

SULFUR AMINO ACID REQUIREMENT
OF GROWING AND FINISHING PIGS

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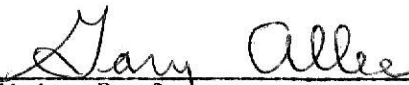
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GENERAL INTRODUCTION

The dramatic changes that are taking place in commercial pork production, plus the availability of new grain varieties and high protein feedstuffs, creates a need to continually evaluate nutritional programs in order to optimize pig performance.

The pork industry has made significant progress in the last decade toward the production of more muscular pigs with decreased fat. This in turn has greatly increased the acceptance of pork by the American housewife. Although much of this improvement has resulted from improved selection and breeding programs, more adequate nutrition has also been a contributing factor. It has been demonstrated (NRC, 1968) that pigs have no protein requirement per se; however, they need specific amounts of certain amino acids, all at one time, plus a minimum amount of non-specific nitrogen (to synthesize the non-essential amino acids) to exhibit their maximum genetic potential.

There are ten amino acids which are considered essential for adequate growth for the pig. These essential amino acids are all present in most feedstuffs, but may not be present in large enough quantities to meet the pig's requirements. One of the amino acids which may not be present in sufficient quantity is methionine. Various researchers have studied the methionine requirement for the pig. A large portion of this work has been done using natural feedstuffs. For this reason, results have been inconsistent and somewhat conflicting due to the variability in the methionine content of the individual feedstuffs. Hence, the purpose of this study is to determine the methionine requirement of growing and finishing pigs using a semi-purified diet.

REVIEW OF LITERATURE

Methionine was first recognized as an essential amino acid for the growth of young swine by Bell et al. (1950). These workers suggested that the methionine requirement of growing pigs is between 0.07% and 0.27% of a diet containing 10% protein.

Curtin et al. (1952a, 1952b) presented evidence that the methionine need of the weanling pig is 0.7% of a 22% protein diet or 3.2% of the dietary protein. Shelton, Beeson and Mertz (1951) reported excellent growth of pigs on a 21% protein diet supplemented to contain 0.6% methionine. This represents 2.9% of the dietary protein.

Becker et al. (1955) reported a methionine requirement of 0.42% on a 12.6% protein diet. This represents 3.33% of the dietary protein. Kroening, Pond and Loosli (1965) reported requirements of 0.5% on a 12% protein diet, 0.6% on an 18% diet and 0.7% on a 25% diet. These values represent a decreased methionine requirement as a percentage of the dietary protein as the protein percentage in the ration decreases. This is in contrast to the work by Pfander and Tribble (1955). Pfander and Tribble comparing 14, 16, and 18% protein rations, reported a constant methionine requirement of 3.5% of dietary protein. However, these researchers only compared a basal ration and a supplemental ration at each protein level.

It is now well known that the methionine requirement cannot be considered without giving attention to the cystine intake, since cystine has a valuable "sparing action" on methionine. Shelton et al. (1951) were the first to discover that a portion of the methionine need of the pig could be met by cystine. They reported that cystine could replace 50% of the methionine requirement. Becker et al. (1955) reported that the replacement value was only 40%.

Using nitrogen retention as criterion, Mitchell et al. (1968) observed cystine could supply at least 70% of the weanling pigs need for sulfur bearing amino acids. Baker et al. (1969) employing both a group and individual ad libitum feeding trial reported that weight gain was as rapid when 56% of the total sulfur amino acid requirement came from cystine as when all was supplied by methionine. When equally fed in nitrogen retention assay, the replacement value of cystine for methionine was 66%.

Because of these and other similar investigations, we now refer to the pig's sulfur amino acid requirement rather than the methionine requirement.

Various workers have been unable to obtain any beneficial response by adding methionine to diets containing a lower level of sulfur amino acids than is recommended by NRC (1968). Meade (1956) employing nitrogen retention studies observed no beneficial effect from adding methionine to a diet containing only 0.27% sulfur amino acids. Jones et al. (1962) observed no significant effect on daily gain and feed conversion, nor did the addition of DL-methionine affect body composition as indicated by specific gravity or loin-eye analyses. Methionine was also without effect on rate and efficiency of gain in work conducted by Meade, Dukelow and Grant (1966). Similar findings have been observed by Oestemer et al. (1970) and by Stockland, Meade and Nordstrom (1971) indicating that the sulfur amino acid requirement as suggested by NRC has been overestimated.

It has been known for some time that the protein requirement for maximum growth decreases with increasing age and body weight. Mitchell et al. (1936) reported that in order to induce maximum nitrogen retention in 20-kg pigs confined in metabolism cages more than 26% of dietary protein was required; for 45-kg pigs, about 22%; for 70-kg pigs, about 17%; and for 80- to 90-kg pigs about 15%.

Since the summation of the individual amino acid requirements totals the protein requirement, it would be expected that amino acid requirements might also decrease with increasing age. This has been demonstrated in the turkey for lysine (Gartley, Slinger and Hill, 1950; Kratzer, Davis and Marshall, 1955) and methionine (Pepper and Slinger, 1955), in the young chick for lysine (Lewis, Elvehjem and Hart, 1958; Zimmerman and Scott, 1965), in the broiler for lysine and sulfur amino acids (Bornstein and Lipstein, 1964, 1966; Bornstein, 1970) and in the rat for several amino acids (Hartsook and Mitchell, 1956; Forbes and Rao, 1959).

Only limited information is available concerning amino acid requirements of the finishing pig. Brown, Harmon and Jensen (1973) studied the lysine requirement of the finishing pig. In these studies, Brown reported a lower requirement for the finishing pig than is considered essential for the growing pig. Brown and Jensen (1972) reported no beneficial effect of adding methionine to a basal diet containing 0.17% total sulfur amino acids, thus indicating a lower sulfur amino acid requirement for the finishing pig than for the growing pig.

The objectives of these studies were to re-evaluate the sulfur amino acid requirement of the growing pig and to determine the sulfur amino acid requirement of the finishing pig.

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SULFUR AMINO ACID REQUIREMENT OF THE GROWING PIG

The National Research Council (1968) lists the methionine requirement of the growing pig (20 - 35 kg) as 0.50% of the diet. Numerous researchers have been unable to obtain any beneficial response by the addition of methionine to diets containing a lower level of sulfur amino acids than is recommended (Meade, 1956; Jones et al. 1962; Meade, Dukelow and Grant, 1966; Oestemer et al. 1970; Stockland, Meade and Nordstrom, 1971). These results suggest that the sulfur amino acid requirement of the growing pig has been overestimated.

The present studies were conducted to re-evaluate the sulfur amino acid requirement of growing pigs using a semi-purified diet supplemented with graded levels of DL-methionine.

EXPERIMENTAL PROCEDURE

General

In the growth trial, pigs were housed in 1.2 x 1.8 m wooden cages with expanded metal floors in a building where temperature was maintained at approximately 22° C. Feed and water were supplied ad libitum. Initial and final weights were recorded and daily gain, feed efficiency and daily intake were determined at the conclusion of the 28-day trial. A randomized complete block design was used for the growth trial and the data was treated statistically using analysis of variance and Duncans New Multiple Range Test (Snedecor and Cochran, 1971).

In the nitrogen retention study, the pigs were housed individually in metabolism cages allowing for separate collection of feces and urine.

Daily feed intake was constant and fed in two equal portions. Fresh water was supplied at each feeding. A five-day pre-test period preceeded a five-day collection period. A ferric oxide marker was fed at the beginning and end of each five-day period. Feces were collected daily and stored in a refrigerator. The entire five-day fecal collection was dried in a forced air oven at 50° C for 7 days, allowed to come to air-dry weight, weighed and ground in a Wiley mill equipped with a 40-mesh screen. Urine was collected in an 8-liter container to which 20-ml. of concentrated HCl had been added. Each daily collection was diluted to a constant volume (3 liters) and a 100 ml. aliquot taken. Accumulated aliquots were stored in a refrigerator at 1° C until analyzed. Representative feed, fecal and urine samples were analyzed in duplicate for nitrogen as outlined by A.O.A.C. (1970).

Composition of the basal diet is shown in Table 1. All essential amino acids, with the exception of methionine-cystine, were present at 120% of NRC (1968) recommended levels. Methionine and cystine were determined by gas-liquid chromatography by the method of Roach and Gehrke, 1969.

Trial 1. A growth trial was conducted using 24 Duroc and Yorkshire barrows and gilts averaging 12.3 kg. Pigs were allotted according to weight, breed and sex to four treatment groups (Table 2): (1) Basal, (2) Basal + 0.10% DL-methionine, (3) Basal + 0.20% DL-methionine, and (4) Basal + 0.30% DL-methionine. The trial consisted of two pigs per pen, was replicated three times and lasted 28 days.

Trial 2. A nitrogen retention study was conducted using 12 Duroc and Yorkshire barrows weighing an average of 11.3 kg. Three groups of four litter-mates were used in a randomized complete block design and allotted to four treatments (Table 3) as in Trial 1. All rations were made isonitrogenous by the addition of glutamic acid. Treatments within groups were randomly

TABLE 1. COMPOSITION OF BASAL DIETS ^a

Ingredient	Growth Trial	Nitrogen Retention
Isolated Soy	15.00	15.00
Cornstarch	74.40	74.40
Cellulose	3.00	3.00
Soybean oil	3.00	3.00
Vitamin premix ^b	1.00	1.00
Dicalcium phosphate	2.78	2.78
Salt	0.50	0.50
Trace mineral premix ^c	0.62	0.62
Antibiotic premix ^d	0.25	0.25
L-Threonine	0.05	0.05
L-Lysine HCl	0.06	0.06
Glutamic acid	0.00	0.30

^a Methionine and cystine determined by analysis - 0.21% of diet.

^b Each kilogram of mix contained the following: Vitamin A palmitate, 500,000 IU; Vitamin D₃, 284,000 IU; Vitamin E (α -tocopherol), 12,000 IU; Vitamin K, 20 mg; riboflavin, 660 mg; d-pantothenic acid, 2.64 g; nicotinic acid, 4.4 g; folic acid, 200 mg; biotin, 20 mg; ascorbic acid, 3 g; pyridoxine, 250 mg; thiamine, 260 mg; and powdered constarch to 1 kg.

^c Containing 0.1% Cobalt, 1.0% Copper, 0.3% Iodine, 10% iron, 10% manganese and 10% zinc. Also included is MgCl 0.08% and Potassuim 0.42%.

^d Supplied as 110 mg each of chlortetracycline and sulfamethazine and 55 mg of penicillin per kg of diet.

assigned and fed for one period (10 days) after which treatments were reallocated for another period so as to provide a second replicate. Daily intake was 1000 g for the first period and 1400 g for the second.

RESULTS

Trial 1. Results of the growth trial are presented in Table 2.

Supplementation of the basal diet with 0.10% DL-methionine resulted in a significant ($P < .05$) improvement in average daily gain. Further supplementation of methionine failed to increase daily gain from the 0.10% level. All additions of methionine resulted in an improved feed/gain ratio and daily feed intake over the basal ration but these were not significantly different.

Trial 2. Results of the nitrogen retention study are presented in Table 3. The addition of 0.10% DL-methionine to the basal diet significantly ($P < .05$) increased nitrogen retention. Further additions of DL-methionine resulted in no significant differences from the 0.10% addition.

DISCUSSION

The addition of 0.10% DL-methionine to the basal (0.21% total sulfur amino acids) resulted in a marked improvement in average daily gain and nitrogen retention. Thus, indicating that the basal diet was deficient in methionine and that the supplementation of this amino acid was necessary in order to obtain maximum growth. Further additions of DL-methionine resulted in no beneficial effect suggesting that the sulfur amino acid requirement has been met by the initial addition of 0.10% DL-methionine.

Although feed intake and feed/gain ratio were not used as criteria for estimating the sulfur amino acid requirement, there was a tendency

TABLE 2. PERFORMANCE OF GROWING PIGS^a (Trial 1)

Diets	Daily Gain (g)	Feed/Gain ^b	Feed Intake (kg) ^b
1. Basal	340 ^c	2.38	1.57
2. Basal + 0.10% DL-methionine	508 ^d	1.98	2.02
3. Basal + 0.20% DL-methionine	490 ^d	1.99	1.95
4. Basal + 0.30% DL-methionine	522 ^d	1.98	2.15

^a Six pigs per diet averaging 12.3 kg initially.

^b F/G and feed intake are pen means, two pigs per pen and three pens per treatment.

^{cd} Means with different superscripts are statistically different ($P < .05$)

TABLE 3. NITROGEN RETENTION OF GROWING PIGS^a (Trial 2)

Diets	Daily N, g			
	Intake	Urine	Feces	Retained
1. Basal	27.25	9.60	1.48	16.17 ^b
2. Basal + 0.10% DL-methionine	27.25	6.79	1.37	19.09 ^c
3. Basal + 0.20% DL-methionine	27.25	6.53	1.91	18.81 ^c
4. Basal + 0.30% DL-methionine	27.25	7.17	1.61	18.57 ^c

^a Six pigs per diet averaging 18.1 kg initially.

^{bc} Means with different superscripts are statistically different ($P < .05$)

toward improvement in these criteria as methionine was added to the basal diet.

The basal diet used in these trials contained cystine at a rate of 50% of the total sulfur amino acids. Previous findings have demonstrated that the replacement value is at least 50% and could be as high as 70% (Shelton et al. 1951; Mitchell et al. 1968; Baker et al. 1969.) NRC (1968) recommends a replacement value of only 40%.

There are numerous indications in the literature that the sulfur amino acid requirements of the growing pig may have been overestimated, as often no response has been observed when diets, containing lower levels of total sulfur amino acids than is recommended, were supplemented with methionine. Meade (1956) observed no beneficial effects from adding methionine to a diet containing only 0.27% methionine. Jones et al. (1962) observed that DL-methionine did not significantly effect weight gain, feed conversion, fat or protein content of the longissimus or the specific gravity of the carcass. Methionine was without effect on rate of gain and efficiency of gain in work conducted by Meade et al. (1966). Similar findings have been observed by Oestemer et al. (1970) and by Stockland et al. (1971).

SUMMARY

A growth and nitrogen retention study was conducted using 36 growing pigs (initial wt. 11.9 kg) to determine the total sulfur amino acid requirement. The addition of 0.10% DL-methionine to a 14.1% protein basal diet containing 0.21% sulfur amino acids significantly ($P < .05$) increased daily gain and nitrogen retention. Further additions of DL-methionine gave no beneficial effect, indicating that the sulfur amino acid requirement had been met by the initial addition of DL-methionine. Thus the sulfur

amino acid requirement for the growing pig on a 14.1% protein diet is not more than 0.31%.

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SULFUR AMINO ACID REQUIREMENT OF THE FINISHING PIG

Considerable evidence is available indicating that methionine is an essential amino acid for the growth of swine (Bell et al. 1950; Shelton et al. 1951; Curtin et al. 1952a, 1952b; Becker et al. 1955; Mitchell et al. 1968). These investigations have dealt with the early growing period and there is only limited information available concerning the sulfur amino acid requirement of the finishing pig. The objective of this study was to determine the sulfur amino acid requirement of the pig from 50 kg to market weight.

EXPERIMENTAL PROCEDURE

General

In the growth trial, pigs were housed individually in 1.5 x 3.0 m pens with concret slats in an open fronted building. Feed and water were supplied ad libitum. Initial and final weights were recorded and daily gain, feed efficiency and daily gain were determined at the conclusion of the trial. Pigs were slaughtered after reaching approximately 95 kg. Specific gravity, backfat thickness and loin-eye measurements were taken on the carcasses. A randomized complete block design was used for the growth trial and the data was treated statistically using analysis of variance and Duncans New Multiple Range Test (Snedecor and Cochran, 1971).

In the nitrogen retention studies, the pigs were housed in metal metabolism cages allowing for separate collection of feces and urine. Daily feed intake was constant and fed in two equal portions. Fresh water was supplied at each feeding. A five-day pre-test period preceeded a five-day collection period. A ferric oxide marker was fed at the beginning and end of each five-day period. Feces were collected daily and stored in a refrigerator. The entire five-day fecal collection was dried in a forced air oven at 50° C for 7 days, allowed to come to an air-dry weight, weighed

and ground in a Wiley mill equipped with a 40-mesh screen. Urine was collected in an 8-liter container to which 20 ml. of concentrated HCl had been added. Each daily collection was diluted to a constant volume (4 liters) and a 100 ml. aliquot taken. Accumulated aliquots were stored in a refrigerator at 10° C until analyzed. Representative feed, fecal and urine samples were analyzed in duplicate for nitrogen as outlined by A.O.A.C. (1970).

Composition of the basal diet is shown in Table 1. All essential amino acids, with the exception of methionine-cystine, were present at 120% of NRC (1968) recommended levels. Methionine and cystine were determined by gas-liquid chromatography by the method of Roach and Gehrke, 1969.

Trial 1. An individual feeding trial was conducted using fifteen Yorkshire barrows averaging 57.1 kg. Pigs were allotted according to litter and weight to 3 treatment groups (Table 2): (1) Basal, (2) Basal + 0.10% DL-methionine and (3) Basal + 0.20% DL-methionine.

Trial 2. A nitrogen retention study was conducted using three litter-mate Yorkshire barrows weighing an average of 58.6 kg. The barrows were randomly assigned to 3 treatments (Table 4) as in Trial 1. A latin square design was used and daily intake was held constant at 2000 g throughout the trial.

Trial 3. A nitrogen retention study was conducted using three litter-mate Yorkshire gilts weighing an average of 58.6 kg. The gilts were randomly assigned to 3 treatments (Table 5) as in Trial 1. A latin square design was used and daily intake was held constant at 2000 g throughout the trial.

RESULTS

Trial 1. Results of the growth trial are presented in Table 2. Addition of DL-methionine to the basal diet containing 0.14% total sulfur amino acids

TABLE 1. COMPOSITION OF BASAL DIET^a

Ingredient	Amount
Isolated Soy	10.00
Cornstarch	80.00
Cellulose	3.00
Soybean oil	3.00
Vitamin premix ^b	1.00
Dicalcium phosphate	2.32
Limestone	0.24
Salt	0.25
Trace mineral premix ^c	0.71
Antibiotic premix ^d	0.25

^a Methionine and cystine determined by analysis - 0.14% of diet.

^b Each kilogram of mix contained the following: Vitamin A palmitate, 500,000 IU; Vitamin D₃, 284,000 IU; Vitamin E (α -tocopherol), 12,000 IU; Vitamin K, 20 mg; riboflavin, 660 mg; d-pantothenic acid, 2.64 g; nicotinic acid, 4.4 g; Vitamin B₁₂, 4.4 mg; choline chloride, 220 g; folic acid, 200 mg; biotin, 20 mg; ascorbic acid, 3 g; pyridoxine, 250 mg; thiamine, 260 mg; and powdered cornstarch to 1 kg.

^c Containing 0.1% Cobalt, 1.0% Copper, 0.3% Iodine, 10% iron, 10% manganese and 10% zinc. Also included is MgCl 0.08% and Potassium 0.42%.

^d Supplied as 110 mg each of chlortetracycline and sulfamethazine and 55 mg of penicillin per kg of diet.

was without any beneficial effect on either daily gain or feed/gain ratio. Carcass data are presented in Table 3. No significant differences were observed between pigs fed the basal diet and those fed supplemental methionine.

Trial 2. The results of nitrogen retention study using barrows is presented in Table 4. Addition of 0.10% DL-methionine to the basal diet resulted in a significant ($P < .05$) increase in nitrogen retention. Further additions of DL-methionine failed to increase nitrogen retention above that observed on the 0.10% addition.

Trial 3. The results of nitrogen retention study using gilts is presented in Table 5. The addition of 0.10% DL-methionine resulted in a significant ($P < .05$) increase in nitrogen retention. Further additions resulted in no significant differences over the 0.10% addition.

DISCUSSION

The results of these studies confirm and extend previous finding by demonstrating, using growth and nitrogen retention studies, that the sulfur amino acid requirement as recommended by NRC (1968) has been overestimated. Supplementation of the 9.0% protein basal diet, containing 0.14% total sulfur amino acids, did not significantly increase average daily gain or feed/gain ratio, indicating that the requirement has already been met with the basal ration. Brown et al. (1972) suggested that the sulfur amino acid requirement is not greater than 0.17% of a 14.1% protein diet.

Animals used in the growth trial were slaughtered after reaching approximately 95 kg and specific gravity and carcass measurements taken. There were no significant differences between pigs fed the basal diet and pigs fed supplemental methionine for any of the measurements. Backfat thickness and loin eye measurements did show slight improvements but these

TABLE 2. PERFORMANCE OF FINISHING PIGS^a (Trial 1)

Diets	Daily Gain (kg)	Feed/ Gain	Daily Intake (kg)
1. Basal	0.63	3.51	2.16
2. Basal + 0.10% DL-methionine	0.66	3.25	2.13
3. Basal + 0.20% DL-methionine	0.73	3.18	2.31

^a Each treatment is the average of five individually fed pigs averaging 57.1 kg initially.

TABLE 3. CARCASS DATA^a (Trial 1)

Diets	Specific Gravity	Backfat Thickness (cm)	Loin-eye area (cm ²)
1. Basal	1.0421	3.58	26.57
2. Basal + 0.10% DL-methionine	1.0476	3.40	27.15
3. Basal + 0.20% DL-methionine	1.0410	3.40	27.41

^a Each value is the mean of five pigs.

TABLE 4. NITROGEN RETENTION OF FINISHING BARROWS^a (Trial 2)

Diets	Daily N, g			
	Intake	Urine	Feces	Retained
1. Basal	27.98	14.48	1.95	11.55 ^b
2. Basal + 0.10% DL-methionine	28.96	11.79	1.56	15.61 ^c
3. Basal + 0.20% DL-methionine	30.10	12.76	1.73	15.61 ^c

^a Latin square design using three littermate barrows weighing 58.6 kg initially.

^{bc} Means with different superscripts are statistically different ($P < .05$).

TABLE 5. NITROGEN RETENTION OF FINISHING GILTS^a (Trial 3)

Diets	Daily N, g			
	Intake	Urine	Feces	Retained
1. Basal	27.98	13.48	2.01	12.49 ^b
2. Basal + 0.10% DL-methionine	28.96	9.19	2.05	17.72 ^c
3. Basal + 0.20% DL-methionine	30.10	10.04	1.71	18.35 ^c

^a Latin square design using three littermate gilts weighing 58.6 kg initially.

^{bc} Means with different superscripts are statistically different ($P < .05$).

were not significantly greater than the basal diet indicating that the sulfur amino acid requirement for these criteria were met by the basal diet.

Nitrogen retention for both barrows and gilts did show a significant increase when 0.10% DL-methionine was added to the basal diet indicating that the sulfur amino acid requirement for maximum nitrogen retention is slightly greater than the requirement for daily gain, feed/gain or carcass measurements. This is in agreement with studies by Brown et al. (1973) which suggests a higher lysine requirement for maximum nitrogen retention than that obtained for daily gain.

The basal ration used in this study contained cystine at a rate of 50% of the total sulfur amino acids. Previous findings have demonstrated that the replacement value of cystine for methionine is at least 50% and could be as high as 70% (Shelton et al. 1951; Mitchell et al. 1968; Baker et al. 1969).

SUMMARY

A growth and two nitrogen retention studies were conducted using 21 finishing pigs (initial wt. 57.5 kg) to determine the sulfur amino acid requirement of the finishing pig. The addition of 0.10% DL-methionine to a 9.0% protein basal diet containing 0.14% total sulfur amino acids significantly ($P < .05$) increased nitrogen retention. Further additions of DL-methionine had no beneficial effect on nitrogen retention indicating that the requirement was met by the initial addition. Daily gain was not significantly affected by the addition of DL-methionine to the basal diet, suggesting a lower sulfur amino acid requirement for daily gain than is essential for maximum nitrogen retention.

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SULFUR AMINO ACID REQUIREMENT
OF GROWING AND FINISHING PIGS

by

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AN ABSTRACT OF A MASTER'S THESIS

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A growth trial and a nitrogen retention trial was conducted with 32 growing pigs to determine the sulfur amino acid requirement of the growing pig. Average daily gain and nitrogen retention were significantly increased when 0.10% DL-methionine was added to a 14.1% protein basal diet containing 0.22% total sulfur amino acids. Further additions of DL-methionine did not result in any significant differences over the 0.10% addition, suggesting that the sulfur amino acid requirement is not more than 0.32% of a 14.1% protein diet.

In the finishing pig studies, a growth trial and two nitrogen retention trials were conducted using 21 finishing pigs. Maximum nitrogen retention was obtained when 0.10% DL-methionine was added to a 9.0% protein basal diet containing 0.14% total sulfur amino acids. Average daily gain, feed/gain ratio, and carcass measurements were not significantly improved by the addition of methionine, indicating a lower sulfur amino acid requirement for these criteria than for nitrogen retention.

These studies confirm and extend previous findings by demonstrating that the sulfur amino acid requirement as suggested by NRC has been overestimated. These studies would indicate that the sulfur amino acid for the growing pig is not more than 0.32% on a 14.1% protein diet while the requirement for the finishing pig is 0.24% on a 9.0% protein diet when nitrogen retention is used as the criterion and 0.14% when average daily gain, feed/gain ratio and carcass measurements are used as the criteria.