AMINO ACID SUPPLEMENTATION
TO SWINE RATIONS

By

WILSON G. POND

Bachelor of Science

University of Minnesota

Minneapolis, Minnesota

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Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The relation of amino acids in feeds to satisfactory growth of swine is well recognized. A large percentage of the weight increase of a growing pig is made up of lean tissue, and the protein in this lean tissue cannot be efficiently synthesized and deposited if a proper combination of essential amino acids is not present in the feed.

Many feeds commonly fed to swine supply proteins of low quality. Corn protein is low in lysine and tryptophan. Soybean meal is relatively lower in methionine than would be desirable for a protein supplement. However, evidence does not yet insure these to be the only amino acids needing consideration. Further work is needed to determine whether other amino acids and/or other factors still unknown may be limiting maximum use of common rations.

With relatively pure forms of both the natural L and racemic DL forms of amino acids now available, it is possible to use them as supplements to common rations in order to test the adequacy of such rations with respect to the amino acid in question and also to observe the effects of the D-isomer on growth.

The feeding trials described here are designed to study primarily 1) the most desirable protein level for growth in a corn-soybean meal type ration under the conditions of this series of experiments, 2) the adequacy of a low protein corn-soybean meal type ration with respect to lysine and methionine, 3) the effect of the D-form of lysine on growth of swine, and 4) the adequacy of a milo-soybean meal type ration with respect to lysine.

LITERATURE REVIEW

In a study of amino acid adequacy of feeds, it is necessary to correlate the amino acid requirements of the animal with the amino acid composition of the feed. The literature bearing on the first of these includes chiefly those amino acids known to be limiting in rations commonly used for swine.

Tryptophan

Beeson et al., (1948) found that tryptophan is essential for weanling pigs by producing deficiency symptoms on a ration in which most of the tryptophan in the protein was destroyed by hydrolysis. Supplementation with DL-tryptophan up to the 0.4 percent level supported normal growth indicating that the tryptophan requirement of weanling pigs did not exceed this figure. In later work, Shelton et al., (1951) showed that growing pigs required 0.2 percent DL-tryptophan when a 24.5 percent protein ration was fed.

Thompson et al., (1952), using suckling pigs on a synthetic milk diet, presented data that support the view that partial utilization of the D-form may occur, although no statistically significant differences in growth or nitrogen retention were obtained between pigs receiving L-and DL-forms.

Berg et al., (1932) tested the utilization of the D-isomer of tryptophan by rats fed a basal diet deficient in tryptophan. When L-tryptophan was replaced by double amounts of the DL-form, rats showed a pronounced increase in growth rate, but when replaced by an equal amount of the DL-mixture, no significant difference was found in the growth rate. They concluded that growth is as rapid, or nearly so, when the ration contains DL-tryptophan as when it contains an equal amount of L-tryptophan. duVigneaud (1932b) obtained equal growth in rats using D-tryptophan and L-tryptophan separately. Oesterling and Rose (1952) in more careful investigations than were possible in the '30's presented data indicating only 75 percent utilization of the D-form by the rat.

Berg et al., (1930a) showed the acetyl derivitive of L-tryptophan to support growth of rats on a tryptophan deficient diet and later (1930b) demonstrated the ability of 3-indolepyruvic acid to replace tryptophan. duVigneaud et al., (1932b) verified the growth promoting ability of acetyl-L-tryptophan but obtained no growth response from acetyl-D-tryptophan fed to rats. Berg (1934) confirmed the above observations by feeding rats on tryptophan deficient diets, graded amounts of acetyl derivitives of L-, D- and DL-tryptophan. It was concluded that acetylation does not impair the utilization of L-tryptophan but does render D-tryptophan useless for growth of rats. Acetyl DL-tryptophan gave no better growth response than acetyl-L-tryptophan, while acetyl-D-tryptophan gave no growth response at all.

Totter and Berg (1939), studying the influence of optical isomerism on the utilization of various amino acids for growth in the mouse, found that D-tryptophan promoted some growth but was not equal to the L-isomer.

Wilkening and Schweigert (1947) indicate partial utilization of D-tryptophan by chicks.

Lysine

Mertz *et al.*, (1949) produced rapid recovery of weanling pigs from symptoms of lysine deficiency by adding 2.0 percent DL-lysine to a purified diet deficient in lysine. Brinegar *et al.*, (1949) fed a 10.6 percent protein diet containing linseed oil meal supplemented with histidine and methionine and found that L-lysine added in levels up to 0.58 percent of the diet increased growth rate of weanling pigs over a four week period. Brinegar *et al.*, (1950b) using sesame meal as the protein supplement, produced an increase in daily gain and in feed efficiency of young pigs on increasing levels of L-lysine up to 1.17 percent of a 22 percent protein ration. They concluded that the increased growth rate obtained on a high protein ration accounts for part of the observed increase in the absolute requirement for lysine. Shelton *et al.*, (1950) using 10 percent gelatin and 16 percent zein as the source of protein supplemented with tryptophan, methionine and histidine, estimated the L-lysine requirement for optimum growth of weanling pigs at 1.0 percent of the diet. Increased growth rate above the basal diet resulted from the additions of 0.5, 0.8 and 1.0 percent, but no further improvement was obtained at the 1.2 and 1.4 percent levels over a 35 day period.

Grau (1948) tested the effect of protein level on the lysine requirement of chicks. Sesame meal was used as the protein source and L-lysine was added at varying levels. Even without supplemental lysine growth rate increased as the protein level was increased. The addition of 0.1 percent L-lysine increased the growth rate at all protein levels, but 0.2 percent added L-lysine was only effective at protein levels above 5 percent, and

0.3 percent added L-lysine was only effective when the ration contained more than 10 percent protein. From these data it was concluded that as protein level is increased, lysine requirement for maximum growth of chicks also increases, but at a decreasing rate. This was true whether the lysine requirement was expressed as a percent of the diet or as the weight of lysine consumed per day per unit body weight. It was suggested that amino acid requirements can best be expressed as a percentage of the diet at a particular protein level, preferably the minimum protein level necessary to promote rapid growth. Grau and Kamei (1950) showed that when zein replaced 20 percent of the glucose in a lysine deficient ration the lysine requirement of the chicks was increased, showing further that the lysine requirement increases with the level of protein.

Kratzer (1950), feeding a 25 percent protein ration t- turkey poults in which sesame meal was the source of protein, obtained increase in growth directly proportional to the L-lysine level in the ration. Approximately twice as much DL-lysine was required to produce growth equal to that obtained from the L-isomer. In another phase of the experiment four groups of eight poults each were fed for 18 days on the same basal diet with graded levels of D-lysine added. Average daily gain for each lot decreased as the D-lysine level was increased, indicating growth depression resulting from presence of the D-isomer.

Berg and Dalton (1934) in studying the influence of optical isomerism on utilization of lysine for growth presented data indicating that only L-lysine can be used by the rat for growth. Later, Berg (1936) fed a purified diet in which zein, supplemented with tryptophan, cystine and histidine was the source of nitrogen. When D-lysine was added he observed no difference in growth or behavior between rats fed D-lysine and those getting no lysine supplement. All the rats supplemented with L-lysine showed an increased growth rate. Rats fed L-lysine following a period of 80 days with no lysine supplement, responded immediately in growth.

Guthnick et al., (1953) tested various proteins, from both animal and plant sources, for differences in degree of utilization of their lysine by protein depleted adult rats. Fecal excretion of lysine was determined and the results showed that a greater percentage of lysine was excreted in the feces of animals fed cereal foods and unheated soybean flakes than was excreted in the feces of rats fed dried eggs and animal protein products.

Totter and Berg (1939), using the mouse to study the utilization of optical isomers of various amino acids, obtained no growth promotion by the addition of D-lysine to a lysine deficient purified ration.

Methionine

Mitchell and Block (1946) indicated that for rats methionine is the limiting amino acid in soybean protein. Bell et al., (1950) showed the deficiency of methionine in soybean oil meal by feeding a purified ration containing 10 percent protein from soybean meal. The unsupplemented soybean meal was less efficiently retained by growing pigs and had a biological value below the control, whole egg protein, but methionine added to equal the amount in the whole egg made the soybean protein equal to egg protein. They estimated the methionine requirement for growing pigs to be between 0.07 and 0.27 percent of the ration with no mention made of cystine. Shelton et al., (1951) with a 21 percent protein basal ration and (1950) with a 22 percent protein basal ration, added various levels and proportions of methionine and cystine to a ration for weanling pigs. They set the methionine requirement at 0.3 percent of the ration in the presence of 0.3 percent cystine or 0.6 percent methionine if no cystine is present.

Curtin et al., (1952b) demonstrated that for pigs there is no practical need for methionine supplementation to a corn soybean meal ration containing 22 percent protein and 0.36 percent cystine. The requirement of methionine was estimated not to exceed 0.31 percent of the ration at this level of protein. Curtin et al., (1952a) in a later evaluation, set the requirements for growing pigs at 0.45 percent of the ration when the ration contains 0.27 percent cystine. The methionine plus cystine requirement in this case was approximately 0.7 percent of the ration.

Bauer and Berg (1943) fed mice mixtures of 20 purified amino acids as a source of nitrogen. It was found that both optical isomers of methionine could be used for growth by the mouse.

duVigneaud et al., (1932a) compared the growth promoting properties of D- and L-cystine in rats. From these data obtained using a purified diet, it was concluded that D-cystine cannot be used for growth in place of the naturally occurring L-form. Loring et al., (1933) found that meso-cystine (inactive DL-mixture) promoted growth equal to that obtained with the L-isomer, indicating complete resolution into the D- and L-forms, but no utilization of the D-form. Jackson and Block (1932) used a diet low in cystine to test the availability of methionine as a supplement for weanling rats. Average growth of 10 rats before methionine supplementation was 0.90 gram per day; after methionine supplementation, 18.2 grams per day. These results show that methionine is capable of stimulating growth in rats on a diet poor in cystine.

Almquist (1949) concluded that the methionine requirement for chicks increases in direct proportion to the rise of protein level of the ration.

Almquist (1951) stated the methionine requirement for the chick to be 0.5 percent of the diet with adequate cystine present or 0.9 percent in the absence of cystine. Bird (1952) fed a methionine deficient basal ration ad libitum to two week old chicks to compare methionine and two of its analogues with respect to improvement of growth and feed efficiency. The analogues used were dl-α-hydroxy-γ-methylmercaptobutyramide and the salt of dl-α-hydroxy-γ-methylmercaptobutyric acid. The growth response obtained from these methionine analogues, in general, paralleled that obtained from methionine. With all three supplements feed utilization was improved above that of the basal at all levels fed (0.1-0.4 percent of the ration). These data indicated that the chick has the ability to utilize both of these methionine analogues as well as methionine itself for growth and improvement of feed efficiency.

Grau and Kamei (1950) also observed a relationship between protein level and methionine requirement, but not a linear one; that is, the methionine requirement increased with the protein level, but at a slower rate. Their explanation for this discrepancy was that the cystine requirement for optimum growth may be unaffected by protein level while the methionine requirement is markedly affected. Thus if cystine requirement were subtracted from methionine plus cystine requirement at all protein levels, the methionine requirement would increase with the protein level. There is no direct evidence, however, concerning cystine requirement and its relation to protein level.

Kade and Sheperd (1948) showed the inhibitory effect of greater than optimum quantities of methionine on growth of rats. DL-methionine added, in varying levels to a casein diet gave the following results: 1.0 percent, increase in growth over basal; 1.5 percent, only slight increase over basal; 2.0 percent and 2.5 percent DL methionine, definitely inhibited growth and protein utilization. It was suggested that the mixture of amino acids in which the proportion most nearly approaches the requirement of the animal for essential amino acids is probably the most efficiently utilized.

Wyzan et al., (1950) produced symptoms of methionine toxicity in adult dogs fed casein or lactalbumin diets. Doses of methionine over the optimum level produced vomiting, negative nitrogen balance, loss of hair, open skin lesions, and dry eyes hypersensitive to light. These symptoms were severe enough to cause death. It was observed that if more than 50 percent of the total nitrogen was supplied as methionine an imbalance was created which impaired utilization of the entire ration. The toxic effects could not be attributed, at least directly, to its labile methyl groups or its sulphur content, since excessive choline chloride and cystine were fed without adverse effects.

Other Amino Acids

Beeson et al., (1951) used weanling pigs to test the essentiality of arginine, leucine, phenylalanine and valine for their growth. These workers showed for the first time that these four amino acids are required along with the other six known to be essential for the rat, for the optimum growth of weanling pigs.

Brinegar et al., (1950a) using blood meal as the protein supplement to a 22 percent protein basal ration, set the isoleucine requirement for optimum growth of weanling pigs at 0.7 percent of the ration.

Sewell et al., (1953) fed a semi-synthetic milk diet containing 11 amino acids but lacking in threonine to suckling pigs to determine their requirement for threonine. L-threonine was added to the 25 percent protein diet at various levels up to 1.12 percent of the ration. Increased growth rate and feed efficiency were obtained with increased L-threonine up to 0.92 percent of the total diet, but no further improvement resulted from additional threonine. From these data the L-threonine requirement of suckling pigs was estimated at approximately 0.9 percent of a 25 percent protein diet.

Mertz et al., (1952) fed a diet to weanling pigs, in which pure amino acids and diammonium citrate provided the nitrogen, to determine their threonine requirement. Based on their data obtained over a 35-day feeding period they estimated that the L-threonine requirement of weanling pigs does not exceed 0.4 percent of the ration.

Cox and Berg (1934), in a comparison of the availability of D-and L-forms of histidine for growth by rats, observed that D-histidine was able to replace partially, but not completely, L-histidine in a purified diet.

Totter and Berg (1939), using zein as a source of protein supplemented with several amino acids, found that mice could utilize D-histidine to some extent, but that the growth was slower than with the natural form.

Bauer and Berg (1943) obtained moderate growth in mice fed amino acid mixtures as the nitrogen source. The study was designed to test the utilization of the D-form of several amino acids. It was concluded that both forms of phenylalanine are used, but only the L-form of valine, leucine, isoleucine and threonine can be used for growth by mice.

Wyzan et al., (1950) showed that large excesses of phenylalanine added to a casein diet for dogs are metabolized without difficulty. The tyrosine formed may be voided in the urine in quantities exceeding its solubility. It was also shown that the addition of tyrosine and leucine was without effect on nitrogen utilization. Tyrosine is poorly absorbed and at high intakes a high proportion appears in the feces.

The delicate balance existing between certain amino acids was emphasized by Stare and Bent (1952) in summarizing results of work where a tryptophan deficiency was produced in rats and then more growth response was obtained by adding niacin than by adding tryptophan itself. It was demonstrated that tryptophan deficiency can be produced easier in the presence of sulfur containing amino acids than in their absence.

Ebisuzaki et al., (1952) produced an amino acid imbalance by adding 0.078 percent threonine to a 9 percent casein diet. Supplying the protein as free amino acids simulating 9 percent casein, results in no imbalance. The results were interpreted as indicating that excess dietary threonine causes imbalance by decreasing the availability of the amino acids in whole casein, possibly by inhibiting digestive processes.

Amino Acid Requirements as a Percentage of Protein in the Diet

It is felt by several workers that the amino acid requirements of pigs can be more accurately measured when expressed as a percentage of dietary protein rather than as a percentage of the total ration. Brinegar et al., (1950a) estimated the isoleucine requirement of the growing pig to be 3.2

percent of the dietary protein. The same workers (1950b) set the L-lysine requirement at 5.5 percent of the dietary protein. Curtin et al., (1952a) reported a DL-methionine requirement equal to 3.2 percent of the protein of a 22 percent protein ration. Beeson et al., (1948) indicated the DL-methionine requirement does not exceed 1.4 percent of the dietary protein. This discrepancy may be due to allowance for cystine in one case but not in the other.

Grau (1948) and Grau and Kamei (1950) have presented data from chick experiments which show that lysine and methionine requirements increase with increased protein in the ration, indicating the desirability of expressing amino acid requirements as a percentage of the protein, since these figures do not differ greatly at widely varying levels of protein intake. This relationship of amino acid requirements to the dietary protein level follows the concept of Almquist (1947) who stated that requirement for any essential amino acid for a given growth rate has a definite proportion to the others present.

Time Factor in Amino Acid and Protein Supplementation

Geiger (1947) fed weanling rats on low protein diets to study the effects on growth of delayed supplementation to incomplete amino acid mixtures. Rats fed a tryptophan deficient diet supplemented with tryptophan incorporated into the feed grew satisfactorily. Those fed the added tryptophan at alternating 12 hour intervals with the rest of the ration displayed no growth at all. Using the same experimental design, similar results were obtained feeding a zein ration deficient in lysine, and a methionine-free casein ration. When the limiting amino acid was incorporated into the ration good growth resulted, but when fed at alternating intervals with the deficient ration very poor growth was obtained. From this finding, it was suggested that incomplete amino acid mixtures are not stored in the body but are irreversibly further metabolized, and that for protein synthesis, all essential components must be present at the same time.

Cannon et al., (1947) made rats protein deficient by dietary depletion. They recovered lost weight steadily when fed a repletion ration adequate in all respects. However, if the repletion ration was divided into two parts, to one of which were added arginine, histidine, leucine, lysine, and threonine and to the other isoleucine, methionine, phenylalanine, tryptophan and valine, and these two rations were fed alternately, poor weight recovery resulted. If the two were mixed and fed using the time intervals as before, good growth occurred. When depleted rats were fed free choice, both incomplete rations at once they still lost weight; presumably because the first ration was not eaten in close enough time relation to the second. The workers concluded that for effective tissue synthesis all essential amino acids must be available at once, since the storage time is apparently very limited.

Geiger (1948) studied the effects of separate feeding of two proteins each lacking in at least one amino acid, but complementary to each other when mixed. The combinations used were wheat gluten meal (low in lysine) plus blood meal (low in isoleucine); yeast (low in methionine) plus blood meal; and wheat gluten plus yeast. Growth of the rats during a 16 day period was measured. One group was divided into three lots and fed a semi-purified ration, each lot being supplemented with one of the three protein combinations described. A similar group was divided into three lots and fed the same ration as the companion lot above but the respective protein supplement pairs were fed alternately. Food was received by each group from 8 AM to 6 PM and 8 PM to 6 AM. When mixed at 4.5 percent each to make a 9 percent protein ration, these pairs gave satisfactory growth, but if fed separately with a time lapse between feedings poor growth resulted. It was therefore concluded that delayed provision of missing essential amino acids is ineffective, not only when fed as amino acids themselves, but when supplied as proteins.

Protein Adequacy in Various Feedstuffs

Hopkins et al., (1903) were first to demonstrate that changes in protein content of corn created by selective breeding are related to changes in proportionate amounts of the anatomical parts of the kernel. Nutritional quality of corn germ protein has been recognized by Block and Bolling (1944) and Mitchell and Beadles (1944) as approximating that of animal proteins both from feeding experiments and comparative amino acid analyses. Osborne and Mendel (1914a) and (1914b) showed that the alcohol soluble protein of corn, zein, was nutritionally inadequate since animals rapidly lost weight on a diet with zein as the source of protein. Normal growth was restored by adding lysine and tryptophan to the basal diet. Zein was also shown to be absent from the corn germ, although it is a major part of the endosperm. The rest of the endosperm protein, largely glutelin, was shown to contain the amino acids which zein lacks.

Showalter and Carr (1922) were the first to show that the proportion of zein to total protein is greater when the total nitrogen of corn is higher. Increases in zein content were accompanied by a corresponding decrease in the glutelin fraction. Upon alcohol extraction they reported 8.1 percent zein in corn containing 15.7 percent protein and 2.2 percent zein in corn containing 8.0 percent protein. Hanson et al., (1946) measured the correlation between zein content and total protein content of 18 corn samples ranging from 6.3 percent to 19.7 percent protein. They found a highly significant correlation between zein content and protein content. They concluded that the feeding quality of corn protein is inversely related to its zein content because of the deficiency of lysine and tryptophan in zein. Frey (1951) analyzed corn for protein, zein, tryptophan, valine, leucine and isoleucine. Correlation coefficients showed that valine, leucine and isoleucine were more closely related to each other than they were to the tryptophan content in corn. Zein became an increasing proportion of the total protein as the protein percentage increased. Tryptophan and valine became a decreasing proportion and leucine an increasing proportion of total protein as the protein percentage increased. No trend was observed for isoleucine. It was concluded that where protein quality is important, low protein corn should be selected. It was suggested that the best method for improving quality would be to select for larger germ size, because of the better quality and higher percentage protein contained in the germ. Mitchell et al., (1952) verified results obtained previously by other workers, that the proportion of zein in corn increases as the total protein increases. Analysis for tryptophan and lysine by microbiological methods showed the decreasing percentage of tryptophan and lysine in the total protein of corn with an increase in the percentage of the protein in corn. Weanling rats were used to determine digestibility and biological values of high and low protein corn. It was concluded that digestibility of mixed proteins of corn increases slightly as the protein content of the corn increases, but the biological value is considerably decreased as the protein content increases.

Dobbins et al., (1950) compared high and low protein corn for growing-fattening pigs. Corn starch was added to each of the two rations used to make them equal in energy. Using nine pairs on equal feed intake, yellow corn containing 11.7 percent protein was no better than corn containing 8.2 percent protein, when each provided the same amount of protein in the ration. In another trial, three groups of pigs on equalized feed intake were fed equal amounts of corn containing 7.7 percent, 9.1 percent and 12.8 percent crude protein with enough alfalfa meal, soybean meal and meat scraps, equal parts, added to raise all rations to 15 percent protein. Average daily gains of pigs fed the ration containing the 12.8 percent protein corn was significantly less than those made by pigs on the other rations. Eggert et al., (1953), in comparing the value of high and low protein corn for growing pigs, obtained a significantly greater apparent digestibility of nitrogen in corn containing 14.9 percent protein than in corn containing 10.6 percent protein. The addition of a slight excess of lysine and tryptophan to both diets largely eliminated this difference. In a second phase of the experiment, high protein corn (13.9 percent and 12.4 percent) and normal protein corn (9.1 percent) were each combined with protein supplements to make 17 percent protein rations and fed to growing pigs. It was shown that the ration containing the normal protein corn resulted in greater daily gains and greater nitrogen retention than were obtained from high protein corn.

Mitchell and Block (1946) with rats and Bell <u>et al</u>., (1950) with pigs demonstrated the relative deficiency of methionine in soybean meal.

Smith (1930) in comparing the nutritive value of corn with that of various grain sorghums, concluded that sorghums are, in general, higher in protein and lower in fat than corn. Shelton <u>et al.,</u> (1951) feeding sorghum gluten meal to growing pigs obtained little or no gains during a short feeding trial. The poor gains were explained by the fact that sorghum gluten meal is extremely low in lysine and is also a poor source of some of the other amino acids. If used in a ration so as to constitute not more than 25 to 30 percent of the protein supplement or not more than 4 percent of the total ration, satisfactory gains were obtained. When sorghum gluten feed was supplied in place of sorghum gluten meal as 30 percent of the protein supplement, the gains were inferior to those produced on the gluten meal ration and 100 pounds more feed were required per 100 pounds of gain.

Heller et al., (1944) found considerable variation (10.5 percent to 15.0 percent protein) in the protein content of different varieties of grain sorghum. Variations between varieties were no greater than variations within a single variety grown under widely different soil and climatic conditions. Sorghum grown under drouth conditions showed consistently higher protein content than that grown under normal conditions. This increase in protein was accompanied, however, by low grain yield, poorly filled kernels and lowered carbohydrate content.

EXPERIMENTAL PROCEDURE

Trial 1

General

The first experiment was designed to test the adequacy of corn-soybean meal rations with respect to lysine and methionine content and also to compare a 12 percent protein ration with a 17 percent protein ration of the same type. The ration containing 17 percent protein was compared to one of similar protein content containing 6.1 percent casein. Growth rate and efficiency of feed utilization were used as the criteria for measuring the adequacy of the rations. The trial was conducted during the summer of 1952, the experiment being initiated May 10, 1952.

Experimental Animals

Seventy-two healthy weanling pigs of mixed breeding were allotted equally on the basis of breeding, weight, sex and age, to eight treatments. Average initial weight of the pigs used was 37.9 pounds. The pigs were assigned to the various rations at random.

Housing

The pigs were housed in individual concrete-floored pens ($3\frac{1}{2}$ x $5\frac{1}{2}$ feet) in a well ventilated building. The pigs were removed from the pens only for weighing. Individual self feeders (1x1x3 feet) were used to supply feed. Water was supplied to each pig in a small trough in which fresh water was placed twice daily.

Rations

Each lot of pigs was self fed one of the mixed rations shown in Table I. The chemical composition of the feeds used appears in Table II. The rations were prepared in the following manner: Number 2 yellow shelled corn, purchased on the open market, was ground to medium fineness and mixed with the other components. Solvent-extracted soybean meal and dehydrated alfalfa meal supplied additional protein. Certain B-complex vitamins and vitamin D were added to all rations in the amounts shown at the bottom of Table I. Each ration was adequate with respect to the energy, mineral and vitamin requirements as outlined by the National Research Council (1950).

Methods of collecting data

Pigs were weighed every fourteen days until they approached 90 pounds when weighing was done more frequently so as to obtain a weight as close to 90 pounds as possible.

Lots IV-VIII were removed from the experiment at 90 pounds. Lots I, II and III were continued to approximately 200 pounds. Feed consumption of each pig through the previous weigh period was measured at every weighing to facilitate periodic calculation of feed efficiency.

Trial II

General

The second experiment was designed to determine whether a 12 percent protein corn-soybean meal ration is adequate during the winter when feed consumption is greater, and also to further test the adequacy of this type of ration with respect to lysine, again using growth rate and efficiency

Table I

Percentage Composition of Rations Fed
Trial I - Summer 1952

Ration Number[1]	I	II	III	IV	V	VI	VII	VIII
Corn (shelled, ground)	78.8	65.5	71.3	78.7	78.6	78.5	78.5	78.5
Soybean meal	10.7	24.0	12.1	10.7	10.7	10.7	10.7	10.7
Alfalfa meal (dehydrated)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Bone meal	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Salt	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Aurofac	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Casein	--	--	6.1	--	--	--	--	--
DL-lysine · HCl[2]	--	--	--	0.1	0.2	0.3	0.2	0.2
DL-methionine	--	--	--	--	--	--	0.025	0.05
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total L-lysine[3]	0.71	1.10	1.30	0.76	0.81	0.86	0.81	0.81
Total protein	12.00	17.00	17.14	11.99	11.99	11.98	11.98	11.98

[1]B vitamins were added to all rations at the following rates: Thiamine, 0.5; riboflavin, 1.5; niacin, 6.0; pantothenic acid, 4.0; pyridoxine, 0.6; choline, 200 milligrams and vitamin B_{12}, 9.0 micrograms per pound of mixed ration to furnish vitamin D. The crystalline B-vitamins were furnished by Merck and Company, Inc.

[2]Furnished by E. I. duPont de Nemours and Company.

[3]Calculated amounts based on microbiological assay of ration components.

Table II

Chemical Composition of Feeds
Trial I - Summer 1952

	H_2O	Ash	Fat	Fiber	NFE	Ca	P	Crude Protein	Lysine			Methionine		
	%	%	%	%	%	%	%	%	%	%[1]	%[2]	%	%[1]	%[2]
Corn	13.6	1.3	3.3	2.3	71.30	0.10	0.30	7.8	0.29	0.34	4.36	0.18	0.21	2.69
Soybean meal	6.5	7.0	4.5	6.2	29.29	0.40	0.61	45.5	3.06	3.27	7.19	0.60	0.64	1.41
Alfalfa meal	8.5	10.5	2.2	26.3	36.98	0.96	0.26	14.3	1.17	1.28	8.90	0.16	0.17	1.20
Casein	--	--	--	--	--	--	--	83.3	--	9.47	11.40	--	2.28	2.74

[1]Expressed as a percentage of the dry matter.

[2]Expressed in grams lysine (or methionine) obtained from 100 grams protein.

of feed utilization as the criteria for interpreting the results. The trial was conducted during the winter of 1952-53, the experiment being initiated on November 25, 1952.

Experimental Animals

Forty healthy Hampshire and Hampshire x Poland China weanling pigs were allotted equally on the basis of weight, sex and age, to five treatments. Average initial weight of the pigs used was 50.9 pounds. Twenty-five barrows and fifteen gilts were used (five barrows and three gilts on each ration). The pigs were assigned to the various rations at random.

Housing

The pigs were housed in the same pens and handled in the same manner as those in Trial I. Since there was a temperature difference of about 10 degrees between the extreme ends of the barn when outside temperatures were +10 degrees F. or lower, the heaviest pigs were assigned to the coldest section and the lightest pigs to the warmest section in order to minimize the effect of temperature differences.

Rations

Each lot of pigs was self fed one of the mixed rations shown in Table III. The chemical composition of the feeds used appears in Table IV. The ration components were similar to those of Trial I and the rations were prepared in the same manner as in Trial I.

Methods of collecting data

Pigs were weighed individually every fourteen days until they approached 200 pounds, when weekly weighing was begun so as to remove each pig at as close to that weight as possible. Feed consumption of

Table III

Percentage Composition of Rations Fed
Trial II - Winter 1952-53

Ration Number[1]	I	II	III	IV	V
Number of pigs	8	8	8	8	8
Corn (shelled, ground)	80.00	79.90	79.80	68.00	76.55
Soybean meal	9.75	9.75	9.75	21.75	13.20
Alfalfa meal (dehydrated)	7.00	7.00	7.00	7.00	7.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Trace mineral salt	1.00	1.00	1.00	1.00	1.00
Aurofac 2A	0.25	0.25	0.25	0.25	0.25
DL-lysine · Hcl[2]	---	0.10	0.20	---	---
Total	100.00	100.00	100.00	100.00	100.00
Total L-lysine[3]	0.64	0.69	0.74	0.99	0.74
Total protein	11.99	11.99	11.99	16.06	13.16

[1]B-vitamins were added to all rations at the following rates: Thiamine, 0.5; riboflavin, 1.5; niacin, 6.0; pantothenic acid, 4.0; pyridoxine, 0.6; choline, 200 milligrams and vitamin B_{12}, 9.0 micrograms per pound of mixed ration. Delsterol was added at the rate of 8 grams per 100 pounds of mixed ration to furnish vitamin D. The crystalline B-vitamins were furnished by Merck and Company, Inc. Both forms of lysine were furnished by E. I. duPont de Nemours and Company.

[2]DL-lysine was replaced by 95 percent L-lysine on an equal L-lysine basis February 1 due to unavailability of DL-lysine.

[3]Calculated amounts based on microbiological assay of ration components.

Table IV

Chemical Composition of Feeds
Trial II - Winter 1952-53

	H_2O %	Ash %	Fat %	Fiber %	NFE %	Ca %	P %	Crude Protein %	Lysine %	Lysine %[1]	Lysine %[2]
Corn	12.7	1.4	2.0	1.7	73.30	0.30	0.20	8.4	0.30	0.34	4.05
Soybean meal	12.2	6.3	1.6	6.7	30.09	0.31	0.50	42.3	2.87	3.27	7.73
Alfalfa meal	8.8	11.8	2.8	24.1	35.25	1.00	0.25	16.0	0.64	0.70	4.38

[1]Expressed as a percentage of the dry matter.

[2]Expressed in grams lysine obtained from 100 grams protein.

each pig through the previous weigh period was measured at every weighing to facilitate periodic calculation of feed efficiency.

Trial III

General

The third experiment was designed to test the adequacy of a milo-soybean meal ration with respect to lysine and to study the effect of the D-form of lysine on growth of swine. Growth rate and efficiency of feed utilization were again the criteria used for interpreting the results. The trial was conducted during the summer of 1953, the experiment being initiated May 4, 1953.

Experimental Animals

Thirty-two healthy Duroc x Landrace-Poland China weanling pigs were allotted equally on the basis of weight, sex and age, to four treatments. Average initial weight of the pigs used was 37.5 pounds. Twenty barrows and twelve gilts were used (five barrows and three gilts on each ration). The pigs were assigned to the various rations at random.

Housing

The pigs were housed in the same pens and handled in the same manner as in the two previous trials.

The same self feeders were used as previously, but they were remodeled in order to reduce feed wastage.

Rations

Each lot of pigs was self fed one of the mixed rations shown in Table V. The chemical composition of the feeds used appears in Table VI.

Table V

Percentage Composition of Rations Fed
Trial III - Summer

Ration Number[1]	I	II	III	IV
Milo (ground)[2]	79.50	79.45	79.40	79.30
Soybean meal	10.25	10.25	10.25	10.25
Alfalfa meal (dehydrated)	7.00	7.00	7.00	7.00
Bone meal	2.00	2.00	2.00	2.00
Trace mineral salt	1.00	1.00	1.00	1.00
Aurofac 2A	0.25	0.25	0.25	0.25
L-lysine ·HCl[3]	---	0.05	0.10	---
DL-lysine ·HCl[3]	---	---	---	0.20
Total	100.00	100.00	100.00	100.00
Total L-lysine equivalent[4]	0.59	0.64	0.69	0.69
Total protein	13.99	13.99	13.99	13.99

[1]B-vitamins were added to all rations at the following rates: Thiamine, 0.5; riboflavin, 1.5; niacin, 610; pantothenic acid, 4.0; pyridoxine, 0.6; choline, 200 milligrams per pound of mixed ration; vitamin B_{12}, 9.0 mcg. per pound of mixed ration. Delsterol was added at the rate of 8 grams per 100 pounds of mixed ration to furnish vitamin D. The crystalline B-vitamins were furnished by Merck and Company, Inc.

[2]Westland variety

[3]Furnished by duPont de Nemours and Company.

[4]Calculated amounts based on microbiological assay of ration components.

Table VI

Chemical Composition of Feeds

Trial III - Summer 1953

	H_2O	Ash	Fat	Fiber	NFE	Ca	P	Crude Protein	Lysine			Methionine		
	%	%	%	%	%	%	%	%	%	%[1]	%[2]	%	%[1]	%[2]
Milo	10.2	1.6	1.5	1.8	74.23	.14	.23	10.3	0.22	0.25	2.43	0.17	0.19	1.84
Soybean meal	10.5	6.0	3.9	7.8	27.84	.41	.45	43.3	3.27	3.65	8.43	0.50	0.56	1.29
Alfalfa meal	6.8	12.2	2.1	19.7	38.35	.94	.21	19.7	1.16	1.24	6.29	0.23	0.25	1.27

[1]Expressed as a percentage of the dry matter.

[2]Expressed in grams lysine obtained from 100 grams protein.

The milo used was of the Westland variety and was locally grown. It was ground to medium fineness before incorporation into the rations. The ration components and mixing were otherwise as in Trials I and II.

Methods of collecting data

Pigs were weighed individually every fourteen days until they approached 120 pounds when weighing was done more frequently to remove each pig from the experiment at as close to 120 pounds as possible.

Feed consumption of each pig through the previous weigh period was measured at every weighing to facilitate periodic calculation of feed efficiency.

RESULTS AND DISCUSSION

Trial I - Summer 1952

The results of Trial I are summarized in Table VII. Statistical analysis, by the method of covariance (Snedecor, 1946), of average daily gain and efficiency of feed utilization of all pigs to 90 pounds showed highly significant differences ($P < .01$) among treatments with respect to daily gain and significant differences ($P < .05$) with respect to feed required per 100 pounds of gain. Orthogonal comparisons of average daily gain and feed efficiency were made between several combinations of treatments. The basal ration (Lot I) containing 12 percent protein was compared with the combined value of the rations supplemented with amino acids (Lots IV through VII inclusive), and was found to be significantly inferior to the supplemented rations both in average daily gain and efficiency of feed utilization. There was no significant difference in growth rate or feed efficiency between the pigs fed the ration supplemented with 0.2 percent DL-lysine (Lot V) and those fed the rations containing 0.2 percent DL-lysine plus 0.025 or 0.05 percent DL-methionine (Lots VII and VIII) respectively. Comparisons of Lot VII versus Lot VIII also failed to show a significant difference in average daily gain or efficiency of feed utilization. The basal ration plus 0.1 percent DL-lysine (Lot IV) was compared orthogonally with the basal ration plus 0.3 percent DL-lysine (Lot VI), and although the average daily gain of the pigs in Lot IV was 0.15 pound greater than that of Lot VI, there was no statistically significant difference between the two lots in average daily gain or feed efficiency.

Table VII
Summary of Results
Trial I - Summer 1952

Ration Number	I	II	III	IV	V	VI	VII	VIII
Number of pigs	9	9	9	9	9	9	9	9
Av. initial weight (lbs.)	37.9	38.0	38.0	38.1	37.4	37.3	38.3	38.4
Av. final weight (lbs.)	92.4	92.0	95.0	94.0	92.6	92.3	92.0	95.5
Av. total gain (lbs.)	54.6	54.0	57.0	56.0	55.1	55.0	53.6	57.1
Av. daily gain (lbs.)	1.03	1.36	1.48	1.27	1.15	1.12	1.19	1.20
Av. daily feed consumption (lbs.)	3.71	4.43	4.54	3.68	3.57	3.86	3.59	3.82
Av. feed per 100 lbs. gain (lbs.)	360.2	325.5	307.1	298.8	310.7	344.4	302.1	318.4
90-200 lbs.[1]								
Av. initial weight (lbs.)	92.4	92.0	95.0					
Av. final weight (lbs.)	201.8	201.8	200.2					
Av. total gain (lbs.)	108.2	109.2	105.0					
Av. daily gain (lbs.)	1.45	1.42	1.48					
Av. daily feed consumption (lbs.)	5.37	5.40	5.92					
Av. feed per 100 lbs. gain (lbs.)	370.2	379.5	401.0					
Entire period								
Av. initial weight (lbs.)	37.9	38.0	38.0					
Av. final weight (lbs.)	201.8	201.8	200.2					
Av. total gain (lbs.)	163.9	165.0	162.0					
Av. daily gain (lbs.)	1.26	1.38	1.48					
Av. daily feed consumption (lbs.)	4.54	4.97	5.33					
Av. feed per 100 lbs. gain (lbs.)	362.1	362.1	361.4					

[1] Only the pigs on rations I, II and III were continued on the trial to market wt.

However, there was an almost linear decrease in average daily gain and an increase in feed required per 100 pounds gain as the level of DL-lysine in the ration was increased from 0.1 percent to 0.3 percent (Lots IV, V and VI). Non-orthogonal comparisons were made between Lots I and IV with respect to averave daily gain and efficiency of feed utilization. The difference in average daily gain (0.24 lb.) between these two lots was highly significant ($P < .01$). The feed required per 100 pounds gain was significantly reduced ($P < .05$) by 61.4 pounds (17.0 percent) by the addition of 0.1 percent DL-lysine to the basal ration, indicating further the inadequacy of a 12 percent protein ration of this type for weanling pigs. Non-orthogonal comparisons were made between Lot I and Lots II and III combined to compare a 12 percent protein ration with a 17 percent protein ration of the same type. A highly significant difference ($P < .01$) between average daily gains of the pigs in the two lots was revealed. Increasing the protein content to 17 percent (Lot II) reduced the feed required per 100 pounds of gain significantly ($P < .05$) by 34.7 pounds (9.6 percent). Replacing 6.1 percent of the ration with casein (to provide 5 percent protein) and adjusting the proportions of corn and soybean meal to maintain a 17 percent protein ration (Lot III) reduced the feed required per 100 pounds gain by 53.1 (14.7 percent) below the basal. Orthogonal comparisons were made between Lot II and Lot III to determine whether the soybean meal ration containing 17 percent protein could be further improved with respect to rate of gain and efficiency of feed utilization by partial replacement with casein. No significant difference in either growth rate or feed efficiency was obtained between the pigs fed these two rations. The 17 percent protein ration with soybean contained 1.05 percent lysine

However, there was an almost linear decrease in average daily gain and an increase in feed required per 100 pounds gain as the level of DL-lysine in the ration was increased from 0.1 percent to 0.3 percent (Lots IV, V and VI). Non-orthogonal comparisons were made between Lots I and IV with respect to averave daily gain and efficiency of feed utilization. The difference in average daily gain (0.24 lb.) between these two lots was highly significant ($P < .01$). The feed required per 100 pounds gain was significantly reduced ($P < .05$) by 61.4 pounds (17.0 percent) by the addition of 0.1 percent DL-lysine to the basal ration, indicating further the inadequacy of a 12 percent protein ration of this type for weanling pigs. Non-orthogonal comparisons were made between Lot I and Lots II and III combined to compare a 12 percent protein ration with a 17 percent protein ration of the same type. A highly significant difference ($P < .01$) between average daily gains of the pigs in the two lots was revealed. Increasing the protein content to 17 percent (Lot II) reduced the feed required per 100 pounds of gain significantly ($P < .05$) by 34.7 pounds (9.6 percent). Replacing 6.1 percent of the ration with casein (to provide 5 percent protein) and adjusting the proportions of corn and soybean meal to maintain a 17 percent protein ration (Lot III) reduced the feed required per 100 pounds gain by 53.1 (14.7 percent) below the basal. Orthogonal comparisons were made between Lot II and Lot III to determine whether the soybean meal ration containing 17 percent protein could be further improved with respect to rate of gain and efficiency of feed utilization by partial replacement with casein. No significant difference in either growth rate or feed efficiency was obtained between the pigs fed these two rations. The 17 percent protein ration with soybean contained 1.10 percent lysine and when the soybean meal was partially replaced by casein the level of lysine was increased to 1.30 percent of the ration. The failure of the higher level of lysine to further increase the growth rate may have been due to having reached the optimum level of lysine at that protein level. The same reasoning may be applied to the results obtained in the lower protein rations. The failure of 0.20 and 0.30 percent level of added DL-lysine to promote growth above that obtained in the ration supplemented with 0.10 percent DL-lysine may have likewise been due to having reached the optimum level of lysine at that level of protein. Kratzer (1950) observed growth depression in turkey poults fed D-lysine. Thus, a second possible cause for no additional growth response at higher levels was the presence of the D-isomer in the synthetic lysine.

The pigs in Lots I, II and III, which were continued on the experiment to market weight, all gained satisfactorily after 90 pounds, averaging 1.45, 1.42 and 1.48 pounds per day, respectively. The pigs on the 12 percent protein ration tended to utilize their feed more efficiently at these heavier weights. However, discretion is necessary in making feed efficiency comparisons during that period since wasting of feed became a problem and accuracy of feed consumption was therefore reduced.

In conclusion, a 12 percent protein ration, fed in the summer when feed consumption was somewhat lower than has often been observed in comparable experiments conducted in the winter at the Oklahoma station, was inadequate to support optimum growth of weanling pigs up to 90 pounds. The addition of 0.1 percent DL-lysine to the basal ration increased the average daily gain significantly, but additions of 0.2 and 0.3 percent DL-lysine were less effective in growth promotion and improvement of feed utilization than the addition of 0.1 percent. The addition of DL-methionine to the basal ration in the presence of 0.2 percent DL-lysine failed to increase growth rate or to improve efficiency of feed utilization.

Trial II - Winter 1952-53

The results of Trial II are summarized in Table VIII. Statistical analysis, by the method of covariance (Snedecor, 1946), of average daily gain and efficiency of feed utilization of all pigs up to 120 pounds showed no statistically significant differences among treatments with respect to either average daily gain or improvement of feed utilization. However, there was a strong tendency toward significant differences among treatments in average daily gain (P = 7.5 percent) of pigs up to this weight. The basal ration (Lot I), containing 12 percent protein, produced 0.15 pound (11.1 percent) less average daily gain than the same ration supplemented with 0.10 percent DL-lysine (Lot II). The 16 percent protein ration (Lot IV) was no better than the 12 percent protein ration supplemented with 0.1 percent of DL-lysine with respect to average daily gain. Average daily gain of the pigs in each lot were 1.52 and 1.50 pounds, respectively. The feed required per 100 pounds gain was 17.6 pounds less on the 16 percent protein ration than on the 12 percent protein ration to approximately 120 pounds average weight.

When 0.2 percent DL-lysine (Lot III) was added to the basal ration no growth stimulation was obtained above that of the basal. Average daily gains of pigs on the two rations were 1.36 and 1.35 pounds, respectively. The feed required per 100 pounds of gain was 44.9 pounds (13.1 percent) greater in Lot III than in Lot I. This failure of higher levels of DL-lysine

Table VIII
Summary of Results
Trial II - Winter 1952-53

Ration Number	I Basal 12% protein	II Basal + 0.1% DL-Lysine	III Basal + 0.2% DL-Lysine	IV 16% protein	V 13.2% protein
<u>Up to 120 lbs.</u>					
Av. initial weight (lbs.)	51.0	49.3	51.6	50.4	52.1
Av. final weight (lbs.)	119.1	123.2	120.3	123.0	122.8
Av. gain (lbs.)	68.1	73.9	68.7	72.6	70.7
Days on feed	53.0	49.5	53.0	47.8	47.8
Av. daily gain (lbs.)	1.35	1.50	1.36	1.52	1.49
Av. daily feed consumption (lbs.)	4.62	5.22	5.27	5.03	5.08
Av. feed per 100 lbs. gain (lbs.)	342.3	348.2	387.2	330.6	340.9
<u>120 to 200 lbs.</u>					
Av. initial weight (lbs.)	119.1	123.2	120.3	123.0	122.8
Av. final weight (lbs.)	199.9	204.9	199.6	200.7	200.3
Av. gain (lbs.)	78.2	81.7	79.4	77.8	77.5
Days on feed	46.8	46.3	48.1	47.3	48.5
Av. daily gain (lbs.)	1.71	1.80	1.63	1.74	1.64
Av. daily feed consumption (lbs.)	7.80	7.63	7.75	7.57	7.45
Av. feed per 100 lbs. gain (lbs.)	456.1	424.0	475.4	435.0	454.3
<u>Entire period</u>					
Av. initial weight (lbs.)	51.0	49.3	51.6	50.4	52.1
Av. final weight (lbs.)	199.9	204.9	199.6	200.7	200.3
Av. gain (lbs.)	144.9	154.4	148.6	148.9	148.2
Days on feed	98.0	95.8	101.1	93.3	96.3
Av. daily gain (lbs.)	1.50	1.63	1.48	1.61	1.55
Av. daily feed consumption (lbs.)	6.30	6.37	6.44	6.16	6.17
Av. feed per 100 lbs. gain (lbs.)	419.7	390.9	434.8	386.0	400.0

in the ration to stimulate growth and improve efficiency of feed utilization is in agreement with the results obtained in Trial I.

Ration V, which contained 13.2 percent protein and approximately the same amount of L-lysine as Ration III, produced 0.13 pound higher average daily gain than Ration III. Efficiency of feed utilization was likewise improved, 46.3 pounds (13.6 percent) less feed being required to produce 100 pounds of gain. The superior results obtained from the 13.2 percent protein ration may have been caused either by the increased supply of amino acids provided by the 1.2 percent extra protein or by presence of the D-isomer of lysine in the 12 percent protein ration. The 13.2 percent protein ration produced growth and feed efficiency comparable to that of the 16 percent protein ration, suggesting the possibility that a ration of this type containing 13 percent protein may be adequate for growing pigs under certain conditions.

All the pigs were continued on their respective rations to market weight. Average daily gain and efficiency of feed utilization were very similar in all lots from 120 pounds to 200 pounds, Lot II tending to be somewhat superior to the other lots in both respects. Wasting of feed became a problem during the last half of the trial, and although adjustments were made for feed losses, the accuracy of measuring individual feed consumption was reduced. Hence, this must be taken into consideration in making comparisons in feed efficiency among the lots during that period. Average daily gain and efficiency of feed utilization summarized over the entire feeding period showed that all rations produced satisfactory gains and that overall feed efficiency was likewise not significantly affected by the ration fed.

In conclusion, although no statistically significant differences were obtained among lots with respect to daily gain or feed efficiency, there was a strong tendency for a 12 percent protein ration supplemented with 0.10 percent DL-lysine to produce faster growth up to approximately 120 pounds in weight than if unsupplemented. Supplementation with 0.20 percent DL-lysine failed to stimulate growth and decreased the efficiency of feed utilization. The increased growth rate obtained from the addition of 0.10 percent DL-lysine was equal to that obtained from similar rations containing 13.2 and 16 percent protein. Efficiency of feed utilization on these three rations was the same. From this it appears that lysine is the first limiting amino acid in a ration of this type and suggests the possibility of producing economical gains in growing pigs using lower soybean meal allowances than now generally recommended if lysine can be obtained from other sources at a reasonable cost.

Growth rate and feed efficiency of pigs on each ration tended to become equal as the trial progressed.

Trial III - Summer 1953

The results of Trial III are summarized in Table IX. Statistical analysis by the method of covariance (Snedecor, 1946) of average daily gain and efficiency of feed utilization of all pigs up to 120 pounds showed no statistically significant differences among treatments with respect to either average daily gain or feed required per 100 pounds of gain. However, the same general tendencies were observed in this trial as in the two previous trials with respect to the effects of supplementing lysine to a low protein ration.

Table IX

Summary of Results
Trial III - Summer 1953

Ration Number	I	II	III	IV
Number of pigs	8	8	8	8
Av. initial weight (lbs.)	37.5	37.4	37.6	37.6
Av. final weight (lbs.)	121.1	122.8	125.6	121.8
Av. gain (lbs.)	83.6	85.4	89.3	83.0
Av. daily gain (lbs.)	1.35	1.48	1.55	1.40
Av. daily feed consumption (lbs.)	4.64	4.95	5.22	4.90
Av. feed per 100 lbs. gain (lbs.)	328.2	322.6	322.6	352.4

The addition of 0.05 percent L-lysine to the 14 percent protein milo-soybean meal ration (Lot II) improved the average daily gain by 0.13 pound. Average daily gains of the pigs in each lot were 1.48 and 1.35 pounds, respectively. The addition of 0.1 percent L-lysine (Lot III) to the same basal ration resulted in further increase in growth rate, the pigs in Lot III having gained an average of 1.55 pounds per day versus the 1.35 pounds gained daily by the pigs in Lot I. When 0.1 percent L-lysine (Lot III) was replaced by 0.2 percent DL-lysine (Lot IV), the improvement in average daily gain over Lot I was only 0.05 pound (1.35 vs. 1.40 pounds).

The L-lysine contained in Ration I was 4.22 percent of the protein while that of Rations, II, III, IV were 4.57, 4.93 and 4.93, respectively. Although the differences in growth rate among the lots of pigs was not statistically significant the tendency for pigs to grow faster on rations supplemented with L-lysine cannot be overlooked. This tendency follows the trend observed in the two previous trials and is in agreement with the work by Brinegar <u>et al.</u>, (1950) who observed a linear relationship between the lysine level of the dietary protein and the performance of pigs at lysine levels below 5.5 percent of the dietary protein, and with Kratzer (1950) who observed growth depression in turkey poults fed D-lysine.

The feed required per 100 pounds gain was almost identical for Lots I, II and III, but pigs in Lot IV tended to require more feed per pound gain although the difference among lots was not statistically significant.

The feed wasting problem was almost completely eliminated in this trial by remodeling the feeders used, so feed efficiency figures were obtained with a higher degree of accuracy than in the first two trials.

In conclusion, the addition of L-lysine to a 14 percent protein milo-soybean meal type ration appeared to improve the growth of pigs. The addition of 0.2 percent DL-lysine tended to be less effective in growth promotion than either 0.05 or 0.10 percent L-lysine. Feed efficiency tended to be reduced in the presence of 0.2 DL-lysine.

It appears that lysine may be the limiting amino acid in a ration of this type and that the presence of the D-isomer in the synthetic lysine may decrease the effectiveness of lysine as a supplement.

SUMMARY

Three feeding trials were conducted to determine the optimum level of protein for growing pigs fed all plant rations and to study the effects of supplementing low protein rations of this type with lysine and/or methionine. In Trial I a 12 percent protein corn-soybean meal ration was compared to identical rations supplemented with 0.1, 0.2, 0.3 percent DL-lysine and with 0.2 percent DL-lysine plus 0.025 and 0.05 percent DL-methionine. The 12 percent protein ration was also compared with a 17 percent protein ration of the same type and with a similar 17 percent protein ration with five percent of its protein supplied by casein. The rate and economy of gain were improved significantly by supplementing a 12 percent protein ration with lysine. The greatest increase in growth rate above the basal occurred when the ration was supplemented with 0.1 percent DL-lysine; higher levels tended to become progressively less effective in improving growth rate and feed efficiency. DL-methionine added in the presence of 0.2 percent DL-lysine gave no significant increase in growth rate or feed efficiency. Increasing the protein content to 17 percent significantly improved the rate of gain and feed efficiency above that obtained on the 12 percent protein basal ration. There was no significant difference in the growth rate or feed efficiency obtained in the two 17 percent protein rations. The pigs fed the 12 percent protein ration and the two 17 percent protein rations were carried to 200 pounds. All three lots of pigs grew equally well during the period from 90-200 pounds.

In Trial II no significant differences in growth or feed efficiency were obtained during the period from weaning to 120 pounds. The 16 and 13.2 percent protein rations tended to produce more rapid gains than the 12 percent protein ration. The 12 percent protein ration supplemented with 0.1 percent DL-lysine was approximately equal to the 17 percent protein ration with respect to growth rate and efficiency of feed utilization. The 13.2 percent protein ration, which contained the same amount of L-lysine as was in the ration supplemented with 0.2 percent DL-lysine, tended to produce growth rate and feed efficiency superior to that of the latter ration. During the period from 120-200 pounds all rations produced satisfactory and similar gains, the ration supplemented with 0.1 percent DL-lysine tending to excell the others somewhat in growth rate produced.

In Trial III a 14 percent protein milo-soybean meal ration was the basal ration fed to weanling pigs. The other rations were basal plus 0.05 and 0.10 percent L-lysine and basal plus 0.20 percent DL-lysine. Although no statistically significant differences in growth rate or feed efficiency were obtained among the lots there was again a strong tendency for rations supplemented with lysine to exceed the basal ration in rate of gain. The 0.10 percent L-lysine ration produced the most rapid gains, followed by the 0.05 percent L-lysine and 0.20 percent DL lysine rations, respectively.

These trials suggest that lysine is the limiting amino acid in a corn-soybean meal and a milo-soybean meal ration containing 12-14 percent protein. The D-isomer of lysine may interfere with the usefulness of DL-lysine as a supplement to swine rations as indicated by an inverse response to added increments in excess of 0.1 percent.

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