirement of medium framed steers gaining over 4 lb per day was not greater than 11.8% of the diet.

Key Words: Steers, Feedlot, Protein

Materials and Methods

Yearling steers were acquired from various sale barns from June 9 to July 15, 1994. The experiment required 360 suitable steers (9 diets x 5 pen replicates x 8 steers) that were selected from 410 purchased animals. To accommodate problems of assembling these numbers of suitable subjects, the experiment was initiated in a staggered sequence. Block 1 (pen replicates 1 and 2) was started on test June 15; Block 2 (pen replicates 3 and 4) was started June 28; and Block 3 (pen replicate 5) was started July 18. All subsequent management steps were outlined related to the number of days the cattle were on feed rather than to a given date.

Initial processing involved ear tagging, BW measurement (for allotment), vaccination using Resvac 3/Somubac[2] (MLV for IBR, BVD, PI_3 and Haemophilus somnus) and Ultrabac 7[2] (7 clostridia sp) and parasite treatment with Ivomec pour on[3]. Cattle had access to long hay during the initial 2 to 3 days in the feedlot and a receiving diet (25% grass hay, 73.2% whole shelled corn, 1.8% supplement) was limit fed at 1.25 x maintenance from receiving until starting on experiment.

Allotment to treatments was done by first stratifying steers by BW among treatments. The BW was then stratified among pen replicates within treatments. Prior to allotment, steers of exceptionally high or low BW, of atypical breed type, or exhibiting an unthrifty appearance were deleted from the allotment pool. Steers were physically sorted to their assigned pens the afternoon prior to starting on test. Treatments were assigned to pens in a manner that balanced their distribution throughout the feedlot facility.

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[1]Professor.
[2]Pfizer, Inc., Lee Summit, MO.
[3]MSDAGVET, Rahway, NJ.

Initial and all subsequent BW were determined on individuals from 0730 to 0930. This was prior to morning feeding. Feed or water were not withheld. Implanting when needed was done during the weighing procedure. The initial implant used was Synovex-S[4]. The implant used at reimplanting (41 or 42 days on feed) was Revalor[5]. Steers were shipped (75 miles) to the abattoir the afternoon following final BW measurement (119, 120, or 121 days on feed) and slaughtered 24 hours after the final BW was determined. Hot carcass weight was recorded at the time of slaughter. Longissimus area and rib fat thickness were measured on chilled carcasses. Marbling score and percentage of KPH noted by the USDA Grader on duty were recorded.

Feed schedules involved feeding the assigned diet at 1.65 x M immediately after initial BW was determined. The level of feed delivery was gradually and systematically increased to achieve expected peak DMI by 28 days without causing metabolic disorders. During the initial 21 days, feed deliveries were made once daily. Thereafter, feed was delivered twice daily in equal amounts. The quantity of feed delivered each day was based on feed calls made at 0700. Treatments were unknown to the feedcaller.

The nine supplement treatments are outlined in Table 1. Complete diet formulations are outlined in Table 2. Feed preparation was accomplished by mixing batches that would feed all five replicates within each treatment. Two batches were manufactured for each diet daily to accommodate morning and afternoon feed schedules. Feed commodity ingredients were sampled once each week and assayed for DM, CP, and ash. Roughages were also assayed for ADF and NDF content. Supplements were assayed for moisture and CP content at the time of manufacture. The diet nutrient contents were back calculated from ingredient assays and the as fed formulations used to manufacture batches of feed. This calculation was done weekly and whenever as fed formulations were adjusted for feed DM values. Means reported reflect all of these weekly composition calculations.

Table 1. Supplement characterizations

Supplement	Treatment	Form	% CP	Source
LS 40	1	liquid	53.9	Urea
DS #1	2	pellet	35.9	urea
LS 50	3,4	liquid	73.9	urea
DS #2	4,5	pellet	36.6	SBM
LS 45B	6	liquid	79.2	urea/blood meal/feather meal
LS 55B	7	liquid	87.9	urea/blood meal/feather meal
LS 460	8,9	liquid	6.4	molasses
DS 8	8	pellet	40.6	SBM
DS 9	9	pellet	42.6	SBM

[4]Roche Animal Health, Paramus, NJ.
[5]Hoechst-Roussel Agri-Vet Co., Tuttlingen, Germany.

Table 2. Basal diet formulations and CP content[a]

	Treatment									
Ingredient	1	2	3	4	5	6	7	8	9	SEM
Ground hay	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.01	8.00	
Whole shelled corn	43.05	39.13	42.87	41.34	37.42	43.50	43.50	39.31	38.07	
High moisture corn	43.45	39.52	43.29	41.71	37.78	43.91	43.91	39.68	38.43	
Molasses		3.59			3.57					
LS 40	5.50									
DS 1		9.76								
LS 50			5.80	3.14						
DS 2				5.80	13.23					
LS 45B						4.59				
LS 55B							4.59			
LS 460								4.00	4.00	
DS 8								9.00		
DS 9									11.50	
DM[b]	81.9	83.1	82.0	82.6	83.2	82.1	82.0	82.5	82.7	.16
CP (target CP)[b]	11.76 (12)	11.54 (12)	12.76 (13)	12.64 (13)	12.52 (13)	12.08 (12)	12.39 (13)	11.89 (12)	12.83 (13)	.063
ADF[b]	5.7	5.5	5.7	5.6	5.4	5.8	5.9	5.5	5.4	.05
NDF[b]	13.2	12.5	13.2	12.9	12.2	13.3	13.3	12.5	12.3	.03
Ash[b]	3.4	4.7	3.6	4.0	4.9	3.2	3.3	3.9	4.0	.11
NE_m, Mcal/cwt[c]	94.2	95.4	92.6	94.2	95.3	94.4	94.3	94.2	94.1	.02
NE_G, Mcal/cwt[c]	63.0	63.2	61.9	62.7	62.9	63.4	63.0	62.5	62.3	.18

[a]Percentage, DMB except when noted otherwise.
[b]Assayed values.
[c]Estimated values.

The DMI of each pen was summarized weekly based on ingredient DM and actual feed deliveries. When feed lost condition due to overfeeding or adverse weather, material was removed from the feed bunk, weighed, and sampled for DM analysis. The dry mass was subtracted from weekly total DM delivered before calculating average daily DMI per steer for the period. These weekly DMI records were used to calculate mean daily DMI during the periods corresponding to each BW determination. The pen mean BW and DMI were used in calculating feed/gain (FG) and statistical analyses.

Because of the complexity of the treatments used in this experiment it was more effective to analyze various treatment combinations as individual studies. Strategies for preplanned comparisons resulted in five separate AOV. Set 1 evaluated urea and SBM at 12 or 13% CP (TRT 1,2,3 5). Set 2 compared only urea or SBM at 13% CP (TRT 3,4,5). Set 3 compared urea with urea + escape protein at 12 or 13% CP (TRT 1,3,6,7). Set 4 compared SBM with urea + escape protein at 12 or 13% CP (TRT 2,5,6,7). Set 5 compared the value of including micro-ingredients in liquid or pelleted forms (TRT 2,5,8,9).

Statistical analyses were accomplished using the GLM procedures of SAS. Pen was considered the experimental unit for comparing feedlot performance variables. The blocks had a significant influence on BW and performance results. Therefore, block was used as a covariate in statistical analyses summarized here. Least squares means are reported in the tables.

Weekly feed records were included in the data base for each block. This resulted in repeated observations during weeks that overlapped between blocks. The repeated measures serve to weight mean feed analysis data for the number of steers consuming diets at any given time.

Carcass data were evaluated by considering individual carcasses as the experimental unit. Adjusted carcass weights were generated using initial live BW as a covariate and as such is a reflection of feedlot carcass gain. Marbling scores were indexed on a scale where 5.0 = small°, 4.0 = slight° degrees of marbling. Percentage choice carcasses among treatments were compared by Chi square analyses.

Results and Discussion

The methods used for diet analyses are quite sensitive. The least significant difference for CP generated by Duncan's New Multiple Range test was .18 units for adjacent means. Actual CP levels of 11.8% and 12.6% for the 12% and 13% CP treatments, respectively, differed ($P<.001$). Differences ($P<.05$) also occurred between diets within CP level (Table 3). No overlap in CP content existed between diets among levels. The biologically relevant differences in CP content are limited and may have compromised the potential to evaluate optimal dietary CP. Even so, some practical interpretations are still possible.

The initial BW (Table 4) was heavier than desired but necessary to meet uniformity and quality standards for this type of experiment. The experiment duration was planned for 140 days but heavy initial BW and excellent performance reduced the days on feed to 119, 120, and 121 for Blocks 1, 2, and 3, respectively. There were no protein source x level interactions evident in the data set, allowing independent discussion of each.

The level of CP did not affect performance of feedlot steers. The actual dietary CP increased 6.9% (11.80 vs 12.62%) considering all diets. A greater increase may have had an effect but in previous studies we have seen no response to elevating CP above that provided by a SBM supplemented 11.25% CP diet.

There were differences evident between CP sources. The diets supplemented with SBM tended ($P<.10$) to promote greater ADG (Tables 5, 6, and 8). Numerical advantages for SBM were evident in each phase of each comparison set used. Oftentimes these differences were not significant, but the consistency of the rankings is a relevant consideration. Considering only diets 1, 2, 3, and 5, the SBM increased ADG 5% ($P<.02$) and tended ($P=.15$) to improve F/G, although this was only a 3% response. When only the 13% CP diets were considered (Set 2; Table 6), a 5% increase ($P=.098$) in ADG occurred when SBM was fed. The 50/50 blend of urea/SBM based supplements resulted in an intermediate rate of gain.

Table 3. Duncan's New Multiple Range test of diet CP content by CP source and level

Level	12% CP				13% CP				
means[a]	11.80				12.62				
Source	Urea		SBM		Urea		SBM		Urea/SBM
means[b]	11.92		11.70		12.58		12.68		12.60
DIET	1	6	2	8	3	7	5	9	4
	11.76[d]	12.08[e]	11.50[c]	11.89[d]	12.76[hi]	12.39[f]	12.52[fi]	12.83[i]	12.60[gh]

[a]Level effect ($P<.001$).
[b]Source within CP level.
[c,d,e,f,g,h,i]Means without common superscripts differ ($P<.05$).

Table 4. Initial, interim, and final BW comparisons

	Treatment								
	1	2	3	4	5	6	7	8	9
Initial BW	787	787	784	794	787	792	791	795	788
Re-implant BW	948	964	956	972	964	971	972	972	981
Final BW	1289	1313	1293	1311	1321	1311	1301	1318	1300

	P<	
Significant diet contrasts	Re-implant BW	Final BW
Urea vs SBM (1, 3 vs 2, 5)	.1326	.0451
Urea 12% vs 13% CP (1 vs 3)	NS	NS
SBM 12% vs 13% CP (2 vs 5)	NS	NS
Urea vs urea + escape (1, 3 vs 6, 7)	.0208	NS
Dry vs liquid (2, 5 vs 8, 9)	.1266	NS

Table 5. Set 1 comparisons: Urea vs SBM and 12 vs 13% CP

	Treatment				P<[a]	
	1	2	3	5		
	Urea (12%)	SBM (12%)	Urea (13%)	SBM (13%)	Urea vs SBM	12 vs 13% CP
Initial to re-implant						
ADG	3.93	4.32	4.20	4.35	NS	NS
DMI	16.85	16.79	16.71	16.64	NS	NS
F/G	4.32	3.90	4.05	3.85	.0785	NS
Re-implant to final						
ADG	4.32	4.43	4.27	4.51	NS	NS
DMI	25.05	25.78	24.71	25.47	NS	NS
F/G	5.81	5.84	5.80	5.65	NS	NS
Cumulative						
ADG	4.19	4.39	4.24	4.46	.0201	NS
DMI	22.25	22.71	21.98	22.46	NS	NS
F/G	5.32	5.18	5.19	5.04	.1436	NS

[a]NS P≥ .15.

Table 6. Set 2 comparisons: Additive response of urea and SBM

	Treatment			P
	3	4	5	
	Urea (13%)	Urea/SBM (13%)	SBM (13%)	Urea vs SBM
Initial to re-implant				
ADG	4.20	4.36	4.35	NS
DMI	16.71	17.10	16.64	NS
F/G	4.05	3.95	3.85	NS
Re-implant to final				
ADG	4.27	4.28	4.51	.1506
DMI	24.71	25.21	25.47	NS
F/G	5.80	5.90	5.65	NS
Cumulative				
ADG	4.24	4.31	4.46	.098
DMI	21.98	22.45	22.46	NS
F/G	5.19	5.23	5.04	NS

Adding escape proteins to a urea based liquid supplement tended (P<.15) to improve steer performance during the initial feeding period (Set 3; Table 7). Performance by steers fed diet 7 was lower after reimplanting and, as a result, cumulative steer performance was not affected (P>.15) by including an escape protein. These diet comparisons should be replicated. The initial performance response to escape protein looked favorable. Further replication would help establish whether post-reimplant responses were real or if they were an artifact of this specific experiment. No mitigating circumstances were evident to explain the change in growth rate associated with diet 7. SBM caused greater ADG (P=.1096) and DMI (P=.0929) than urea + escape protein supplements. Most of this response occurred after re-implanting. When urea was fed without escape protein the SBM response existed during the initial feeding period as well. This further substantiates the evidence that there may be some advantage to including urea + escape protein.

The inclusion of microingredients in the liquid supplement depressed ADG (P=.0383) and DMI (P=.0674) after reimplanting (Set 5; Table 9). Overall DMI was depressed (P=.0552) when the liquid carrier was used. This is in direct contrast with previous research at this station. Possibilities for this outcome include reduced product mix stability or differences in actual monensin content of the diets. Unfortunately, monensin assays were not conducted on the dry and liquid supplements used.

Overall mean carcass values were dressing percent 60.5; carcass weight 792 lb; rib eye area 14.01 in.^{2}; rib fat thickness .44 in., and marbling score 5.00. We observed 51% choice carcasses. The carcass variables fit well within industry objectives. Table 10 depicts how purchase groups (blocks) affected carcass variables.

Carcass weights were greater (P<.01) when steers were fed SBM (Table 11). This confirms that the increases in ADG attributed to SBM were in fact gain and not a function of digestive tract fill. Diets had no other notable effects on carcass traits.

In previous experiments we have observed that when growth potential is high, SBM based supplements support higher ADG than urea based supplements. In most of those situations, SBM also stimulated DMI. In those experiments when the level of NPN was increased substantially, DMI was reduced with only slight decreases in ADG. This resulted in a favorable reduction in F/G as compared to lower CP, urea supplemented diets.

The conditions of this experiment substantiate the role of SBM for improving ADG although DMI was not affected. The numerical peak in performance was observed on treatment 5 which was 12.5% CP using a SBM based supplement. This level of performance was not different (P>.15) from that associated with the 11.5% CP (SBM) treatment 2.

The addition of escape proteins to urea based liquid supplements showed evidence of potential benefits, especially during the initial 42 days on feed. The change in relative performance during initial and final feeding phases for cattle fed diet 7 is unexplained. This treatment merits re-evaluation to determine if the response is in fact repeatable.

The basal diets used in this experiment could be labelled as typical, but they are not representative of all feedlot diets. Diets containing other ingredients may respond differently to these supplements. Most notably are diets containing higher protein corn co-products prevalent in this region. All high moisture corn or steam-flaked corn diets may also respond differently to the NPN based diets because of differences in ruminal starch fermentation.

Table 7. Set 3 comparisons: Urea vs urea + escape CP and 12 vs 13% CP

	Treatment				P	
	1	3	6	7		
	Urea (12%)	Urea (13%)	Urea + escape (12%)	Urea + escape (13%)	Urea vs urea + escape	12 vs 13% CP
Initial to re-implant						
ADG	3.93	4.20	4.36	4.42	.1221	NS
DMI	16.85	16.71	16.89	16.91	NS	NS
F/G	4.32	4.05	3.88	3.84	.0651	NS
Re-implant to final						
ADG	4.32	4.27	4.31	4.16	NS	NS
DMI	25.05	24.71	24.34	24.70	NS	NS
F/G	5.81	5.80	5.66	5.94	NS	NS
Cumulative						
ADG	4.19	4.24	4.33	4.25	NS	NS
DMI	22.25	21.98	21.80	22.04	NS	NS
F/G	5.32	5.19	5.05	5.19	NS	NS

Table 8. Set 4 comparisons: SBM vs urea plus escape protein

	Treatment				P	
	2	5	6	7		
	SBM (12%)	SBM (13%)	Urea + escape (12%)	Urea + escape (13%)	SBM vs urea + escape	12 vs 13% CP
Initial to re-implant						
ADG	4.32	4.35	4.36	4.42	NS	NS
DMI	16.79	16.64	16.89	16.91	NS	NS
F/G	3.90	3.85	3.88	3.84	NS	NS
Re-implant to final						
ADG	4.43	4.51	4.31	4.16	.0412	NS
DMI	25.78	25.47	24.34	24.70	.0514	NS
F/G	5.83	5.65	5.66	5.94	NS	NS
Cumulative						
ADG	4.39	4.46	4.33	4.25	.1096	NS
DMI	22.71	22.46	21.80	22.04	.0929	NS
F/G	5.18	5.04	5.05	5.19	NS	NS

Table 9. Set 5 comparisons: Dry and liquid micro-ingredient carriers

	Treatment				P<	
	2	5	8	9		
	Dry (12%)	Dry (13%)	Liquid (12%)	Liquid (13%)	Dry vs Liquid	12 vs 13% CP
Initial to re-implant						
ADG	4.32	4.35	4.35	4.73	.1414	.1341
DMI	16.79	16.64	16.86	16.24	NS	NS
F/G	3.90	3.85	3.88	3.44	.0561	.0296
Re-implant to final						
ADG	4.42	4.51	4.37	4.04	.0383	NS
DMI	25.78	25.47	24.89	24.11	.0674	NS
F/G	5.84	5.65	5.69	5.98	NS	NS
Cumulative						
ADG	4.39	4.46	4.37	4.27	NS	NS
DMI	22.71	22.46	22.15	21.43	.0552	NS
F/G	5.18	5.04	5.07	5.02	NS	NS

Table 10. Variation in carcass traits among blocks

	Least squares means		
	Block 1	Block 2	Block 3
Carcass weight, lb	763[b]	808[c]	816[c]
Dressing, %	60.0[b]	61.2[c]	60.3[b]
Rib eye area, in.^{2}	13.98	14.08	13.91
Rib fat thickness, in.	.44[b]	.43[b]	.47[c]
Marbling score[a]	5.1[b]	4.9[c]	5.0[bc]
Choice percent[d]	61.2	39.6	52.8

[a]4.0 = slight; 5.0 = small.
[b,c]Means without common superscripts differ ($P<.05$).
[d]Block effect ($P<.001$).

Table 11. Carcass traits for all treatments[a]

	Diets								
	1	2	3	4	5	6	7	8	9
Carcass weight[b]	785	802	789	797	804	794	792	797	799
Dressing, %	60.3	60.6	60.5	60.6	60.3	60.4	60.7	60.2	61.0
Rib eye area, in.^{2}	13.7	14.2	13.4	14.3	13.9	14.0	13.7	14.1	14.7
Rib fat thickness, in.	.45	.48	.46	.45	.44	.44	.41	.42	.46
Marbling score[c]	4.9	4.9	5.2	5.0	5.0	5.1	5.0	4.9	4.9
Choice, %[d]	50	38	67	43	63	62	55	45	38

[a]Least squares means.
[b]1 and 3 vs 2 and 5 ($P<.01$).
[c]4.0 = slight; 5.0 = small.
[d]Diet effect ($P=.050$).