FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

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AREA CODE 813 — 463-4744

March 1990 No. 185

ROLE OF MEAT AND BONE MEAL, HYDROLYZED FEATHER MEAL AND BLOOD MEAL IN THE DIETS OF NEW FEEDLOT CATTLE

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INTRODUCTION

Feed intake and therefore the provision of protein and other nutrients is a problem in newly received, stressed feeder cattle when they arrive at the feedlot. Urea, which is readily degraded in the rumen, is not the protein source of choice for new feeder cattle. We have shown that a mixture of slowly degraded protein (blood meal-corn gluten meal) is a more optimum protein source (J. Anim. Sci. 66:1871, 1988). Since blood meal is high in lysine, this may increase the biological value when blood meal is fed to cattle.

Feather meal is high in methionine and cystine, and methionine is thought to be the most limiting amino acid in ruminants. Feather meal is also slowly degradable in the rumen. Therefore, feather meal may also be a protein source of choice for new feeder cattle.

Meat and bone meal is moderately degraded in the rumen. With the exception of methionine + cystine, meat and bone meal has a fairly well-balanced amino acid profile for supplying the limiting amino aicds in rumen microbial protein. Therefore, a mixture of feather meal and meat and bone meal may provide complimentary amino acids to rumen microbial protein.

After methionine + cystine, the most limiting amino acid in rumen microbial protein is histidine and tryptophan. Since blood meal is a good source of these amino acids, some blood meal may be required to provide these amino acids.

Therefore, the objectives of the research reported here were as follows:

1. Determine amino acids that are first limiting in rumen bypass protein.
2. Determine the optimum proportion of supplemental animal byproduct proteins for receiving feeder cattle.

MATERIALS AND METHODS

Six supplemental protein combinations were compared by their inclusion in a typical receiving diet calculated to contain 12.2% crude protein in the diet dry matter; 40% of the dietary protein was supplied by the supplemental protein sources. These diets are shown in Tables 1-6. Cottonseed meal was fed as a standard supplemental protein source in the High Plains cattle feeding area and the combination of iso-protein amounts of blood meal and corn gluten meal was fed since this combination has given a marked improvement in the performance of newly received feeder cattle. Urea was also fed as a supplemental protein source which does not supply any rumen bypass protein. The remaining three treatments were combinations of meat and bone meal, hydrolyzed feather meal and blood meal to optimize the intake of various amino acids as follows: combination amounts are on a protein basis:

Meat and bone meal:hydrolyzed feather meal (38:62); optimize methionine + cystine.

Meat and bone meal:hydrolyzed feather meal (91:9) optimize histidine.

Meat and bone meal:hydrolyzed feather meal:blood meal (30:35:35); optimize methionine + cystine, histidine, tryptophan and lysine.

Feeder steers (518 head) were received at the Burnett Center for Beef Cattle Research from South Dakota and northern Nebraska on December 4, 1989. When they arrived, they were weighed, ear tagged, tails bobbed, vaccinated with a 4-way viral vaccine (Horizon IV) and injected subcutaneously with a systemic paraciticide (Ivomec). Most of the steers (480 head) were randomly placed into 60 partially slotted floor pens (8 head/pen; 10 pens per diet); the remaining 38 steers were used in another receiving experiment. Each pen had an automatic heated waterer and provided 20 ft^2 of floor space and 1 ft of bunk space per steer. Feed mixtures were prepared daily by a computer controlled batching and mixing system, and delivered to their respective bunks by a belt delivery system. Aureo-S-700 was fed for the first 21 days.

Feed intake and any health conditions were recorded during the experiment. After 31 days, the steers were weighed and reallotted to subsequent experiments. Average feed intake, gain and gain efficiency were calculated and statistically analyzed by least squares analysis using SAS.

RESULTS

Average initial weight ± standard deviation of these steers was 615 ± 18 lbs. Average daily feed intake, gain and feed efficiency are shown in Table 7. None of the daily gain differences presented in this table were statistically significant ($P > .05$). Intake of DM by steers fed the meat and bone meal, hydrolyzed feather meal and blood meal combinations was decreased (P=.004 to =.022) compared to steers fed urea. The blood meal:corn gluten meal fed steers also (P=.05) had lower DM intake. Feeding urea tended (P=.10) to decrease gain efficiency compared to feeding cottonseed meal. All of the steers fed supplemental protein from the animal sources had higher gain efficiences (P=.003 to =.03) than steers fed urea but were similar to steers fed cottonseed meal (P=.15 to =.60).

Part of the reason for the lack of statistical significance in daily gain in spite of differences that were 14% greater than steers fed urea, is the large variation (CV=15.7%) which is typical results during the receiving period.

Numerically, gains and efficiencies were greater in steers fed the three meat and bone meal plus hydrolyzed feather meal combinations compared to steers fed the blood meal:corn gluten meal combination (+3% and +6%, respectively), which inturn was numerically greater than for steers fed cottonseed meal (+2% and +4%, respectively), or urea (+10% and +18%, respectively).

When gain efficiency was correlated with the calculated bypass protein value of the supplemental protein, a fairly high correlation coefficient resulted

(+.92; Table 8) indicating that 84% of the variation in gain efficiency in this experiment was associated with the bypass protein value of the supplemental protein. Similar correlations with the essential amino acids, assuming their rumen bypass value is the same as the protein source supplying the amino acid, are also shown in Table 8. These correlations are large and positive indicating that the bypass of these essential amino acids was related to an improvement in gain efficiency of receiving cattle.

Figures 1 and 2 show the gain efficiency results as a function of the calculated bypass protein and bypass isoleucine, methionine + cystine and threonine. Linear regressions and correlations as well as the least-squares cubic response curves and correlation coefficients over the linear regressions and in the case of isoleucine, a near perfect fit (r=.998) resulted in this method of evaluating the data.

While the higher correlations using the cubic curves may be tentative, they do provide an estimate of bypass protein and amino acids which maximizes gain efficiency. This leads to the conclusion that 60% of the supplemental protein, or 41% of the total dietary protein, should be bypass protein to maximize gain efficiency. Similarly, 2.4%, 2.0% and 2.4% of the supplemental protein should be bypass isoleucine, methionine + cystine and threonine, respectively. Alternately, a protein combination with a 60% bypass protein value should contain 4%, 3.3% and 4% isoleucine, methionine + cystine and threonine, respectively, in the supplemental protein to optimize gain efficiency in newly received cattle.

In Table 9 are listed the calculated bypass levels of these amino acids in the protein sources used in this experiment. These figures indicate that hydrolyzed feather meal is the best source of bypass isoleucine followed by corn gluten meal, that hydrolyzed feather meal followed by corn gluten meal and blood meal are the best sources of bypass methionine + cystine, and that blood meal followed by hydrolyzed feather meal are the best sources of bypass threonine. These conclusions require verification in subsequent research.

Table 10 shows the analyzed crude protein values on the five supplemental sources of protein versus calculated values used in formulating the diets. In general, there is good agreement. Blood meal was higher (+13%) and cottonseed meal somewhat lower (-7%) in crude protein than calculated.

CONCLUSIONS

All bypass supplemental protein sources improved gains and gain efficiency of newly received feeder steers. Numerically, steers fed any of the meat and bone meal plus hydrolyzed feather meal combinations had better performance than steers fed any of the other supplemental protein sources. The major effect appeared to be due to total bypass protein with gain efficiency maximized when 60% of the supplemental protein, or 41% of the total dietary protein, was rumen bypass protein. When potential rumen bypass amino acids were calculated from the supplemental protein sources used in this experiment, bypass isoleucine, methionine + cystine and threonine appeared to be important. It was calculated that gain efficiency was maximized in newly received feeder steers when 2.4%, 2.0% and 2.4% of the supplemental protein was rumen bypass isoleucine, methionine + cystine and threonine, respectively.

Table 1. Calculated diet composition.

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TEXAS TECH UNIVERSITY

FORMULA: RECEIVING DIET (UREA, 12.5% CP)
DECEMBER 1989

FEED	% OF RATION	DM	COMPOSTION (DRY MATTER BASIS) NEM	CP	EE	CA	P	NA	K	S	ZN	Vit A	NDF	ROUGH EQUIV
CACO3	0.51	99				39.00	0.04	0.06	0.06					
DICAL PHOSPHATE	0.58	96				22.00	18.65		0.08	1.10	70			
KCL	0.41	99				0.05		1.00	50.00	0.45				
NACL	0.11	99						39.34						
TM PREMIX	0.28	92	0.85	10.34	3.01	1.28	0.30	0.03	0.38	0.13	7843		19	
VIT A PREMIX	0.19	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18	333333	20	
VIT E PREMIX	0.03	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
AS700 PREMIX	0.50	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
UREA	1.09	99		288.00										
COTTONSEED MEAL		91	0.81	46.00	1.90	0.20	1.15	0.05	1.50	0.35	72		32	
BLOOD MEAL		92	0.66	86.00	1.30	0.32	0.25	0.35	0.10	0.42	5			
MEAT & BONE MEAL		93	0.74	54.00	10.40	11.06	5.48	0.77	1.40	0.27	96			
FEATHER MEAL, HYD		93	0.71	90.00	3.80	0.22	0.80	0.76	0.30	1.70	53		20	
CORN GLUTEN MEAL		91	0.99	67.00	2.40	0.08	0.54	0.06	0.10	0.62	35	51400	14	
COTTONSEED HULLS	25.00	90	0.46	4.00	1.60	0.18	0.10	0.02	1.20	0.09	22		87	100
CORN SILAGE	40.00	32	0.71	8.40	2.90	0.24	0.22	0.01	1.00	0.13	16	68000	52	68
MILO STEAM FLAKED	26.80	82	0.96	11.50	3.20	0.04	0.32	0.03	0.40	0.14	18		20	
ANIM/VEG FAT	1.20	99	2.39		99.00									
MOLASSES, CANE	3.30	76	0.79	5.00		1.10	0.10	0.22	3.40	0.46	30			
COMPOSITION:														
AS-FED BASIS	100.00	65	0.46	7.83	2.65	0.43	0.23	0.07	0.78	0.09	32	9274	31	31
DM BASIS		100	0.72	12.14	4.11	0.67	0.36	0.10	1.21	0.14	50	14371	48	48

DP/NEM 50.25 gm/Kcal
NPN/CP 39.68 % OF CP
N/S 14.18
Ca/P 1.87

Table 2. Calculated diet composition.

DR.R.L. PRESTON
TEXAS TECH UNIVERSITY

FORMULA: RECEIVING DIET (CSM, 12.2% CP)
DECEMBER 1989

			COMPOSTION (DRY MATTER BASIS)											
FEED	% OF RATION	DM	NEM	CP	EE	CA	P	NA	K	S	ZN	Vit A	NDF	ROUGH EQUIV
CACO3	0.70	99				39.00	0.04	0.06	0.06					
DICAL PHOSPHATE	0.15	96				22.00	18.65		0.08	1.10	70			
KCL	0.21	99				0.05		1.00	50.00	0.45				
NACL	0.11	99						39.34						
TM PREMIX	0.22	92	0.85	10.34	3.01	1.28	0.30	0.03	0.38	0.13	7843		19	
VIT A PREMIX	0.19	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18	333333	20	
VIT E PREMIX	0.03	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
AS700 PREMIX	0.50	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
UREA		99		288.00										
COTTONSEED MEAL	9.39	91	0.81	46.00	1.90	0.20	1.15	0.05	1.50	0.35	72		32	
BLOOD MEAL		92	0.66	86.00	1.30	0.32	0.25	0.35	0.10	0.42	5			
MEAT & BONE MEAL		93	0.74	54.00	10.40	11.06	5.48	0.77	1.40	0.27	96			
FEATHER MEAL, HYD		93	0.71	90.00	3.80	0.22	0.80	0.76	0.30	1.70	53		20	
CORN GLUTEÑ MEAL		91	0.99	67.00	2.40	0.08	0.54	0.06	0.10	0.62	35	51400	14	
COTTONSEED HULLS	25.00	90	0.46	4.00	1.60	0.18	0.10	0.02	1.20	0.09	22		87	100
CORN SILAGE	40.00	32	0.71	8.40	2.90	0.24	0.22	0.01	1.00	0.13	16	68000	52	68
MILO STEAM FLAKED	19.00	82	0.96	11.50	3.20	0.04	0.32	0.03	0.40	0.14	18		20	
ANIM/VEG FAT	1.20	99	2.39		99.00									
MOLASSES, CANE	3.30	76	0.79	5.00		1.10	0.10	0.22	3.40	0.46	30			
COMPOSITION:														
AS-FED BASIS	100.00	65	0.47	7.91	2.61	0.43	0.23	0.07	0.78	0.10	33	9274	32	31
DM BASIS		100	0.72	12.15	4.00	0.66	0.35	0.10	1.20	0.16	50	14240	50	48

DP/NEM 50.00 gm/Kcal
NPN/CP 0.00 % OF CP
N/S 12.20
Ca/P 1.85

Table 3. Calculated diet composition.

DR.R.L. PRESTON
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FORMULA: RECEIVING DIET (50BM:50CGM, 12.2% CP)
DECEMBER 1989

			COMPOSTION (DRY MATTER BASIS)											
FEED	% OF RATION	DM	NEM	CP	EE	CA	P	NA	K	S	ZN	Vit A	NDF	ROUGH EQUIV
CACO3	0.52	99				39.00	0.04	0.06	0.06					
DICAL PHOSPHATE	0.50	96				22.00	18.65		0.08	1.10	70			
KCL	0.42	99				0.05		1.00	50.00	0.45				
NACL	0.09	99						39.34						
TM PREMIX	0.27	92	0.85	10.34	3.01	1.28	0.30	0.03	0.38	0.13	7843		19	
VIT A PREMIX	0.19	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18	333333	20	
VIT E PREMIX	0.03	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
AS700 PREMIX	0.50	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
UREA		99		288.00										
COTTONSEED MEAL		91	0.81	46.00	1.90	0.20	1.15	0.05	1.50	0.35	72		32	
BLOOD MEAL	2.25	92	0.66	86.00	1.30	0.32	0.25	0.35	0.10	0.42	5			
MEAT & BONE MEAL		93	0.74	54.00	10.40	11.06	5.48	0.77	1.40	0.27	96			
FEATHER MEAL, HYD		93	0.71	90.00	3.80	0.22	0.80	0.76	0.30	1.70	53		20	
CORN GLUTEN MEAL	2.93	91	0.99	67.00	2.40	0.08	0.54	0.06	0.10	0.62	35	51400	14	
COTTONSEED HULLS	25.00	90	0.46	4.00	1.60	0.18	0.10	0.02	1.20	0.09	22		87	100
CORN SILAGE	40.00	32	0.71	8.40	2.90	0.24	0.22	0.01	1.00	0.13	16	68000	52	68
MILO STEAM FLAKED	22.80	82	0.96	11.50	3.20	0.04	0.32	0.03	0.40	0.14	18		20	
ANIM/VEG FAT	1.20	99	2.39		99.00									
MOLASSES, CANE	3.30	76	0.79	5.00		1.10	0.10	0.22	3.40	0.46	30			
COMPOSITION:														
AS-FED BASIS	100.00	65	0.47	7.91	2.64	0.43	0.23	0.07	0.77	0.11	32	10644	31	31
DM BASIS		100	0.73	12.21	4.07	0.66	0.35	0.10	1.20	0.17	49	16420	47	48

DP/NEM 49.96 gm/Kcal
NPN/CP 0.00 % OF CP
N/S 11.70
Ca/P 1.89

Table 4. Calculated diet composition.

DR.R.L. PRESTON
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FORMULA: RECEIVING DIET (38MBM:62HFM, 12.2% CP)
DECEMBER 1989

FEED	% OF RATION	DM	NEM	CP	EE	CA	P	NA	K	S	ZN	Vit A	NDF	ROUGH EQUIV
		COMPOSTION (DRY MATTER BASIS)												
CACO3	0.15	99				39.00	0.04	0.06	0.06					
DICAL PHOSPHATE		96				22.00	18.65		0.08	1.10	70			
KCL	0.34	99				0.05		1.00	50.00	0.45				
NACL	0.02	99						39.34						
TM PREMIX	0.24	92	0.85	10.34	3.01	1.28	0.30	0.03	0.38	0.13	7843		19	
VIT A PREMIX	0.19	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18	333333	20	
VIT E PREMIX	0.03	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
AS700 PREMIX	0.50	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
UREA		99		288.00										
COTTONSEED MEAL		91	0.81	46.00	1.90	0.20	1.15	0.05	1.50	0.35	72		32	
BLOOD MEAL		92	0.66	86.00	1.30	0.32	0.25	0.35	0.10	0.42	5			
MEAT & BONE MEAL	2.59	93	0.74	54.00	10.40	11.06	5.48	0.77	1.40	0.27	96			
FEATHER MEAL, HYD	2.54	93	0.71	90.00	3.80	0.22	0.80	0.76	0.30	1.70	53		20	
CORN GLUTEN MEAL		91	0.99	67.00	2.40	0.08	0.54	0.06	0.10	0.62	35	51400	14	
COTTONSEED HULLS	25.00	90	0.46	4.00	1.60	0.18	0.10	0.02	1.20	0.09	22		87	100
CORN SILAGE	40.00	32	0.71	8.40	2.90	0.24	0.22	0.01	1.00	0.13	16	68000	52	68
MILO STEAM FLAKED	24.20	82	0.96	11.50	3.20	0.04	0.32	0.03	0.40	0.14	18		20	
ANIM/VEG FAT	0.90	99	2.39		99.00									
MOLASSES, CANE	3.30	76	0.79	5.00		1.10	0.10	0.22	3.40	0.46	30			
COMPOSITION:														
AS-FED BASIS	100.00	65	0.47	7.90	2.63	0.44	0.27	0.07	0.78	0.13	32	9274	31	31
DM BASIS		100	0.72	12.22	4.06	0.68	0.42	0.10	1.20	0.19	50	14337	48	48

DP/NEM 50.09 gm/Kcal
NPN/CP 0.00 % OF CP
N/S 10.07
Ca/P 1.63

Table 5. Calculated diet composition.

DR.R.L. PRESTON
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FORMULA: RECEIVING DIET (91MBM:9HFM, 12.2% CP)
DECEMBER 1989

FEED	% OF RATION	DM	NEM	CP	EE	CA	P	NA	K	S	ZN	Vit A	NDF	ROUGH EQUIV
			COMPOSTION (DRY MATTER BASIS)											
CACO3		99				39.00	0.04	0.06	0.06					
DICAL PHOSPHATE		96				22.00	18.65		0.08	1.10	70			
KCL	0.27	99				0.05		1.00	50.00	0.45				
NACL		99						39.34						
TM PREMIX	0.21	92	0.85	10.34	3.01	1.28	0.30	0.03	0.38	0.13	7843		19	
VIT A PREMIX	0.19	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18	333333	20	
VIT E PREMIX	0.03	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
AS700 PREMIX	0.50	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
UREA		99		288.00										
COTTONSEED MEAL		91	0.81	46.00	1.90	0.20	1.15	0.05	1.50	0.35	72		32	
BLOOD MEAL		92	0.66	86.00	1.30	0.32	0.25	0.35	0.10	0.42	5			
MEAT & BONE MEAL	6.31	93	0.74	54.00	10.40	11.06	5.48	0.77	1.40	0.27	96			
FEATHER MEAL, HYD	0.38	93	0.71	90.00	3.80	0.22	0.80	0.76	0.30	1.70	53		20	
CORN GLUTEN MEAL		91	0.99	67.00	2.40	0.08	0.54	0.06	0.10	0.62	35	51400	14	
COTTONSEED HULLS	25.00	90	0.46	4.00	1.60	0.18	0.10	0.02	1.20	0.09	22		87	100
CORN SILAGE	40.00	32	0.71	8.40	2.90	0.24	0.22	0.01	1.00	0.13	16	68000	52	68
MILO STEAM FLAKED	23.20	82	0.96	11.50	3.20	0.04	0.32	0.03	0.40	0.14	18		20	
ANIM/VEG FAT	0.60	99	2.39		99.00									
MOLASSES, CANE	3.30	76	0.79	5.00		1.10	0.10	0.22	3.40	0.46	30			
COMPOSITION:														
AS-FED BASIS	99.99	65	0.46	7.87	2.59	0.76	0.44	0.07	0.78	0.10	32	9274	30	31
DM BASIS		100	0.72	12.15	4.00	1.17	0.68	0.10	1.20	0.15	50	14321	47	48

DP/NEM 50.16 gm/Kcal
NPN/CP 0.00 % OF CP
N/S 12.68
Ca/P 1.72

Table 6. Calculated diet composition.

DR.R.L. PRESTON
TEXAS TECH UNIVERSITY

FORMULA: RECEIVING DIET (30MBM:35HFM:35BM, 12.2% CP)
DECEMBER 1989

FEED	% OF RATION	DM	NEM	CP	EE	CA	P	NA	K	S	ZN	Vit A	NDF	ROUGH EQUIV
			COMPOSTION (DRY MATTER BASIS)											
CACO3	0.25	99				39.00	0.04	0.06	0.06					
DICAL PHOSPHATE		96				22.00	18.65		0.08	1.10	70			
KCL	0.36	99				0.05		1.00	50.00	0.45				
NACL	0.03	99						39.34						
TM PREMIX	0.25	92	0.85	10.34	3.01	1.28	0.30	0.03	0.38	0.13	7843		19	
VIT A PREMIX	0.19	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18	333333	20	
VIT E PREMIX	0.03	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
AS700 PREMIX	0.50	90	0.90	10.78	5.20	0.04	0.31	0.03	0.39	0.14	18		20	
UREA		99		288.00										
COTTONSEED MEAL		91	0.81	46.00	1.90	0.20	1.15	0.05	1.50	0.35	72		32	
BLOOD MEAL	1.50	92	0.66	86.00	1.30	0.32	0.25	0.35	0.10	0.42	5			
MEAT & BONE MEAL	2.05	93	0.74	54.00	10.40	11.06	5.48	0.77	1.40	0.27	96			
FEATHER MEAL, HYD	1.44	93	0.71	90.00	3.80	0.22	0.80	0.76	0.30	1.70	53		20	
CORN GLUTEN MEAL		91	0.99	67.00	2.40	0.08	0.54	0.06	0.10	0.62	35	51400	14	
COTTONSEED HULLS	25.00	90	0.46	4.00	1.60	0.18	0.10	0.02	1.20	0.09	22		87	100
CORN SILAGE	40.00	32	0.71	8.40	2.90	0.24	0.22	0.01	1.00	0.13	16	68000	52	68
MILO STEAM FLAKED	24.10	82	0.96	11.50	3.20	0.04	0.32	0.03	0.40	0.14	18		20	
ANIM/VEG FAT	1.00	99	2.39		99.00									
MOLASSES, CANE	3.30	76	0.79	5.00		1.10	0.10	0.22	3.40	0.46	30			
COMPOSITION:														
AS-FED BASIS	100.00	65	0.47	7.89	2.65	0.42	0.24	0.06	0.78	0.11	32	9274	31	31
DM BASIS		100	0.72	12.19	4.10	0.66	0.37	0.10	1.20	0.17	50	14334	47	48

DP/NEM 49.99 gm/Kcal
NPN/CP 0.00 % OF CP
N/S 11.21
Ca/P 1.79

Table 7. Effect of protein source for receiving feedlot steers on intake, gain and efficiency.

Supplemental protein	Av. daily intake[a]	Av. daily gain[b]	Gain/intake[c]
Urea	16.55	2.40	14.43
Cottonseed meal	15.87	2.59	16.36
50 BM:50 CGM[d]	15.66	2.65	16.96
38 MBM:62 HFM	15.22	2.75	18.05
91 MBM:9 HFM	15.52	2.74	17.72
30 MBM:35 HFM:35 BM	15.32	2.74	17.88
SEM	.311	.131	.807

[a]DM intake, lb.

[b]lb.

[c]Gain, lb/100 lb DM intake.

[d]Abbreviations:

BM = blood meal
CGM = corn gluten meal
HFM = hydrolyzed feather meal
MBM = meat and bone meal

Table 8. Correlations between the calculated supplemental bypass protein or amino acids and gain efficiency.

Bypass protein or amino acid	Correlation coefficient
Bypass protein	+ .92
Bypass arginine	+ .87
Bypass histidine	+ .52
Bypass isoleucine	+ .92
Bypass leucine	+ .59
Bypass lysine	+ .83
Bypass methionine + cystine	+ .86
Bypass phenylalanine + tyrosine	+ .62
Bypass threonine	+ .89
Bypass tryptophan	+ .66
Bypass valine	+ .85

Table 9. Calculated rumen bypass amino acids in sources of supplemental protein.

Supplemental protein source	Amino Acid		
	Isoleucine	Methionine + cystine	Threonine
	(% of crude protein)		
Blood meal	.89	2.18	3.66
Corn gluten meal	2.44	2.66	2.12
Cottonseed meal	1.43	1.37	1.33
Feathermeal, hydrolyzed	3.44	3.21	3.37
Meat and bone meal	1.69	1.18	1.70

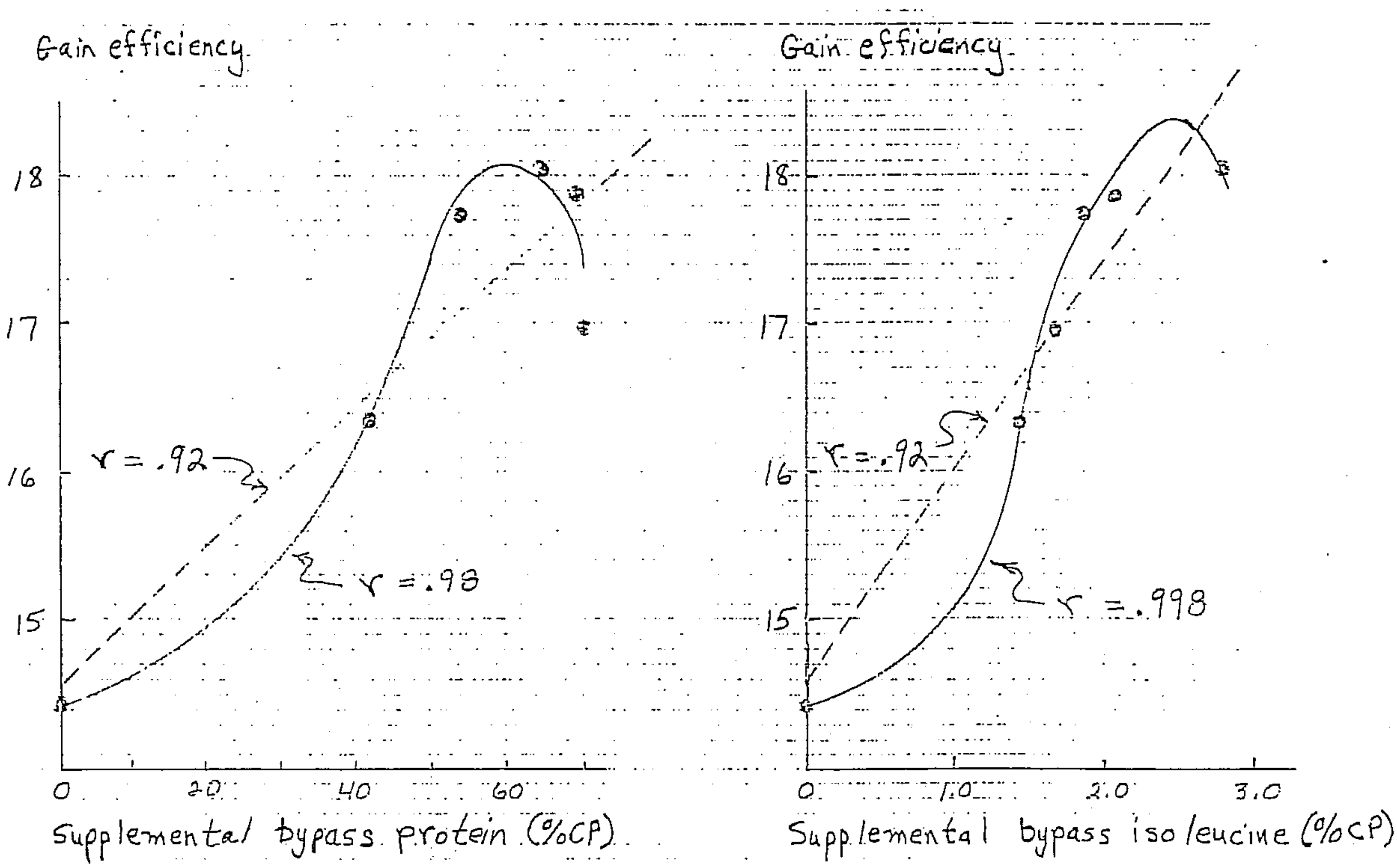

Figure 1. Gain efficiency as affected by rumen bypass protein and isoleucine.

Table 10. Actual versus calculated crude protein values for supplemental sources of protein.

Feed	% Dry matter	% Crude protein (DM basis)	
		Actual	Calculated
Blood meal	91.2	97.0	86
Corn gluten meal	90.2	67.3	67
Cottonseed meal	91.4	42.8	46
Feather meal, hydrolyzed	95.6	87.2	90
Meat and bone meal	96.1	53.9	54

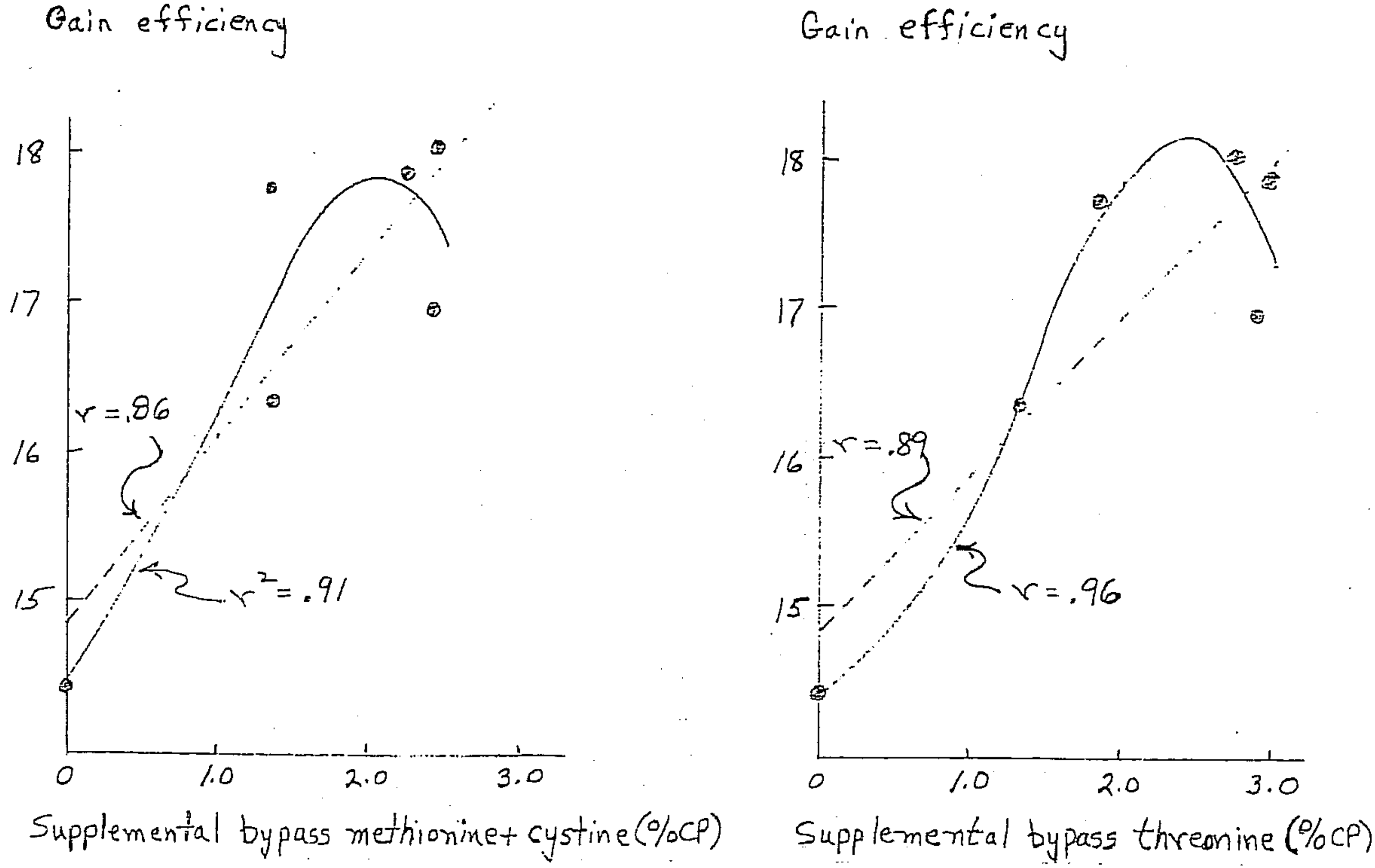

Figure 2. Gain efficiency as affected by rumen bypass methionine + cystine and threonine.