PROTEIN AND AMINO ACID SUPPLEMENTATION TO MILO FOR RATS AND SWINE

By

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INTRODUCTION

Milo (grain sorghum) has become a popular feed grain for swine in the Great Plains area. Research has shown that milo fed alone does not provide sufficient protein for growing pigs. However, when adequately supplemented with soybean meal it has been shown to produce satisfactory rate of gain and efficiency of feed utilization. Although soybean meal is an excellent protein supplement to milo, the soybeans are grown and processed outside the areas where milo is the chief grain fed to swine. A protein supplement produced from a crop grown in the major milo producing areas could mean much in the way of providing more economical swine rations in these areas.

Guar meal, a high protein concentrate produced in the processing of guar beans, seemed worthy of investigation as a protein supplement to milo. Guar has been grown successfully, but on a limited scale, in the dryer areas of Oklahoma and Texas. Guar meal, which contains approximately 45 percent protein, has been used mainly as a source of protein for beef cattle. This high protein feed seems to have possibilities as a protein supplement in milo-type rations for swine. In addition, guar meal has been used as a binder in the pelleting of livestock feeds. From 2 to 3 percent guar meal in the ration has been found to be very effective in binding together the feed ingredients involved in the pelleting process. It seemed desirable to obtain information relative to guar meal as a protein supplement to milo grain and to determine if soybean meal can be satisfactorily replaced by guar meal.

LITERATURE REVIEW

REQUIREMENTS OF PIGS OF VARIOUS AGES

Protein Requirement

Growing and fattening pigs require relatively high levels of high quality protein in their diet. The protein requirements of pigs of various ages as set forth by the National Research Council are: 50 to 100 pounds, 16 percent; 100 to 150 pounds, 14 percent; 150 to 200 pounds, 13 percent protein in the ration. These requirements are based on a corn-soybean meal type ration.

Miller and Keith (1941), found the optimum quantity of protein in the ration for pigs to be from 15 to 17 percent for the growth span from 40 to 210 pounds. Levels of protein of 20, 22, 25 and 27 percent were not outstandingly superior to the 15 and 17 percent levels in rate of gain or efficiency of feed utilization, but the trend favored the higher levels of protein from weanling up to a weight of approximately 75 pounds. The 15 and 17 percent levels of protein intake were superior to the higher levels for pigs between the weights of 120 and 200 pounds. Rations containing 10 and 12 percent protein were definitely unsatisfactory as measured by rate of gain and feed efficiency.

Catron et al. (1952) determined the protein requirement for pigs on the basis of three weight groups: (1) weaning to 75 pounds, (2) 75 to 150 pounds, and (3) 150 to 200 pounds. Corn-soybean meal type rations, supplying initial protein levels of 20, 18, 16 and 14 percent were used in the evaluation of the protein requirement. The protein level in each series was reduced 3 percent when the pigs reached 75 pounds and again at 150 pounds. The 16-13-10 percent protein levels supplied the pigs need for protein from weanling to market most efficiently, when no antibiotics were included in the ration. In the presence of the antibiotic the 14-11-8 percent combination produced gains equivalent to those produced by higher levels of protein.

Lassiter et al. (1955), determined the minimum protein requirement by studying the growth of pigs fed mixed rations containing 8, 10, 12, 14 and 16 percent protein. In dry lot, the average daily gain was significantly lower at the 10 percent protein level than at the 12, 14, or 16 percent levels, for pigs from weanling to 100 pounds. The 12 percent ration produced significantly lower gains than the 16 percent ration. From these trials, the minimum protein allowances appeared to be 14 to 16 percent from weaning to 100 pounds. When the same protein levels were fed for the entire period from weanling to 200 pounds, the minimum allowance appeared to be 12 to 14 percent.

Hillier et al. (1957) determined the protein needs of growing-fattening pigs on the basis of three weight groups: (1) 55-100 pounds, (2) 100-150 pounds, and (3) 150-190 pounds. Milo-soybean rations containing 16, 14, and 12 percent protein were used. Pigs receiving a 16 percent protein ration throughout the trial gained 0.21 pounds more per day than those receiving a 14, 12, 12 percent protein ration for the three periods. There was only one case in which pigs fed any combination of protein levels starting at 14 percent protein out gained those starting on a 16 percent protein ration. It appeared that weanling pigs, weighing about 55 pounds need at least 16 percent protein in their ration to start with, possibly more, on this type of ration. Reducing the protein as the pigs reached 150 pounds had little effect on the rate of gain, nor did a change from a 16 to a 14 percent ration at 100 pounds. Only slightly more feed was required when the protein level was reduced as the pigs became older than was required when a 16 percent protein ration was fed throughout the trial.

Amino Acid Requirements

Mertz *et al*. (1952), in feeding experiments with mixtures of purified amino acids demonstrated that arginine, leucine, phenylalanine, and valine are required for growth of weanling pigs. The pig resembles the rat in its ability to synthesize part, but not all of the arginine required.

Early work by Beeson *et al*.(1949), Mertz *et al*. (1949) and Shelton *et al*. (1950) has shown the indispensible nature of lysine, threonine and tryptophan.

Bell *et al*. (1950) and Brinegar *et al*.(1950) added methionine, isoleucine and histidine to the list of indispensible amino acids.

Since the growing pig requires these "essential" amino acids in the diet, the requirements of these amino acids have been established by research and presented by the National Research Council (1953).

The essential amino acid requirements as set by the National Research Council (1953) for the growing pig are: L-arginine, 0.20; L-histidine, 0.40; L-isoleucine, 0.70; L-leucine, 0.80; L-lysine, 1.00; DL-methionine, 0.60; DL-phenylalanine, 0.46; L-threonine, 0.40; DL-tryptophan, 0.20; L-valine, 0.40 percent of the ration.

Brinegar (1950) observed that when a 22 percent protein diet was fed to weanling pigs, 1.2 percent L-lysine was needed for optimal growth. This was double the requirement found earlier by the same author, when the protein level was only 10.6 percent. This requirement for lysine would be approximately 5.5 percent of the dietary protein.

Brinegar (1952) reported that the lysine requirements expressed as percentages of the protein are not largely different at widely different levels of protein intake. Since protein intakes of swine are variable, depending on the size of the animal, amino acid needs expressed in relation to the dietary protein find a wider application than if the requirements are expressed as percentages of the total diet.

Shelton _et al_. (1951), using a 23.8 percent protein diet containing zein and gelatin as the source of protein supplements, reported that rate of gain and feed efficiency was markedly improved up to a level of 1.0 percent total L-lysine in the diet. This value represented 4.2 percent of the total protein.

In a study to re-evaluate the L-lysine requirement of the weanling pig, Germann _et al_. (1958) added different amounts of L-lysine to a semi-purified diet containing 15 percent protein standardized on a moisture-free basis. The level of utilizable L-lysine which supported maximum gains and feed efficiency was 0.70 percent of the moisture-free ration (0.60 percent of a ration containing 14.1 percent moisture, or 0.62 percent of a 10.6 percent moisture ration). This level of lysine was equivalent to 4.7 percent of the total protein and was only 0.5 percent higher than the level found earlier by Shelton _et al_. (1951).

In a study of the methionine and cystine needs of the weanling pigs, Shelton _et al_. (1951) reported that a level of 0.60 percent total

DL-methionine in a 21.1 percent protein purified ration containing 0.01 percent cystine was needed for maximal growth and feed efficiency. If adequate L-cystine (0.61 percent) was present in a ration only 0.3 percent DL-methionine was required by weanling pigs.

Evidence presented by Curtin et al. (1952) indicates that the combined methionine and cystine requirement of weanling pigs fed a 22 percent protein semi-purified diet, was no higher than 0.7 percent of the diet. This corresponds to 3.2 percent of the protein. Cystine apparently can be used to replace methionine up to 1.7 percent of the protein.

Becker et al. (1955) found the methionine-cystine need of the weanling pig fed a 12.6 percent protein synthetic diet to be 0.25 percent total methionine and 0.17 percent cystine. Expressed as a percentage of the dietary protein the combined methionine and cystine requirement is approximately 3.33 percent. Cystine was found to provide about 40 percent of the need for the sulfur bearing amino acids.

Beeson et al. (1949) demonstrated that a purified ration containing 19.5 percent protein and adequate in all the known nutrients except tryptophan, would not support adequate growth. Pigs fed the basal supplemented with 0.40 percent DL-tryptophan gained at the rate of 1.42 pounds per day. The pigs receiving the additional tryptophan had a glossy, smooth coat and showed no signs of ill health or unthriftiness.

In a study of the tryptophan requirement, Shelton et al. (1951) found that when a 24.5 percent protein purified diet was fed to weanling pigs, 0.2 percent total DL-tryptophan was required in the diet for maximum growth, provided adequate ~~nicotinic acid~~ niacin was present. ~~Nicotinic acid~~ Niacin was employed in order to minimize the conversion of tryptophan to nicotinic acid, (Powick et al. 1948). On this basis the tryptophan requirement approached 1.0 percent of the dietary protein.

Brinegar et al. (1950) determined the isoleucine requirement by adding various levels of DL-isoleucine to a 22 percent protein basal diet in which blood flour provided the supplemental protein. The maximum response in growth and feed efficiency was obtained from the diet containing 0.7 percent L-isoleucine. This isoleucine requirement is equivalent to 3.2 percent of the dietary protein.

In a similar study, Becker et al. (1957), using blood meal as a source of protein in a diet containing 13.35 percent protein, reported that maximum rate and efficiency of gain was obtained with a minimum level of 0.46 percent L-isoleucine, an amount equal to 3.4 percent of the dietary protein. However, using a 26.7 percent protein diet, the maximum rate and efficiency of gain occurred at a minimum of 0.65 percent L-isoleucine, which is equal to 2.4 percent of the dietary protein.

The work of Mertz et al. (1955) indicated that the L-histidine and L-leucine requirement of the weanling pig fed a 13.0 percent protein semipurified diet was approximately 0.2 and 0.60 percent of the ration, respectively. These requirements for histidine and leucine represent 1.5 and 4.6 percent of the protein.

Eggert et al. (1954), in a study with suckling pigs, found that a level of 1.00 percent L-leucine in a simulated milk diet containing 25 percent protein (air-dry basis) was inadequate for good growth. However, levels of 1.25, 1.50, 1.75 and 2.00 percent L-leucine did not produce significantly different rates of gain. From the standpoint of growth, feed efficiency, and storage in the tissue, it appears that the requirement of L-leucine for the suckling pig is between 1.00 and 1.25 percent of the diet. This is equivalent to not more than 5.0 percent of the dietary protein.

Beeson et al. (1953) reported that a level of 0.4 percent total L-threonine was needed in a 13.2 percent protein purified diet for maximum growth and feed efficiency. The level of L-threonine (0.4 percent of the ration) represents 3.0 percent of the dietary protein.

In a study of the phenylalanine requirement, Mertz et al. (1954) found that when a 12.6 percent semi-purified diet was fed to weanling pigs, 0.32 percent DL-phenylalanine and 0.14 percent tyrosine was needed for optimal growth. Assuming that the 0.14 percent tyrosine was substituted for an equal weight of phenylalanine, (Womack and Rose, 1946), the phenylalanine requirement for the weanling pig is 0.46 percent of the ration. This requirement is equivalent to 3.6 percent of the total protein in the diet.

Evidence presented by Jackson et al. (1953) indicates that the L-valine requirement of weanling pigs fed a 12.8 percent protein semi-purified diet was approximately 0.4 percent of the diet. The L-valine requirement expressed as a percent of the protein would be equal to 3.1 percent.

GRAIN SORGHUMS AS A FEED FOR SWINE

The two leading grains fed to swine in this area are corn and grain sorghum. The analyses presented by the National Research Council (1953) indicated that milo and corn contain 11.3 and 8.6 percent protein, respectively. On the average the grain sorghums will exceed corn from 2-3 percent in protein.

Block and Weiss (1956), showed that the protein of corn contains a higher percentage of lysine, threonine, methionine, histidine, and arginine than the protein of yellow milo. However, the protein of yellow milo contains a higher percentage of leucine, isoleucine, phenylalanine, tryptophan and valine than that of corn.

Schneider (1947) reported that corn (9.1 percent protein) contained 77.5 percent total digestible nutrients, while milo (11.9 percent protein) contains 77.9 percent total digestible nutrients.

Barham et al. (1946) from an analysis of fourteen varieties of grain sorghum, reported that the extremes in tannin content were 0.003 and 0.1667 percent for Altas and Early Sumac, respectively. Tannin (tannic acid) is an organic substance found in the seed of grain sorghums. This substance ranges from yellow to light brown in color and has a characteristic astringent effect in the mouth and a bitter taste.

Hillier et al. (1954) in four trials found pigs preferred the varieties of grain sorghum in the order of Kafir 44-14, Westland, Redlan, Martin and Darset. The grain sorghums tested were found to have values from 93 to 98 percent the value of number 2 yellow corn in producing gain in pigs.

Aubel and Alexander (1937) reported that shelled corn and a supplement composed of alfalfa meal and tankage when self-fed free-choice produced slightly more rapid gains than ground Atlas Sargo grain and the same protein supplement self-fed free-choice. The two groups consumed about equal quantities of supplement but slightly more Atlas Sargo was consumed than corn. The Atlas Sargo proved to be worth 93.5 percent as much as corn in producing 100 pounds of gain.

Baker and Reinmiller (1939) with nine comparisons between shelled corn and grain sorghum, found that gains made by pigs self-fed grain sorghum and mixed protein supplement free-choice were in general as rapid as the gains made by the pigs fed shelled corn and protein supplement free-choice. On the basis of amount of feed required per unit of gain both whole and ground milo were 90 percent as valuable as shelled corn. Other comparable figures were as follows: whole kafir 89 percent, ground kafir 91 percent, whole Early Kalo 87 percent and ground Early Kalo 91 percent as efficient as shelled corn. In the nine comparisons, the grain sorghums proved to be 89 percent as efficient as shelled corn. In four comparisons between whole and ground milo, the whole milo was approximately 97 percent as efficient as ground milo. If the grain was hard and flinty the advantage of grinding became greater.

Aubel (1950) determined in dry lot and on pasture, the value of various grain sorghums for finishing swine. In dry lot, whole Wheatland milo self-fed free-choice with a protein supplement produced more rapid gains than shelled corn, whole Colby milo, whole Blackhull kafir or whole Westland milo. Pigs fed whole Blackhull kafir and whole Colby milo gained somewhat slower than those fed corn. The relative values for the various sorghums as compared to shelled corn, were as follows: whole Colby, 96.5 percent; ground Colby, 98.9 percent; whole Wheatland, 97.6 percent; ground Wheatland, 98.3 percent; whole Blackhull kafir, 98.2 percent; whole Westland milo, 88.9 percent.

The sorghum grains were very efficient as swine feeds when fed to pigs on pasture. In all cases except where whole Colby milo was fed, the daily gains made on milo excelled the gains made on corn. The value of each of the various grain sorghums as compared to corn was as follows: whole Colby 91.9 percent, ground Colby 101.2 percent, whole Wheatland 91.2 percent, ground Wheatland 84.2 percent, whole Westland milo 94.2 percent.

Wheatland milo produced greater gains than Colby milo when fed to pigs grazing on green pasture but required more feed to produce a pound of gain. With the exception of ground Wheatland milo, whole Blackhull kafir produced the most rapid gains of all the sorghums. However, it was the least efficient in terms of pounds of feed required per pound of gain. Whole Westland milo was found to be about equal to whole Wheatland milo in rate of gain and required less feed per 100 pounds of gain.

On the average, both on dry lot and on pasture, grinding the sorghum grain increased the rate of gain and reduced the amount of feed required per unit of gain 2-5 percent.

Aubel (1952) compared Colby, Westland, Midland and Martin varieties with corn. The shelled corn, ground milos, ground alfalfa hay and tankage were self-fed free-choice as a mixed ration. Corn produced approximately seven percent less gain per day than Westland milo. Westland milo was superior to Martin, Midland, or Colby milo in terms of both rate and efficiency of gain. There was no significant difference in daily gain or efficiency of gain among groups of pigs fed either Martin milo, Midland milo, or Colby milo.

In a succeeding test very little difference was found in the daily gain produced by Westland milo and Midland milo, but the daily gain produced by each was about 12 percent greater than that produced by corn. There was very little difference in the efficiency of Westland milo and Midland milo in producing 100 pounds of gain. Each proved to be somewhat more efficient than corn.

Aubel (1955) compared shelled corn with whole and with coarsely ground milo when self-fed with a mixed protein supplement of 4 parts tankage, 4 parts soybean meal, 1 part linseed meal and 1 part alfalfa. Whole and ground milo produced 8 to 12 percent greater gains, respectively, than was produced on corn. The pigs fed ground milo made slightly faster and more efficient gains than those receiving whole milo.

Loeffel (1957), in eleven trials, compared yellow shelled corn and protein supplement self-fed free-choice with whole grain sorghum and the same protein supplement. There were two trials involving Wheatland, two with Sooner Milo, three with Early Kalo, two with white kafir, one with Coes, and one with Cheyenne. Pigs fed the grain sorghums made slightly faster gains than those fed shelled corn. The sorghums were from 80 to 95 percent as efficient as corn in producing 100 pounds of gain. The average efficiency of all the grain sorghums used was 89 percent that of corn.

In five trials there was no appreciable difference in rate of gain between whole or coarsely ground grain sorghum, but the coarsely ground sorghum proved to be two percent more efficient than whole grain sorghum. Fine grinding (modulus 3.48) decreased the feed consumption and reduced gains as compared to coarse grinding (modulus 4.02).

SUPPLEMENTATION OF MILO RATIONS

Warren (1923) demonstrated that it was economical to supplement grain sorghum with a protein concentrate (tankage) and pasture. The feeding of milo "chops" alone in dry lot would not support growth from birth to market weight. However, milo chops and tankage fed to pigs on green pasture promoted a satisfactory growth rate of 1.0 pound per day from birth to market weight.

Hillier <u>et al</u>. (1955) reported that a combination of milo, soybean meal, alfalfa meal and minerals plus an antibiotic and B complex vitamins produced rapid and efficient gains. The addition of three percent fish solubles at the expense of soybean meal in a milo-soybean type ration gave a slight but significant increase in rate of gain. Tankage or cottonseed meal alone or a combination of tankage, cottonseed meal or blood meal along with soybean meal produced slower and less economical gains than soybean meal alone. The addition of 0.2 percent L-lysine to a milo-cottonseed meal type ration improved the rate of gain only about five percent but did not improve the efficiency of gain.

Hillier <u>et al</u>. (1954) obtained an increase in growth rate by adding either 0.05, 0.10, or 0.20 percent L-lysine to a milo-soybean meal type ration containing 14 percent protein. There was only a slight increase in daily gain when 0.1 L-lysine was added to a 12 percent protein ration. However, the addition of 0.1 percent L-lysine improved the rate of gain of a 16 percent protein ration by 0.25 of a pound per day and reduced the feed required per pound of gain by 0.57 of a pound. This information indicates rather clearly that lysine is the first limiting amino acid in the ration fed.

Hillier et al. (1956), in a comparison between various protein supplements or combinations of proteins in a supplement, reported that soybean meal produced the most rapid and most efficient gains of any of the combinations tested. The substitution of 3 percent fish meal or 3 percent dry buttermilk for a part of the soybean meal did not improve the economy of gain.

The addition of 2 or 4 percent sesame meal at the expense of soybean meal in a milo-soybean meal type ration reduced the rate and economy of gain as the percentage of sesame meal in the ration was increased. The addition of 0.1 percent L-lysine to the ration containing 4 percent sesame meal, improved rate of gain by 0.1 of a pound daily but did not change the feed economy.

It was indicated that soybean meal and cottonseed meal in the ratio of 3 parts of soybean meal to 1 part of cottonseed meal provided supplemental protein that produced about the same rate and economy of gain as soybean meal alone. Straight cottonseed meal, and combinations of cottonseed meal with soybean meal, with tankage and with blood meal were all unsatisfactory from the standpoint of both rate and economy of gain. Cottonseed meal toxicity symptoms showed up as the experiment progressed, when the ration contained as much as 7.2 percent cottonseed meal.

Hillier et al. (1957) tested combinations of soybean meal and cottonseed meal in mixed milo rations containing about 14 percent protein. It appeared from the standpoint of rate of gain and economy of gain that low gossypol cottonseed meal may be fed with satisfactory results in a ratio of 2 parts soybean meal to 1 part of cottonseed meal. When equal parts of soybean meal and cottonseed meal were fed, the rate of gain was not reduced but twenty-two pounds more feed was required per 100 pounds of gain.

Shelton _et al_. (1951) found that sorghum gluten meal containing 41.7 percent protein was unsatisfactory as the only protein supplement for swine. Sorghum gluten meal is extremely low in several essential amino acids particularly lysine. In feeding trials it was found that for best results this meal should constitute not more than 25 to 30 percent of the protein supplement or not more than 4 percent of the total ration.

Sorghum gluten feed which contains 25 percent protein appears to have only limited use in swine feeds because of amino acid limitations.

GUAR

Guar is a drouth resistant, summer-growing annual legume which requires a warm weather season of 125-130 days for maturity as a seed production crop. According to Brooks and Harvey (1950) guar was introduced into the United States by the U. S. Department of Agriculture in 1930. In its native home, East India, guar is grown as a vegetable for human consumption and as forage for cattle. Since its introduction into the United States, guar has been grown on a limited scale in the dryer areas of Texas, Oklahoma, and other southwestern states.

Although the characteristics of the plants vary, depending on the variety, they generally grow vertical and have a hollow stalk, 3 to 6 feet tall, having large leaves and clusters of bean-like pods. Each pod, if properly formed bears from six to nine seeds. The seeds are greyish buff in color, (some varieties have white seeds) about the size of wheat, but flattened on the sides and ends, and have a very hard, gritty surface (Matlock and Aepli, 1948). The two leading varieties grown in this country are Texsel and Mesa, which can be grown under dryland or irrigated conditions. Generally guar is adapted to sandy soils in the cotton and sorghum growing areas of the 15 inch rainfall belt and south of the 36th parallel. It does not compete well with weeds and is subject to insect and disease damage as with other crops. Brooks and Harvey (1950) found that the average seed production of guar over a five-year period was about 700 pounds per acre. Normally these beans or seeds average from 28 to 31 percent protein.

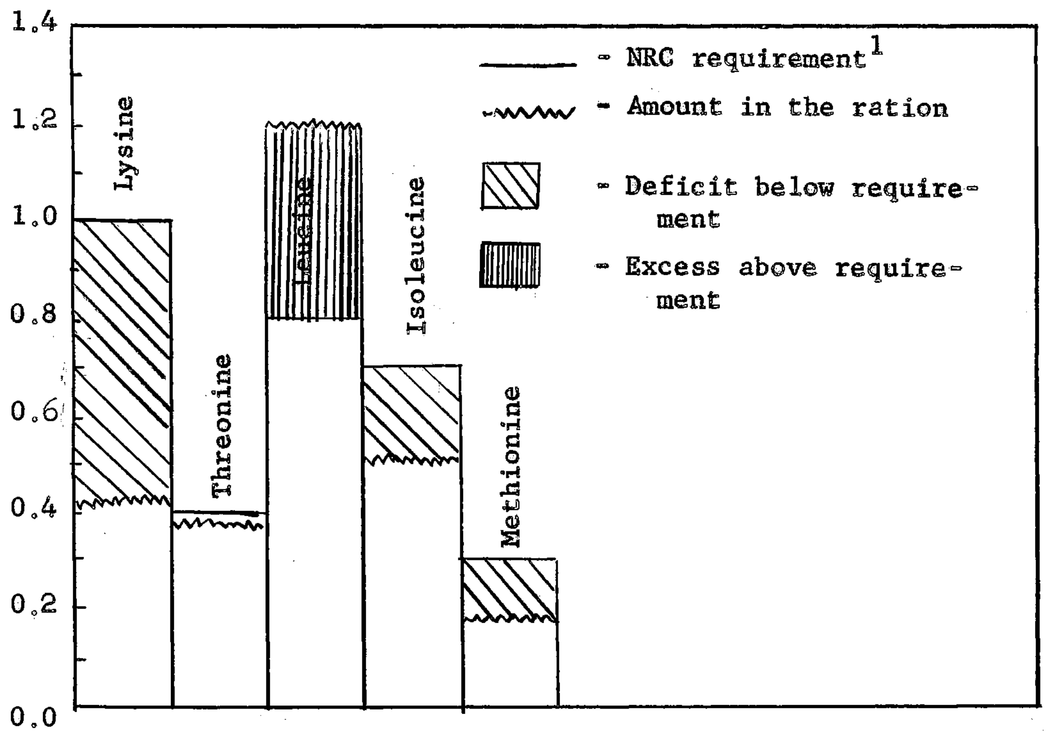
The beans produced by this soil improving crop may be used as a protein supplement for livestock. However, research work concerning the value of guar seed as a livestock feed is rather limited. McIlvain and Baker (1955) compared rolled guar beans (containing 26.4 percent protein) with 41 percent cottonseed meal pellets for wintering beef steers on native grass pasture. Steers receiving a daily allowance of 3.33 pounds of rolled guar beans gained 17 pounds more during a 136-day winter feeding period than steers fed 1.94 pounds of cottonseed meal pellets. Steers fed 1.87 pounds rolled guar beans per day made 40 pounds less winter gains and 49 pounds less yearly gains than steers receiving 1.91 pounds cottonseed meal pellets per day.

In addition to the use of guar beans for livestock feeds, a process has been developed for the extraction of vegetable gum products from the endosperm of the guar bean. These gum products are used in the manufacture of paper, pastes and for other specialized uses. The other by-product from the processing of guar beans is a high protein guar meal used for animal feeds.

Guar meal in its natural and uncooked state is a light greyish-tan color. It is a fine granular material that has a "beany" or "weedy" odor. Cooking the guar meal was suggested as a possible means of removing this "weedy" odor and making it more acceptable by swine and poultry. Either raw or cooked guar meal are high protein products guaranteed to contain not less than 45 percent protein. Guar meal exhibits a sticky, water-holding characteristic which makes it very effective in the pelleting of feeds for various classes of livestock. It has had some, but limited, use in poultry feeds, primarily as a binder to produce an improved pellet and crumble by controlling "mealing down" or "fining" of the feeds in the shipping and handling process.

A comparison of the National Research Council amino acid requirements with the average amino acid composition of a 14 percent protein milo-guar meal ration is given in Figure 1.

Figure 1. A COMPARISON OF THE AMINO ACID REQUIREMENTS OF GROWING PIGS WITH THE AVERAGE ESSENTIAL AMINO ACID COMPOSITION OF A 14 PERCENT MILO-COOKED GUAR MEAL RATION[2]



(1) National Research Council requirements for the growing pig are, in percent of the ration: lysine, 1.0; threonine, 0.4; leucine, 0.8; isoleucine, 0.7; and methionine, 0.3 (assuming adequate cystine is present).

(2) Includes only a partial essential amino acid composition.

EXPERIMENTAL

EXPERIMENT I

Swine Growth Studies

Trial I (Winter, 1957-58)

Procedure:

The purpose of this trial was to determine the relative value of soybean meal, uncooked guar meal and cooked guar meal as sources of supplemental protein to milo-type rations fed to growing-finishing pigs in dry lot. In this trial rate of gain was used as the only criterion for measuring differences between the supplements.

Twenty-eight purebred Poland China, Yorkshire, and Hampshire pigs averaging 64 pounds in weight were allotted on the basis of weight, breed and age to four lots in a randomized block design. The different rations fed were assigned at random to each of the four lots.

The rations fed the different lots are presented in Table I. Kafir 44-14 was ground to medium fineness and mixed with the other ingredients. The chemical composition of the feeds used appears in Tables II and III.

Lot I received the mixed ration containing soybean meal as the source of supplemental protein, which served as the control ration. Lot II received the same ration with the exception that the soybean meal was replaced by uncooked guar meal. In Lot III the soybean meal was replaced by cooked guar meal, while in Lot IV only one-half of the soybean meal was replaced by cooked guar meal.

Table I

Percentage Composition of Rations
Fed to Growing-Finishing Swine
Experiment I (Trial I) Winter 1957-58

Ration Number	I	II	III	IV
Kafir 44-14 (ground)	78.1	78.1	78.1	78.1
Soybean meal	14.0	---	---	7.0
Guar meal (uncooked)	---	14.0	---	---
Guar meal (cooked)	---	---	14.0	7.0
Alfalfa meal (dehydrated)	5.0	5.0	5.0	5.0
Dicalcium phosphate	1.5	1.5	1.5	1.5
Calcium carbonate	.5	.5	.5	.5
Salt (TM)[1]	.5	.5	.5	.5
Aurofac[2]	.3	.3	.3	.3
Fortafeed[3]	.1	.1	.1	.1
Zinc Sulfate[4]	.02	.02	.02	.02
For-fut-D[5]	+	+	+	+
Total	100.02	100.02	100.02	100.02
Total protein (calculated)	15.71	15.72	15.82	15.76

[1]Trace mineral salt furnishes 5.68 mg. Mn., 3.63 mg. Fe., .68 mg. Cu., .23 mg. Co., .16 mg. I, and .11 mg. Zn. per pound of ration.

[2]Supplied 5.4 milligrams of chlortetracycline and 5.4 micrograms of vitamin B_{12} per pound of ration.

[3]Furnishes 2.0 mg. riboflavin, 4.0 mg. pantothenic acid, 9 mg. niacin, and 90 mg. choline per pound of feed.

[4]Zinc sulfate supplies 50 ppm. of zinc.

[5]Supplied 270 I. U. of vitamin D per pound of finished ration.

In both swine studies a ration containing 16 percent protein was fed up to 120 pounds. The protein level was reduced to 14 percent for the period from 120 to 200 pounds.

The pigs were placed in individual pens with concrete floors in a well ventilated, enclosed type barn. Self feeders were used in each of

TABLE II

Chemical Composition of Feeds
Experiment I and II - Winter and Summer 1957-58

	H_2O percent	Ash percent	Protein percent	Crude Fiber percent	Fat percent	Ca percent	P percent	NFE percent
Kafir 44-14[1]	10.56	1.65	10.55	1.63	3.30	0.040	.280	82.36
Soybean meal[1]	9.18	6.31	46.88	5.98	0.85	0.270	.640	30.88
Guar meal (uncooked)[1]	7.82	4.59	47.06	4.13	5.13	0.170	.440	31.27
Guar meal (cooked)[1]	9.69	4.75	47.81	3.37	5.80	0.167	.575	28.58
Alfalfa meal (dehydrated)[2]	7.20	10.10	17.80	24.60	2.40	1.700	.280	38.00

[1]Chemical composition of feeds obtained in the laboratory of Mr. G. R. Waller.

[2]Average values from Morrison (1956).

TABLE III

Partial Amino Acid Composition of Feeds
Experiment I and II

	Protein percent	Lysine percent	Threonine percent	Isoleucine percent	Leucine percent	Methionine percent
Kafir 44-14[1]	10.55	.23	.27	.41	1.26	.160
Soybean meal[1]	46.88	2.80	1.70	2.30	3.50	.500
Guar meal (uncooked)[1]	47.06	2.10	1.43	1.29	1.43	.478
Guar meal (cooked)[1]	47.81	2.10	1.43	1.29	1.43	.478
Alfalfa meal (dehydrated)[2]	17.80	.75	.60	.90	1.16	.320
Casein[3]	85.00	6.97	3.83	5.61	8.59	2.810

[1]Amino acid values obtained by microbiological assay produced in the laboratory of Dr. R. J. Sirny.

[2]Average values from Morrison (1956).

[3]Average values from Block and Weiss (1956).

the pens to supply the ration assigned to each of the pigs. Water was supplied in a small trough which was filled at least twice daily.

The pigs were weighed at 14-day intervals until they approached 200 pounds, when they were weighed every seven days. The pigs were removed from the trial when they weighed approximately 200 pounds.

Results and Discussion

The results are summarized in Table IV. Analysis of variance (Snedecor, 1957) showed a highly significant difference ($P < .01$) among the different ration groups with respect to daily gain.

The average daily gains of the pigs fed cooked guar meal, equal parts of soybean meal and cooked guar meal, and soybean meal alone as the supplemental protein were: 1.32, 1.56, and 1.73 pounds per day, respectively. These average daily gains show what appears to be a linear relationship between the amount of soybean meal in the ration and the performance of the pigs. As the percent soybean meal was increased in the ration, the daily gains also increased. There was a distinct difference observed in the appearance of pigs fed cooked guar meal and soybean meal. Those fed soybean meal showed more bloom throughout the trial than those fed guar meal.

The substitution of cooked guar meal (Lot III) for soybean meal (Lot I) in a milo-type ration reduced the average daily gain about 24 percent. A combination of equal parts cooked guar meal and soybean meal (Lot IV) increased the daily gains 18 percent over those obtained with cooked guar meal as the supplemental protein; however, this combination still produced gains that were 10 percent below the gains produced by a ration containing soybean meal alone as the source of supplemental protein.

There was only a slight difference in rate of gain produced by pigs receiving cooked (Lot III) or uncooked (Lot II) guar meal as the source of supplemental protein.

Table IV

Summary of Results
Experiment I
Trial I Winter 1957-58

Ration Number Source of Supplemental Protein (Treatment)	I soybean meal	II uncooked guar meal	III cooked guar meal	IV soybean meal + c guar meal
Number of pigs in lot	7	7	7	7
Av. initial weight (lbs.)	64.1	64.4	64.4	64.3
Av. final weight (lbs.)	201.4	201.0	197.4	198.0
Av. total gain (lbs.)	137.3	136.6	133.0	133.7
Av. daily gain (lbs.)	1.73	1.27	1.32	1.56
Av. days on feed	80.4	107.6	102.4	87.4

These data indicate that guar meal alone or a combination of equal parts cooked guar meal and soybean meal would not satisfactorily replace soybean meal as a protein supplement to milo. There appeared to be very little difference between uncooked and cooked guar meal in producing gain in pigs. It should be borne in mind that feed efficiency values were not taken into consideration. Apparently the rations containing the guar meal were quite unpalatable to the pigs for those groups receiving guar meal were very persistant in rooting out and wasting feed even though the feeders were closed as much as possible. Special adjustments were made to prevent feed wastage in the second trial.

Trial II Summer (1958)

Procedure:

A second trial was initiated in the summer (1958) to further evaluate uncooked and cooked guar meal as protein supplements to milo type rations.

In this trial both rate of gain and efficiency of feed utilization were used as criteria for the interpretation of the results.

Thirty-two purebred Hampshire, Yorkshire, and Poland China pigs were allotted as equally as possible on the basis of weight, age and breed to four lots in a randomized block design. The initial weight of the pigs was approximately 53 pounds. The treatments were assigned at random to the different lots.

Each lot was fed one of the mixed rations presented in Table V. The chemical composition of the feeds used appears in Tables II and III. Lots I, II and III received the same source of supplemental protein that was fed in Trial I. In Lot IV the supplemental protein was supplied by a mixture of 3 parts soybean meal to 1 part cooked guar meal.

The pigs were placed in individual pens in the same manner as in Trial I. Feed was supplied ad libitum in individual feeders and water supplied at least twice daily.

Individual feed consumption was recorded to determine efficiency of feed utilization.

The pigs were weighed at 14-day intervals during the trial. This trial was terminated at the end of 112 days.

Results and Discussion

The results of Trial II are summarized in Table VI. Highly significant ($P < .01$) differences were obtained among the treatments both in rate of gain and in efficiency of feed utilization. Soybean meal alone (Lot I) or a combination of 3 parts soybean meal to 1 part guar meal (Lot IV) as a protein supplement to milo produced significantly ($P < .01$)

Table V

Percentage Composition of Rations
Fed to Growing-Fattening Swine
Experiment I (Trial II) Summer 1958

Ration Number	I	II	III	IV
Kafir 44-14 (ground)	78.0	78.0	78.0	78.0
Soybean meal	14.1	---	---	10.6
Guar meal (uncooked)	---	14.1	---	---
Guar meal (cooked)	---	---	14.1	3.5
Alfalfa meal (dehydrated)	5.0	5.0	5.0	5.0
Dicalcium phosphate	1.5	1.5	1.5	1.5
Calcium Carbonate	.5	.5	.5	.5
Salt (TM)	.5	.5	.5	.5
Antibiotic-vitamin-mineral mix[1]	.4	.4	.4	.4
Total	100.0	100.0	100.0	100.0
Total protein (calculated)	15.74	15.77	15.87	15.77
Percent lysine	.61	.51	.51	.59
Percent threonine	.48	.44	.44	.47
Percent isoleucine	.69	.55	.55	.65
Percent leucine	1.53	1.24	1.24	1.46
Percent methionine	.21	.20	.20	.21

[1]Contains the following feed additives: Aurofac, .3 lb; Fortafeed, .1 lb.; zinc sulfate, .02 lb.; For-fut-D, 2 gm; iron oxide, 2.4 gm.; copper sulfate, .8 gm. These additives supplied 5.4 mg. chlortetracycline, 5.4 mcg. vitamin B_{12}, 9 mg. niacin, 4 mg. pantothenic acid, 2 mg. riboflavin, 90 mg. choline, 540 I. U. vitamin D, 250 USP vitamin A, 2.0 mg. cobalt, 15 mg. iron, and 2 mg. copper per pound of feed.

greater gains than uncooked (Lot II) or cooked (Lot III) guar meal alone. The replacement of soybean meal with cooked guar meal reduced the rate of gain .75 pound per day and required 1.44 pounds more feed per pound of gain. It will be noted in Table V that the ration in which guar meal was the source of supplemental protein contained less lysine, threonine, isoleucine and leucine than a ration in which soybean meal alone provided the supplemental protein.

The guar meals produced almost identical rates of gain (.70 lb. vs. .73 lb.). However the pigs on guar meal made only about one half the daily gain made by those on soybean meal (.70 vs. 1.44). Although an attempt was made to reduce feed wastage, the pigs receiving guar meal in their diet appeared to waste more feed than those receiving soybean meal. This feed wastage indicates that the ration containing guar meal as the only source of supplemental protein was unpalatable or unacceptable to swine.

Table VI

Summary of Results
Experiment I
Trial II Summer 1958

Ration Number Source of Supplemental Protein (Treatment)	I soybean meal	II uncooked guar meal	III cooked guar meal	IV soybean meal + c guar meal
Number of pigs in lot	8	8	8	7[1]
Av. initial weight (lbs.)	53.4	53.3	53.3	54.0
Av. final weight (lbs.)	197.5	124.3	124.3	197.7
Av. total gain (lbs.)	144.1	71.0	71.6	143.7
Av. daily gain (lbs.)	1.48	.70	.73	1.42
Av. days on Feed	98.0	99.8	99.8	99.8
Av. feed/lb. gain	3.54	5.43	4.98	3.30

[1]One pig was removed from the experiment because of Chronic Vegatative Valvular Endocarditis.

The ration containing a combination of 3 parts soybean meal to 1 part cooked guar meal (Lot IV) as the source of supplemental protein produced gains and feed efficiency values that were not significantly different from the ration in which soybean meal (Lot I) provided the supplemental protein. This ration in which a mixture of soybean meal and cooked guar meal provided the source of supplemental protein contained only slightly less lysine, threonine, isoleucine and leucine than a ration in which soybean meal alone provided the supplemental protein.

On the basis of two trials, it is apparent that cooked or uncooked guar meal alone as the source of supplemental protein to milo will not produce a satisfactory rate of gain or feed efficiency. The reason for this poor performance appears to be associated with the palatability or acceptability of the rations containing guar meal. There is also the possibility that the quality of protein in the guar meal was inferior to that provided by the soybean meal.

EXPERIMENT II

Rat Growth Study (Summer, 1958)

Procedure:

In view of the results obtained in the swine growth studies it seemed desirable to study the extent of deficiencies of the three amino acids: lysine, threonine and isoleucine in a 14 percent protein ration containing milo and cooked guar meal.

Weekly gain was used as the criterion for interpreting the results. Feed consumption was not measured because feed wastage was uncontrolable.

Seventy-two albino male rats of the Sprague-Dawley strain were divided into nine groups of eight rats each and randomly assigned to the nine experimental treatments. The first eight treatments make up a 2x2x2 factorial arrangement and these treatments consist of a basal ration with all possible combinations of the three supplemental amino acids. The average initial weight of the rats was approximately 53 grams.

The basal ration used for the factorially arranged portion of this study is shown in Table VII. Both the Kafir 44-14 and the cooked guar meal were the same products as were used in Experiment I. The amino acid supplementation was as follows in percent: L-lysine, 0.50 (95 percent L-lysine.HCl); DL-threonine, 0.30; DL-isoleucine, 0.30. These amino acids were added to the basal ration in every possible combination to give eight different experimental rations. The different combinations are shown in Table VIII.

Table VII

Percentage Composition of Rations
Fed to Growing Rats
Experiment II-Summer 1958

Ration Components	Percent Basal 1	2
Kafir 44-14 (ground)	80.88	86.88
Guar meal (cooked)	11.00	---
Casein	---	5.00
Salts XIV[1]	6.00	6.00
$ZnSO_4$	.02	.02
B-Vit mix[2]	2.00	2.00
Quadrex[3]	.10	.10
Total	100.00	100.00
Total protein (calculated	13.76	13.42
Percent lysine	.41	.55
Percent isoleucine	.47	.64
Percent threonine	.38	.43
Percent leucine	1.18	1.52
Percent methionine	.18	.23

[1]Composed of the following ingredients: Calcium carbonate, 6.86 gm.; calcium citrate, 30.8 gm.; calcium biophosphate, 11.3 gm.; magnesium carbonate, 35.2 gm.; magnesium sulfate, 38.3 gm.; potassium chloride, 12.5 gm.; dibasic potassium phosphate 21.9 gm.; sodium chloride 7.7 gm.; cupric sulfate 8.0 mg.; ferric ammonium citrate, 1.5 mg.; manganese sulfate, 20 mg.; ammonium alum, 9.0 mg.; potassium iodide, 4.0 mg.; sodium floride, 51.0 mg. per 100 gms of salt mix.

[2]Composed of sucrose and the following vitamins to provide in milligrams per 100 grams of ration: thiamin HCl., 0.5; riboflavin, 0.8; niacin, 4.0; pyridoxine HCl., 0.5; calcium pantothenate, 4.0; biotin, 0.04; folic acid, 0.2; menadione, 0.5; vitamin B_{12}, 3.00; inositol, 10.0; para amino benzoic acid, 10.0; choline chloride, 100.0.

[3]Contains vitamin A and D to supply 2000 units and 250 units respectively per gram of ration.

The other treatment included in the experiment was a milo-casein type ration calculated to contain about the same percentage protein as the other experimental rations. The component parts of the ration appears in Table VII. The purpose of the milo-casein ration was to serve as an index for growth at this particular protein level.

Table VIII

Summary of Results - Experiment II
Effect of Adding Lysine, Isoleucine and Threonine
Alone and in Combination to the Basal Ration

Ration No.	1	2	3	4	5	6	7	8	9
Treatment[1]	B	B+L	B+I	B+T	B+L+I	B+L+T	B+I+T	B+L+I+T	Casein
Percent L-lysine	.41	.89	.41	.41	.89	.89	.41	.89	.55
Percent L-isoleucine	.47	.47	.62	.47	.62	.48	.62	.62	.64
Percent L-threonine	.38	.38	.38	.53	.38	.53	.53	.53	.43
Number of rats	8	8	8	8	8	8	8	8	8
Av. initial wt. (gms.)	52.5	54.0	53.3	52.3	53.0	54.0	53.3	53.8	52.8
Av. final wt. (gms.)	120.4	146.1	111.5	117.8	142.4	148.4	119.9	161.8	144.3
Av. gain/week (gms.)	22.7	30.7	19.4	21.8	29.8	31.5	22.2	36.0	30.5

[1]B Basal ration (Table VII),
I .3 percent DL-isoleucine,
L 0.5 percent L-lysine (95 percent, L-lysine.HCl)
T 0.3 percent DL-threonine
Casein ration appears in Table VII.

The component parts of each ration were thoroughly mixed and stored in large containers in a closed cabinet.

The rats were placed in wire bottom cages where they were fed and watered ad libitum from small metal containers.

The experiment was terminated at the end of 21 days. During this experimental period individual body weights were recorded weekly.

Results and Discussion:

The results are summarized in Table VIII. Of the three amino acids added to the basal ration, the addition of 0.5 percent L-lysine·HCl produced the greatest effect on growth rate. The addition of L-lysine alone produced a highly significant ($P < .01$) increase in weekly gains above those gains obtained when lysine was not present in the ration. The addition of 0.3 percent DL-threonine or DL-isoleucine alone did not change the growth rate significantly. The addition of either threonine or isoleucine in combination with lysine did not improve the growth rate significantly above that produced by the addition of lysine alone. However, there was a significant ($P < .05$) interaction between threonine and isoleucine in producing rate of gain in rats. When a combination of threonine and isoleucine was added to the ration, the growth rate was significantly improved above the gains obtained with rations containing either threonine or isoleucine alone.

It was noted that the average weekly gains of the rats receiving a ration containing lysine alone; lysine plus iosleucine; and lysine plus threonine were quite similar to those gains made by the animals consuming the milo-casein type diet. These results indicate that a 14 percent protein milo-cooked guar meal type ration supplemented with 0.5

percent L-lysine·HCl is comparable to a milo-casein diet containing about the same protein level. The ration containing a combination of lysine, threonine and isoleucine produced 5.5 grams more weekly gains than the ration containing casein as the source of supplemental protein. The additional amount of lysine in the ration containing the combination lysine, threonine and isoleucine appears to be the cause of the increased gain above that obtained from the milo-casein type diet.

From these data it appears that lysine is the first limiting amino acid in a milo-cooked guar meal ration when fed to rats.

SUMMARY

Two feeding trials involving a total of 60 pigs were conducted to evaluate uncooked and cooked guar meal as protein supplements to milo for growing-finishing pigs fed on a concrete floor. The basal ration, in which soybean meal alone provided the source of supplemental protein to milo, produced gains at the rate of 1.48 pounds per day and required 3.54 pounds of feed per pound of gain.

Both uncooked and cooked guar meal proved to be unsatisfactory sources of supplemental protein. Each produced gains that were about 50 percent below the gains produced by soybean meal alone as the supplemental protein. When one-fourth of the soybean meal was replaced by cooked guar meal the rate of gain and feed efficiency of the pigs were not significantly different from those fed soybean meal alone. This combination of soybean meal and cooked guar meal produced gains at the rate of 1.42 pounds per day and required 3.30 pounds of feed per pound of gain. A combination of equal parts soybean meal and cooked guar meal produced gains that were intermediate as compared to the gains produced by soybean meal or cooked guar meal alone as the source of supplemental protein.

An experiment with rats was conducted to determine the amino acid adequacy of the protein in a milo-cooked guar meal type ration. L-lysine·HCl, DL-threonine and DL-isoleucine were added separately and in combination to a basal ration containing Kafir 44-14, cooked guar meal, minerals and vitamins. The addition of 0.5 percent L-lysine·HCl alone produced a significant increase in weekly gains above those gains obtained when lysine was not added. This information indicates that lysine is the first limiting amino acid in a milo-guar meal ration. The gains produced by a ration containing 0.5 percent added L-lysine·HCl; 0.5 percent L-lysine·HCl plus 0.3 percent DL-threonine; and 0.5 percent L-lysine·HCl plus 0.3 percent DL-isoleucine were quite similar to those gains produced by a milo-casein type ration containing about the same percentage of protein.

The addition of 0.3 percent DL-threonine or 0.3 percent DL-isoleucine alone did not produce a significant change in the growth rate, but an interaction was shown to exist between threonine and isoleucine in producing rate of gain in rats. A ration containing a combination of threonine and isoleucine produced greater gains than the rations containing either threonine or isoleucine alone.

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A P P E N D I X

Table IX
Experiment I (Trial I) Winter 1957-58
Swine Growth Study

Analysis of Variance
Average Daily Gain

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	27	1.7644		
Block	6	.2723		
Treatment	3	.9604	.3201	10.8508**
Treatment 3vs4vs1	2	.5897	.2949	9.9966**
Linear	1	.5843	.5843	19.8070**
Deviations	1	.0054	.0054	
Treatment 2vs3	1	.0087	.0087	.2949
Error	18	.5317	.0295	

**Significant at the 1 percent level.

Table X
Experiment I (Trial II) Summer 1958
Swine Growth Study

Analysis of Variance
Average Daily Gain

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	30	5.3386		
Block	7	.4448		
Treatment	3	4.1964	1.3610	33.03**
1vs4	1	.0390	.0390	.95
2vs3	1	.0030	.0030	.07
1 4vs2 3	1	4.1544	4.1544	100.83**
Error	20	.8255	.0412	

**Significant at the 1 percent level.

Table XI
Experiment I (Trial II) Summer 1958
Swine Growth Study

Analysis of Variance
Feed per Pound of Gain

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	30	64.7661		
Block	7	8.2514		
Treatment	3	26.6400	8.8800	5.95**
1vs4	1	.2328	.2328	.16
2vs3	1	.8281	.8281	.55
1 4vs2 3	1	25.5791	25.5791	17.12**
Error	20	29.8747	1.4937	

**Significant at the 1 percent level.

Table XII
Experiment II
Rat Growth Study

Analysis of Variance
Weekly Gain

Source of Variation	Degrees of Freedom	Mean Square	F Value
Total	63		
Block	3		
Treatment	7	283.5486	14.0516**
Lysine	1	1752.0503	86.8254**
Isoleucine	1	.6045	.0299
Threonine	1	79.8789	3.9585
Lysine x Isoleucine	1	41.9904	2.0808
Lysine x Threonine	1	24.8004	1.2290
Isoleucine x Threonine	1	82.0836	4.0678*
L x I x T	1	3.4318	.1701
Error	53	20.1790	

*Significant at the 5 percent level.

**Significant at the 1 percent level.

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Personal data: Born near Tyrone, Oklahoma, March 31, 1935, the son of Glenn E. and Mildred E. Woodward.

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