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Effect of Amino Acid Supplementation of Rations Containing Meat and Bone Scraps on Rate of Gain, Feed Conversion and Digestibility of Certain Ration Components for Growing-Finishing Swine

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EFFECT OF AMINO ACID SUPPLEMENTATION OF RATIONS CONTAINING MEAT AND BONE SCRAPS ON RATE OF GAIN, FEED CONVERSION AND DIGESTIBILITY OF CERTAIN RATION COMPONENTS FOR GROWING-FINISHING SWINE [1]

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PREVIOUS work at this station (Peo and Hudman, 1962) has shown that meat and bone scraps, when fed at levels from 5 to 10% of the total ration, significantly depress rate of gain of growing-finishing swine. Similar results have been reported by Bloss *et al.* (1953), Terrill *et al.* (1954), Meade and Teter (1957), and Becker and Jensen (1961).

Some possible reasons for this depression in rate of gain are (1) poor quality meat and bone scraps (Rohlf, 1954), (2) reduction in the consumption of rations containing high levels of meat and bone scraps (Peo and Hudman, 1962), (3) an imbalance of certain essential amino acids (Bloss *et al.*, 1953), and (4) lack of availability of essential amino acids (Meade and Teter, 1957). Of these the latter two appear to be more plausible, since Bloss *et al.* (1953) and Meade and Teter (1957) have reported significant growth responses with the addition of tryptophan to meat and bone scrap rations. However, the opportunity for a tryptophan deficiency was greater in their studies, since more of the total ration protein originated from meat and bone scraps (known to be low in tryptophan) than in the rations used by Peo and Hudman (1962).

In the present study rations containing meat and bone scraps were supplemented with lysine, methionine or tryptophan and combinations of these amino acids. The effect of these regimens on rate of gain, feed efficiency and digestibility of certain dietary components was determined in growing-finishing swine.

Experimental

Experiment 1. Seventy Duroc x Hampshire-Yorkshire pigs averaging 48.3 lb. live weight were allotted at random within weight groups to two replications of five experimental treatments. The pigs were housed and group-fed in concrete-floored pens which were equipped with self feeders and waterers.

Composition of the experimental rations is presented in table 1. A corn-soybean meal (CSB) ration was used as the comparative basal ration. Meat and bone scraps (MBS) were substituted for soybean meal at levels of 5.0% and 10.0% of the total ration. A blend of four commercial products served as the source of meat and bone scraps. The MBS rations were fed with and without L-lysine and DL-methionine. At the 5% level of MBS, the respective lysine and methionine additions were 0.039% and 0.009% of the total ration. At the 10% MBS level, the additions of lysine and methionine were 0.093% and 0.088% of the total ration. The level of amino acid supplementation was determined by the calculated level of lysine (0.605%), and methionine and cystine (0.489%) in the CSB ration. The level of tryptophan was held constant at 0.13% of the total ration for all treatments. Since the ration formulated with 10% MBS calculated 1.0% calcium and 0.7% phosphorus, all rations were adjusted to these levels. The rations were fed in meal form. The experiment was conducted for 84 days.

Experiment 2. Eighty-four Duroc x Hampshire-Yorkshire pigs averaging 43.7 lb. live weight were allotted at random within weight groups to two replications of six experimental treatments. Housing and management were essentially the same as described for Experiment 1. Composition of the experimental rations is shown in table 1. A CSB ration was used as the comparative basal ration. For the other treatments, meat and bone scraps replaced soybean meal at a level of 10.0% of the total ration. One 10% MBS ration was fed at the 16.0% protein level; the others

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were fed at the 14.0% protein level. A blend of four commercial products served as the source of MBS. Three MBS rations were supplemented with DL-tryptophan, DL-methionine and a combination of DL-tryptophan+DL-methionine. The respective levels of DL-tryptophan and DL-methionine additions were 0.041% and 0.021% of the total ration. All rations were adjusted to a constant level of 1.0% calcium and 0.7% phosphorus. The experiment was terminated at the end of 77 days.

Experiment 3. Eighty Duroc x Hampshire-Yorkshire pigs averaging 55.7 lb. live weight were allotted at random within weight groups to two replications of five experimental treatments. Housing and management were the same as described previously. Composition of the experimental rations is shown in table 1. A 14% protein CSB ration was again used as the comparative basal ration. For the other treatments, meat and bone scraps replaced soybean meal at a level of 10.0% of the total ration. A blend of three commercial products served as the source of MBS. Three MBS rations were supplemented with DL-tryptophan, DL-tryptophan+L-lysine, and DL-tryptophan+L-lysine+DL-methionine. DL-tryptophan, L-lysine and DL-methionine were added at levels of 0.025%, 0.10%, and 0.05% of the total ration, respectively. All rations were adjusted to a constant level of 1.0% calcium and 0.7% phosphorus. The experiment was conducted for 77 days.

Digestion trials were conducted by the indicator method on all animals during the eighth week of the experiment using a 5 x 5 factorial with a randomized complete block design. Chromic oxide was used as the indicator at a level of 0.5% of the total ration. It was mechanically mixed into the ration and was self-fed to the pigs in meal form for 9 days. A grab fecal sample was collected daily from each pig during the last 5 days of the 9-day period. A different time was used each day for the collection, i.e., 10 a.m., 1 p.m., 3 p.m., 8 a.m., and 9 a.m., for days 5 to 9, respectively. The selection of time for a par-

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS

	Experiment 1			Experiment 2			Experiment 3	
Ration designation	A	B,C[a]	D,E[b]	A	B	C,D,E,F[c]	A	B,C,D,E[d]
Treatment[e]	CSB	5% MBS	10% MBS	CSB	10% MBS	10% MBS	CSB	10% MBS
Ingredients, lb.								
Ground yellow corn	81.3	83.1	84.9	81.3	80.4	84.9	81.3	85.1
50% soybean meal	13.8	8.6	3.5	13.8	8.0	3.5	13.8	3.3
50% meat and bone scraps[f]	...	5.0	10.0	...	10.0	10.0	...	10.0
Salt (iodized)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	2.4	1.2	...	2.4	...	...	2.4	...
Ground limestone	0.9	0.5	...	0.9	...	...	0.9	...
Trace minerals[g]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin-antibiotic premix[h]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calculated content, %								
Protein	14.0	14.0	14.0	14.0	16.0	14.0	14.0	14.0
Calcium	1.00	1.03	1.01	1.00	1.02	1.01	1.00	1.01
Phosphorus	.73	.73	.73	.72	.75	.73	.72	.73
DL-tryptophan[i]	.137	.137	.137	.137	.137	.114	.137	.114
L-lysine[j]	.605	.566	.512	.613	.667	.540	.540	.535
DL-methionine[k]	.489	.480	.401	.489	.527	.468	.489	.469

[a] Supplemented with 0.039% L-lysine and 0.009% DL-methionine for ration C.
[b] Supplemented with 0.093% L-lysine and 0.088% DL-methionine for ration E.
[c] Supplemented with 0.041% DL-tryptophan for rations D and F, 0.021% DL-methionine for rations E and F.
[d] Supplemented with 0.025% DL-tryptophan for rations C, D, and E, 0.10% L-lysine for rations D and E, and 0.05% DL-methionine for ration E.
[e] CSB-corn-soybean meal basal, MBS-meat and bone scraps.
[f] Blend of four commercial sources in Experiments 1 and 2, three sources in Experiment 3.
[g] Calcium Carbonate Company standard swine mix (5% zinc), 0.015% additional zinc was added to the total rations in Experiment 3.
[h] Contributed the following amounts of vitamins and antibiotics per pound of complete rations. Experiment 1 and 2: vit. A, 1200 I.U.; vit. D_2, 180 I.U.; riboflavin, 1.0 mg.; niacin, 4.5 mg.; calcium pantothenate, 2.0 mg.; choline chloride, 105.0 mg.; vit. B_{12}, 5.0 mcg.; oxytetracycline, 10.0 mg. Experiment 3—Ration A: vit. A, 1200 I.U.; vit. D_2, 120 I.U.; riboflavin, 0.92 mg.; calcium pantothenate, 3.38 mg.; choline chloride, 8.0 mg.; vit. B_{12}, 5.0 mcg.; oxytetracycline, 10 mg.—Rations B, C, D, and E: vit. A, 1200 I.U.; vit. D_2, 120 I.U.; riboflavin, 0.88 mg., calcium pantothenate 3.75 mg.; choline chloride, 61.9 mg.; vit. B_{12}, 5.0 mcg.; oxytetracycline, 10.0 mg.
[i] Source: DL-Tryptophan (84.8%).
[j] Source: Lyamine (20.0% L-lysine).
[k] Source: DL-methionine (98.2%).

TABLE 2. EFFECT OF AMINO ACID SUPPLEMENTATION OF MEAT AND BONE SCRAP RATIONS ON RATE OF GAIN AND FEED EFFICIENCY OF SWINE (EXPERIMENT 1)[a]

Ration designation[b]	E	C	B	A	D
Treatment	10% MBS + lys. and met.	10% MBS	5% MBS	CSB	5% MBS + lys. and met.
Pens per treatment, no.	2	2	2	2	2
Pigs per pen, no.	7	7	7	7	7
Av. initial wt., lb.	48.3	48.4	48.1	48.5	48.3
Av. final wt., lb.	176.4	190.0	193.6	201.8	201.9
Av. daily gain, lb.[c, d]	1.52	1.68	1.73	1.82	1.83
Av. daily feed intake, lb.[c, d]	5.18	5.73	5.86	5.93	6.10
Feed per lb. gain, lb.[c, d]	3.40	3.39	3.38	3.24	3.34

[a] Duration of experiment, 84 days.
[b] See table 1 for composition.
[c] Means not underlined by the same line are significantly ($P<.05$) different.
[d] Error mean squares (replication x treatment) for gain, feed intake and feed/lb. gain are 0.0028, 0.0599 and 0.0048, respectively.

ticular day was made at random from the five designated time periods. The samples were composited for each pen and frozen immediately in tightly sealed plastic bags until they could be processed. The samples then were thoroughly mixed with a home-type, twin-beater mixer, dried at 65° C. for 48 hours and ground through a 1.0 mm. screen in a Wiley mill. Chromic oxide was determined by the dry ash method as outlined by Christian and Coup (1954). Dry matter, energy, and nitrogen analysis were determined by modified methods of the procedures outlined by the A.O.A.C. (1950).

In all three experiments, pig weights and feed data were collected at 2-week intervals. The average of the pen of pigs was used as the experimental unit for each criterion. Duncan's new multiple range test (Steel and Torrie, 1960) was used to test for significance among treatment means. Statements concerning statistical significance are made at $P<.05$.

Results and Discussion

Experiment 1. The results of this experiment are presented in table 2. The greatest average daily gains (1.82 and 1.83 lbs., respectively) were made by pigs fed the CSB ration (treatment A) and the 5% MBS ration supplemented with 0.039% L-lysine and 0.009% DL-methionine (treatment D). These gains were significantly greater than the 1.52 lb./day made by the pigs fed the 10% MBS ration supplemented with lysine and methionine (treatment E). The difference in average daily gain between treatments A and C approached significance. The addition of lysine and methionine to the 5% MBS ration resulted in a significant increase in average daily gain over treatments C and E, but the increase gain was not significantly greater than that obtained with treatment A or the 5% MBS ration without amino acid supplementation (treatment B). When methionine and lysine were added to the 10% MBS ration, a significant decrease was noted in average daily gains. It appears, therefore, that lysine and methionine are not the first limiting amino acids in a ration containing 10% MBS. As indicated by Bloss *et al.* (1953), tryptophan is probably the first limiting amino acid in a ration containing high levels of meat and bone scraps. Thus, when lysine and methionine were added to the 10% meat and bone scrap ration, an amino acid imbalance was created which did not appear to occur at the 5% MBS level. Apparently, the tryptophan level was adequate for optimum growth at the 5% but not at the 10% level of MBS.

There was a significant increase in average daily feed intake with ration treatments A and D as compared with treatment E. The decrease in daily feed intake with treatment E might have been caused by the apparent amino acid imbalance which existed with this ration. There were no significant differences among rations for feed required per pound of gain. However, less feed was required per pound of gain with treatment A (0.10 to 0.16 lb.) than with the other treatments.

Experiment 2. The results of this experiment are shown in table 3. No significant

TABLE 3. EFFECT OF AMINO ACID SUPPLEMENTATION OF MEAT AND BONE SCRAP ON RATE OF GAIN AND FEED EFFICIENCY OF SWINE (EXPERIMENT 2)[a]

Ration designation[b]	C	E	A	F	D	B
Treatment	10% MBS	10% MBS + met.	CSB	10% MBS + met. and try.	10% MBS + try.	10% MBS
Protein level, %	14.0	14.0	14.0	14.0	14.0	16.0
Pens per treatment, no.	2	2	2	2	2	2
Pigs per pen, no.	7	7	7	7	7	7
Av. initial wt., lb.	43.5	43.7	43.9	43.6	43.8	43.8
Av. final wt., lb.	163.9	166.9	173.4	173.8	177.7	180.1
Av. daily gain, lb.[c, d]	1.56	1.60	1.68	1.69	1.74	1.77
Av. daily feed intake, lb.[c, d]	5.05	4.96	5.52	5.45	5.81	5.72
Feed per lb. gain, lb.[c, d]	3.23	3.07	3.28	3.22	3.33	3.24

[a] Duration of experiment, 77 days.
[b] See Table 1 for composition.
[c] No significant differences were noted among treatment means.
[d] Error mean squares (replication x treatments) for gain, feed intake and feed/lb. gain are 0.0064, 0.1356 and 0.0123, respectively.

differences were observed among treatments in rate of gain, daily feed intake or feed required per pound of gain. However, the greatest average daily gain (1.77 lb.) was made with pigs fed the 16% protein-10% MBS ration (treatment B). These gains were 0.21 and 0.09 lb. per day higher than the 14% protein-10% MBS ration (treatment C) and the 14% protein-CSB ration (treatment A), respectively. The difference in gain between treatments B and C approached significance. The results suggest, therefore, that meat and bone scraps can effectively replace part of the soybean meal as a protein supplement if a greater percent of total protein is used in the ration.

Although it was non-significant, an increase in average daily gains was noted with the 10% MBS ration supplemented with tryptophan (0.05 to 0.18 lb.). Again, it appears that methionine may not be a primary limiting amino acid in a high level meat and bone scrap ration (treatment E), as only a slight increase in growth rate was noted compared to the 10% MBS ration without amino acid supplementation (treatment C).

Experiment 3. The results of the growth study are presented in table 4. The greatest gains were made by the pigs fed the CSB ration, but they were followed closely by those fed the 10% MBS ration supplemented with tryptophan (treatment C) and the 10%

TABLE 4. EFFECT OF AMINO ACID SUPPLEMENTATION OF MEAT AND BONE SCRAP RATIONS ON RATE OF GAIN AND FEED EFFICIENCY OF SWINE (EXPERIMENT 3)[a]

Ration designation[b]	E	D	B	C	A
Treatment	10% MBS + try., lys. and met.	10% MBS + try. and lys.	10% MBS	10% MBS + try.	CSB
Pens per treatment, no.	2	2	2	2	2
Pigs per pen, no.	8	8	8	8	8
Av. initial wt., lb.	55.2	56.0	56.6	55.1	55.7
Av. final wt., lb.	176.1	184.4	189.2	190.2	192.8
Av. daily gain, lb.[c, d]	1.57	1.66	1.72	1.76	1.78
Av. daily feed intake, lb.[c, d]	5.51	5.56	5.99	6.08	6.23
Feed per lb. gain, lb.[d]	3.51[e]	3.34[e]	3.48	3.46	3.48

[a] Duration of experiment, 77 days. One pig removed from Ration A because of parakeratosis.
[b] See Table 1 for composition.
[c] Means not underlined by the same line are significantly (P<.05) different.
[d] Error mean squares (replication x treatments) for gain, feed intake and feed/lb. gain are 0.0024, 0.0277, and 0.0037, respectively
[e] Difference between these two means is significant (P<.05).

MBS ration without amino acid supplementation (treatment B). The gains for these three treatments were significantly greater than gains obtained with the 10% MBS ration supplemented with a combination of tryptophan, lysine and methionine (treatment E). Gains were also depressed when tryptophan and lysine were added in combination to a 10% MBS ration (treatment D). The addition of amino acids other than tryptophan may have caused an imbalance or, as suggested by Pfander and Tribble (1955), the added amino acids may have been rapidly absorbed from the digestive tract and excreted before the bound amino acids of the ration were made available by the digestive tract. Pigs fed ration treatments A and C consumed significantly greater amounts of feed per day than those fed treatments D and E. Significantly less feed was required per pound of gain with treatment D than with treatment E.

It is apparent from growth studies of the three experiments that neither lysine nor methionine is the second limiting amino acid in a 10% MBS ration for growing-finishing swine. It also appears that a 14% protein ration containing 10% MBS nearly meets the pig's requirements for tryptophan. The 10% MBS ration was calculated to contain 0.114% tryptophan, a level slightly higher than that suggested by Hays (1961) as the requirement for swine fed a 14% protein ration. However, since a growth response was obtained with additional tryptophan, it appears that the tryptophan requirement of swine on a 14% protein ration is either greater than 0.11%, or the availability of tryptophan in meat and bone scraps is poor.

Digestion coefficients for dry matter, energy, and nitrogen for the various treatments in experiment 3 are presented in table 5. No significant differences due to treatment were observed for nitrogen digestibility. However, the 10% MBS (treatment B) was highest, while those on the CSB ration (treatment A) were lowest in nitrogen digestibility (72.3% vs. 69.1%). Also, nitrogen digestibility tended to decrease with the 10% MBS rations as the number of amino acids supplemented was increased. Although nitrogen digestibility decreased with the addition of tryptophan to a 10% MBS ration, average daily gains showed a small increase. It ap-

TABLE 5. EFFECT OF RATION TREATMENT AND TIME OF SAMPLING ON THE DIGESTIBILITY OF DRY MATTER, ENERGY AND NITROGEN BY SWINE (EXPERIMENT 3)

Ration designation	Treatments [a]	Ration component	Digestion coefficients [b]					Av. of treatment
			Time of collections [c]					
		Dry matter [e, f]	3 p.m.	8 a.m.	1 p.m.	10 a.m.	9 a.m.	
E	10% MBS+try.+lys.+met.		78.1	75.8	78.8	81.1	81.2	79.0
A [d]	CSB		77.2	76.5	79.8	79.4	83.0	79.2
D	10% MBS+try.+lys.		80.6	77.2	77.4	82.2	81.1	79.7
C [d]	10% MBS+try.		78.4	82.1	79.7	83.1	81.7	81.0
B	10% MBS		79.0	82.2	80.2	83.1	82.7	81.4
		Av. of time	78.7	78.8	79.2	81.8	81.9	
		Energy [e, f]	3 p.m.	8 a.m.	1 p.m.	10 a.m.	9 a.m.	
E	10% MBS+try.+lys.+met.		77.5	76.0	78.4	81.1	80.9	78.8
D	10% MBS+try.+lys.		80.6	78.1	78.5	81.2	83.2	80.3
A [d]	CSB		79.2	77.8	81.0	81.4	83.6	80.6
C [d]	10% MBS+try.		79.0	83.8	80.3	83.4	82.0	81.7
B	10% MBS		81.4	82.6	80.7	82.2	82.8	82.0
		Av. of time	79.5	79.7	79.8	81.8	82.5	
		Nitrogen [e, f]	8 a.m.	1 p.m.	3 p.m.	10 a.m.	9 a.m.	
A [d]	CSB		63.4	68.2	69.5	68.2	76.2	69.1
E	10% MBS+try.+lys.+met.		65.2	69.2	68.6	73.3	71.6	69.6
D	10% MBS+try.+lys.		66.2	69.1	72.8	71.8	71.8	70.4
C [d]	10% MBS+try.		74.4	70.4	66.8	74.5	73.2	71.9
B	10% MBS		74.4	67.9	69.4	75.0	74.8	72.3
		Av. of time	68.8	69.0	69.4	72.6	73.5	

[a] See table 1 for exact composition.
[b] Each coefficient is a composited average of two replications of 8 pigs per pen (16 pigs per treatment).
[c] Samples taken daily for 5 days. Time was randomly selected.
[d] Samples collected from only 14 pigs on ration A and 15 pigs on ration C at 3 p.m.
[e] Error mean squares (rations x time) for dry matter, energy and nitrogen digestion coefficients are 4.96, 4.60 and 18.45, respectively.
[f] Means not joined by same line are significantly ($P<.05$) different.

pears that the amount of tryptophan available for gain (nitrogen digestion coefficients x percent tryptophan in total ration) may have been as much as 0.10% for the 10% MBS ration plus tryptophan, as compared to only 0.084% for the 10% MBS ration without amino acid supplementation, indicating that additional tryptophan may be desirable for optimum growth in a 10% MBS-14% protein ration.

A significant difference in nitrogen digestibility was observed due to the time the collections were made. Digestion coefficients obtained from collections made at 8 a.m. and 1 p.m. were significantly lower than were obtained from the 9 a.m. collection. There was no significant treatment x time interaction.

Pigs on treatment B showed a significantly higher dry matter digestibility than those on treatment E. Similarly to nitrogen, the digestibility of dry matter tended to decrease with the 10% MBS rations as the number of amino acids supplemented was increased. There was a significant difference in dry matter digestibility due to time of collection. Collections made at 3 p.m., 8 a.m. and 1 p.m. resulted in significantly lower digestibilities than those made at 9 a.m. and 10 a.m. There was no significant treatment x time interaction.

Treatment C and B produced significantly higher energy digestibilities than treatment E. Energy digestion by the pigs on the 10% MBS rations tended to decrease as the number of amino acids supplemented was increased. Time of fecal collection appeared to influence energy digestibility. Significantly lower digestion coefficients were obtained from collections made at 3 p.m. and 8 a.m., than from collections made at 10 a.m. and 9 a.m. Energy digestion coefficients obtained from collections made at 1 p.m. were significantly lower than from collections made at 9 a.m. There was no significant treatment x time interaction.

It is apparent from dry matter, energy and nitrogen digestion coefficients, that the successive addition of amino acids tended to lower digestibility. The lowered digestion coefficients help explain the depressed growth rate resulting from the addition of amino acids with the exception of tryptophan. As previously indicated, although the digestion coefficient was lowered slightly by the addition of tryptophan, it appears that actually a greater amount of tryptophan was available to the animal, thus explaining the slight growth response.

In nitrogen digestibility the CSB ration was lowest of all treatments compared, although it produced the highest average daily gains. However, the average daily feed intake of pigs on the CSB ration was 0.15 to 0.72 lb. higher than the intake of pigs on the other treatments, suggesting that the pigs ate more than was required for optimum growth, which perhaps resulted in lower digestion coefficients.

Time of collection in a digestion trial using an indicator appears to be a factor of importance. The collections made at 10 a.m. and 9 a.m. were consistently higher in dry matter, energy and nitrogen digestibility than collections made at 8 a.m., 1 p.m. and 3 p.m. This is in agreement with the findings of Clawson *et al.* (1955) that the rate of recovery of chromic oxide is slightly higher in the morning than in the afternoon, thus affecting the digestion coefficients accordingly. Although collections made at 8 a.m. were the reverse of this pattern, it is felt that collections made at 8 a.m. were essentially the same as those that could have been made at 5 p.m. The collections were taken in January with the temperature approaching 0° F., which probably resulted in the pigs' being relatively inactive from 5 p.m. to 8 a.m. the next morning.

It appears that collections should be made at different times and for several days to establish the true pattern of digestibility of ration components. However, the lack of interaction of treatment with time of day indicates that any one time of day is sufficient for comparing treatments.

Summary

Three experiments were conducted with 234 crossbred pigs to determine the effects of lysine, methionine and tryptophan supplementation to rations containing 5 and 10% meat and bone scraps on rate of gain, feed conversion and digestibility of certain ration components of growing-finishing swine. In all three experiments the addition of amino acids to rations containing meat and bone scraps failed to give a significant increase in rate of gain. However, in most instances the addition of tryptophan did result in improved gain. The failure of amino acid supplementation other than trytophan to give a growth re-

sponse appeared to be due to an amino acid imbalance.

In experiments 1 and 3 average daily feed intake tended to decrease with the 10% MBS rations when lysine and methionine or combinations of these amino acids were added to the ration. Feed required per pound of gain was not affected by the treatments.

Digestion studies using the chromic oxide indicator showed that dry matter, energy, and nitrogen digestibility tended to decrease as the number of amino acids supplemented was increased. Time of collection also appeared to be an influencing factor since dry matter, energy and nitrogen digestion coefficients tended to be higher in the morning than in the afternooon except for the collection made at 8 a.m.

It is evident from these experiments that meat and bone scraps with or without amino acid supplementation do not improve a properly supplemented corn-soybean ration. However, meat and bone scraps can effectively replace part of the soybean meal as a protein supplement if a greater percent of total protein is used in the ration.

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