



Effect of addition of amino acids to barley rations for rats and swine  
by Richard M Davidson

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of  
MASTER OF SCIENCE in Animal Science  
Montana State University  
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Abstract:

The trials reported herein were initiated to study the effect of adding amino acids to barley rations.

The results of Rat Trial I indicated average daily gains were slightly greater when feeding rations containing a low protein barley when compared to rations containing a high protein barley. All rations were corrected to 10 percent protein before the addition of amino acids. P.E.R. values were increased when lysine was added to the rations containing either the high or the low protein barley. Supplemental methionine appeared to have little effect on P.E.R. values.

When rats were fed rations containing 17.0 percent protein barley (rations corrected to 15.9 percent protein) added lysine increased the P.E.R. value. Lysine and methionine added together gave slightly greater P.E.R. values than when lysine alone was added. Little response was observed when adding only methionine.

Seventeen percent protein barley rations (rations corrected to 15.9 percent) with lysine added at the 0.4 or 0.6 percent levels and methionine added at the 0.3, 0.4, 0.5 and 0.6 percent levels, all resulted in similar P.E.R. values. All rations compared favorably with rations containing casein as the sole source of protein in gains.

The results of Swine Experiment I indicated pigs fed L-lysine HCl gained slightly more than pigs fed Lyamine. The addition of lysine to barley rations indicated trends for increased gains and feed efficiency. Source or levels of lysine did not appear to affect the fat content of the carcass. Results, however, indicated adding lysine to the barley rations increased the ribeye area and the loin weights of the carcasses. Gilt carcasses contained a heavier ham, shoulder, loin, butt, lean trim and had a greater ribeye area than barrows.

Results of Swine Experiment II indicated pigs fed rations containing a low protein barley (13.3 percent protein) resulted in greater gains than pigs fed rations containing a high protein barley (17.0 percent protein). The grower rations, using both barley sources, contained approximately 15.0 percent protein. The fattening rations using the 13.3 percent protein barley contained approximately 12 percent protein and those having the 17.0 percent protein barley had an approximate protein content of 15 percent.

The pigs fed the low protein rations (12.0 percent) had greater gains and increased feed efficiency in the fattening phase when compared to the pigs receiving the greater protein rations (15.0 percent). Average daily gain and feed efficiency were slightly greater when adding lysine, especially to the rations containing the low protein barley. Results indicated supplementary lysine produced greater effect on gain and feed efficiency in the growing phase than in the fattening period.

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RATIONS FOR RATS AND SWINE**

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**RICHARD M. DAVIDSON**

A thesis submitted to the Graduate Faculty in partial  
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**Animal Science**

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June, 1962

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to Dr. L. G. Young for assistance and council throughout the graduate program and especially for helpful suggestions while conducting the experimental work and preparation of the manuscript; to Dr. O. O. Thomas for suggestions and assistance throughout the graduate program; to Dr. D. W. Blackmore for helpful suggestions in the preparation of the manuscript; to Dr. E. P. Smith for assistance in the statistical analyses of the data and to Professor J. R. Dynes for assistance with the carcass work.

Appreciation is also extended to all members of the staff and employees of the Animal Industry and Range Management Department for their cooperation and assistance throughout the graduate program. Special thanks, also, to Mr. Donald R. McCarl, the swine herdsman, for his cooperation while conducting the experimental work.

Appreciation is also expressed to Merck and Company who contributed to the support of the trials and who furnished the lysine.

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## ABSTRACT

The trials reported herein were initiated to study the effect of adding amino acids to barley rations.

The results of Rat Trial I indicated average daily gains were slightly greater when feeding rations containing a low protein barley when compared to rations containing a high protein barley. All rations were corrected to 10 percent protein before the addition of amino acids. P.E.R. values were increased when lysine was added to the rations containing either the high or the low protein barley. Supplemental methionine appeared to have little effect on P.E.R. values.

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## INTRODUCTION

Barley production is increasing in the United States and especially in the western states. To maintain a desirable market for this increase in production the use of barley must also be expanded.

Barley is an excellent grain for swine feeding and produces pork of high quality. The protein content of barley varies from approximately 10 to 17 percent. Barley supplies only slightly less total digestible nutrients than corn. In several experiments, pelleted barley, fed in properly balanced rations, has produced nearly as rapid gains as corn.

Barley, however, is deficient in calcium, vitamin D and vitamin A. Also, the protein of barley may be deficient in certain of the essential amino acids. In feeding swine efficient results cannot, therefore, be realized unless protein supplements of good quality are fed in addition to barley so sufficient amounts of these amino acids will be supplied. Some of the higher quality protein feeds that have been used to supplement barley are fish meal, meat scrap, tankage and soybean oil meal.

Today's nutritional and industrial technology makes possible the manufacturing of barley rations, formulated to include those ingredients which have been found to be deficient in swine rations. With improved methods of obtaining pure amino acids the addition of certain limiting amino acids to these formulated rations may have economic advantages.

Little research has been conducted to determine the effects of adding amino acids to barley rations for swine. Therefore, it appeared important to conduct additional experimental work to determine the desirability of adding amino acids to barley rations as a means of increasing rate of gain, feed efficiency and carcass quality of swine.

Additional experimental work was conducted with rats to determine the effect of adding amino acids to barley rations.

## LITERATURE REVIEW

The nutritive importance of proteins and the dependence of animals on plants for these substances were first pointed out by G. J. Mulder around 1840 (Encyclopedia Americana, 1960). A few years later Boussingault, writing in the *Economie Rurale* (Encyclopedia Americana, 1960) said, "The alimentary virtues of plants reside above all in the nitrogenous substances, and consequently their nutritive potency is proportional to the quantity of nitrogen entering into their composition."

McCollum, as quoted by Mendel (1923, p. 121), remarked that the investigations carried out during the period between 1910 and 1920 on protein foods of plant origin "leave no room for doubt that all the amino acids necessary for the nutrition of an animal are contained in the proteins found in each of these foods. Certain of these are, however, present in such limited amounts as to restrict the extent to which the remaining ones, which are more abundant, can be utilized."

Flodin (1953) states, "the quantity and quality of protein supplied by the diet are of vital importance to health at every portion of the life span. Wherever total quantity or average quality of the protein consumed fall significantly below accepted standards for good nutrition, the signs and symptoms of protein deficiency (hypoproteinosis) appear, involving various degrees of retardation or failure of tissue synthesis." The discovery that many of the amino acids composing body proteins must be supplied as such by food protein explains why different foods and rations of the same protein content have different protein values in nutrition. They differ in protein quality. It must be kept in mind that there are certain qualitative differences as to the essential amino acids required by

different species and for different functions in the same species. There are also quantitative differences per unit of body weight or of growth tissue formed. These considerations mean that one cannot generalize from one species to another or one function to another as to either qualitative or quantitative requirements.

#### MEASUREMENT OF PROTEIN QUALITY

One of the most common methods of determining the quality of protein utilizes the criterion adapted by Osborne and Mendell, viz-the gain in weight per gram of protein ingested or protein efficiency ratio (P.E.R.). From theoretical consideration, the maximal utilization of absorbed protein for the synthesis of body protein is the most valid expression of the growth promoting quality of dietary protein, according to Barnes et al. (1945). They go on to state, "The establishment of the maximal ratio of body weight gained to protein consumed is the most useful of the methods of measuring nutritive value of proteins for growth that do not involve fecal and carcass nitrogen analysis, but it does not necessarily provide wholly accurate indices of protein values." Chapman et al. (1959) have standardized this procedure, by using rats of certain age, correcting protein of diet to 10 percent, maintaining the trial for a four week period, and adjusting results to a constant value of 2.5 for casein. Morrison and Campbell (1960) using this procedure found that female rats tended to give maximal P.E.R. values at lower dietary protein levels than did males. It was also found that differences between casein and a plant protein mixture were greatest during the early stages of the experiment in both sexes.

Hegsted (1947) found a very high correlation between weight gain and protein efficiency. He also found that protein efficiency is a function of gain in weight rather than a characteristic of protein fed. He concludes that, in studies on the relative nutritive value of various proteins using growing rats fed ad libitum, little additional information is gained by taking into account the amount of protein eaten, i.e., the calculation of protein efficiency.

McHenry et al. (1961) employed the liver-N method with rats to determine the nutritive value of a number of proteins. The liver-N method is based on the fact that, for relatively small protein intakes, the values of liver-N [(mg) per 100 g. initial body weight] varied linearly with the amount of protein eaten, provided the nutritive value of the protein was not better than that of casein. When they used casein as the standard of reference for a series of proteins there was good agreement between values obtained by the liver-N and balance sheet methods for proteins with nutritive values equal to or less than that of casein.

A method to determine protein quality with respect only to lysine has been described by Carpenter (1960) employing the Sanger reaction with 1 fluoro-2:4 dinitro benzene for the determination of the free  $\epsilon$ -amino groups of lysine units in purified proteins. Baliga et al. (1959) in using this method in cottonseed meal found a relationship between the content of lysine with the free  $\epsilon$ -amino groups and protein quality as determined in rat protein repletion tests.

Mitchell (1924) used a method based upon nitrogen balance data involving direct determination of the amount of nitrogen in the feces and in the



urine and indirect determinations of the fractions of the fecal nitrogen and of the urinary nitrogen that were of dietary origin. The biological value of the protein is taken as the percentage of the absorbed nitrogen (nitrogen intake minus fecal nitrogen of dietary origin) that is not eliminated in the urine.

McLaughlan et al. (1959) based their determination on the content of lysine and methionine or methionine and cystine and developed a simplified chemical score. Because the simplified chemical score method is relatively rapid, yields reproducible results, and correlates with animal assays, it was proposed as a rapid screening procedure for the evaluation of protein in food, but was not intended to replace the rat bio-assay method.

Physico-chemical methods of amino-acid analysis by isotope dilution may also be employed (Foster 1945). This procedure, which appears to be the most accurate method now available for the determination of amino-acids in protein hydrolyzates, is limited only by the availability of the equipment and the material.

There has been considerable use of biological methods employing micro-organisms and specific enzyme systems for the routine estimation of all the known amino acids.

The results of the microbiological assay may be affected by many factors such as oxygen (Bohonos et al., 1942), carbon dioxide (Lascelles et al., 1954), sparing of amino acids by the addition of other amino acids or compounds (McClure et al., 1954), interactions with other amino acids (Fildes 1953), and the relative proportions of various amino acids and other compounds (Brickson et al., 1948) and (Sirny et al., 1951).

However, Stokes et al. (1945) found that, in general the microbiological values for purified and impure proteins are in reasonably good agreement with those obtained by the more recent improved chemical methods. Block and Mitchell (1947) indicated a higher degree of reproducibility than was noted in the work conducted by Stokes.

The evaluation of bacteriological methods for the determination of protein quality by comparisons with protein efficiency ratio (P.E.R.) values determined by standardized rat growth assay was conducted by Rogers et al. (1959). Results with enzyme hydrolyzates correlated poorly with P.E.R. values, whereas with acid hydrolyzates, a good correlation was obtained for cereal proteins.

Bayne et al. (1961) reports on evaluation of 130 samples of seven different types of protein concentrates, which were evaluated by the Gross Protein Value (G.P.V.) procedure as supplements to cereal protein for chicks. In addition Net Protein Utilization (N.P.U.), with the samples as the sole source of protein for rats, was determined for a limited number. Microbiological procedure correlated well with these methods.

#### THE QUALITY OF PROTEIN IN CEREALS

Maynard and Loosli (1956) states, "Cereal grains are deficient in lysine." Morrison (1956) also concludes "when fed as the only source of protein, the grains all fall decidedly below such a food as milk in quality of protein." In fact, it has been concluded by Morrison and Campbell (1960) that P.E.R. values for bread and flour diets were a direct function of the lysine content of the protein. McLaughlan and Morrison (1960) found that for mixtures of foods in which cereal products contribute

approximately half or more of the protein, the lysine content is a reliable guide to the nutritional value of the protein mixture.

Carroll and Krider (1956) states, "The proteins of all cereal grains are deficient in certain essential amino acids. For this reason protein supplements must provide not only more protein but protein having a good balance of the essential amino acids."

The results obtained by McElroy et al. (1948) agreed with the established fact that grain protein is lacking in quality for the promotion of efficient growth in swine.

Morrison (1956), and the National Research Council Publications 648 and 659 (1959) show barley as deficient in some amino acids for swine and rats, especially lysine.

#### THE EFFECT OF PROTEIN CONTENT ON THE BIOLOGICAL VALUE OF THE PROTEIN

Marked differences in the growth response of both rats and pigs attributable to variation in the protein content of the grain was observed by McElroy et al. (1949). Mitchell (1924) found biological values were smaller at the higher protein content of corn. Mitchell et al. (1952) observed the proportion of tryptophan and of lysine in the total protein of corn decreased with increasing content of protein. However, Miller et al. (1950) found that amino acid content of corn varied directly with protein content and there was no change in protein quality with increase in the amount of protein within the range from 8.49 percent to 14.12 percent.

Esh et al. (1960) working with Bengal gram of different protein levels found the P.E.R. with the high protein gram was slightly higher than with

the low protein sample.

Sure (1957) observed that order of the rations, based on their protein efficiency ratios, varied at different planes of protein intake. For example, at the 15 percent level of intake the P.E.R. of defatted soybean flour and cottonseed meal are far superior to that of corn gluten meal, whereas at 25 and 30 percent planes of intake, the P.E.R. of the corn gluten meal is appreciably higher than that of either the soybean flour or cottonseed meal.

Bressani et al. (1958) determined lysine requirements for rats at 4 percent increments from 8 to 24 percent and at 32 and 40 percent crude protein. The maximum lysine requirements expressed as a percentage of the diet remained essentially constant in the protein range of 16 to 40 percent. Expressed as a percentage of the total protein, the lysine requirements were 6.7, 5.6, 4.2, 3.6, 2.6 and 2.2 percent with 8, 12, 16, 20, 24, 32 (and 40 percent of total protein (N X 6.25) respectively.

Grav (1948) found that, as the protein level was increased, the lysine requirement for maximum growth at a particular protein level increased.

In a somewhat different approach Bruneger et al. (1950a) found that a ration containing 10.6 percent protein, the lysine requirement was 0.6 percent of the ration. When rations were fed containing approximately 22 percent protein, the lysine requirement increased to 1.2 percent of the ration. The difference in these requirements is largely eliminated if they are expressed in terms of their proportion to the protein in the ration. The lysine requirements of 0.6 percent and 1.2 percent of the ration correspond to 5.7 and 5.5 percent of the protein in the 10.6 and 22 percent

protein rations respectively.

Almquist (1952) also indicated the amino acid requirements increase as the protein level in the diet increases. However, amino acid requirements expressed as a percentage of the dietary protein appeared to decrease as the protein level increased. However, Graw and Kamei (1950) found that, as the protein level of the chickens' diet is increased, the lysine and methionine plus cystine requirements also increase, but at a slower rate.

#### EFFECT OF AMINO ACID IMBALANCES IN RATS AND SWINE

Working with amino acid imbalances in rats Sauberlich (1952) found that such imbalances resulted in depressed growth. It was found that this condition could be corrected by the addition of the deficient amino acid or acids to the diet.

Harris et al. (1943) found that a deficiency of lysine in a diet produced cessation of growth and hypoproteinaemia in young rats. The changes observed were assumed to be due to general inhibition of protein formation. This resulted in a reduced growth of some organs which developed at the expense of others and protein was transferred according to a fixed system of growth priorities.

Gillespie et al. (1945) found a loss of protein from the liver and a hypoproteinaemia, while the body protein content seemed to be unchanged. The importance of the liver for protein metabolism and its possible role in connection with the synthesis of serum proteins was postulated.

Conducting experimental work with baby pigs Mertz et al. (1949) showed that lysine is indispensable for growth and development. Lack of lysine

resulted in cessation of growth, decreased feed consumption and decreased feed efficiency. Lysine deficient pigs manifested a depraved appetite, rough hair coat, emaciated look and inanition.

The findings of Elvehjem (1956) show that excess quantities of amino acids also affect growth. He found that the addition of 0.4 percent of methionine to an 18 percent casein diet caused growth depression. He also found an amino acid-vitamin relationship in which pyridoxine will counteract the effect of moderate excess amounts of methionine.

Hanks et al. (1949) found the addition of 0.2 percent DL-methionine in place of 0.2 percent L-cystine in a 9 percent casein ration for rats gave the same growth effect as 0.2 percent L-cystine in the presence of either 0.078 percent DL-threonine or 2 percent acid hydrolyzed casein. They postulated that the growth inhibitions obtained by adding the various combinations of amino acids appeared to be due to the increased requirements of the limiting amino acid when all others were supplied in adequate or generous amounts.

By raising the levels of certain essential amino acids in diets containing marginal levels of tryptophan Henderson et al. (1953) induced a niacin deficiency in rats. It was found that levels of lysine above approximately 0.5 percent and valine above 0.7 percent caused a growth suppression which was corrected by an addition of niacin.

A relationship between methionine and vitamin B<sub>6</sub> was found by DeBey et al. (1952). They found that levels of methionine only slightly above those necessary for growth depressed the growth of rats fed limited amounts of vitamin B<sub>6</sub>. Vitamin B<sub>6</sub> counteracted the effect of moderate by excess

amounts of methionine although, when the diet contained 3.5 percent of methionine, high levels of the vitamin failed to restore growth.

Rose (1937) emphasized that in determining amino acid imbalances many factors such as proportion of fat and carbohydrates in the ration must be taken into consideration and that the age, weight and sex of the animals may play important roles in determining the minimum level of a given component.

#### THE ESSENTIAL AMINO ACIDS

Classifying the essential amino acids for the pig Mertz et al. (1952) found that arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine must be present in the diet.

Beeson (1951) states, "If any one of the essential amino acids is dropped out of the ration the growth of the pig will stop immediately."

#### SUPPLEMENTATION WITH NATURAL PROTEIN TO IMPROVE PROTEIN QUALITY

Hoagland and Snider (1927) conducted experiments to determine the value of beef protein as a supplement to the proteins in certain vegetable products. These tests showed that the rations containing equal parts of beef and cereal proteins were practically of the same value in promoting growth in rats as rations containing only meat protein.

Animal proteins have also been used effectively to supplement chicken rations, Almquist et al. (1935).

Carpenter et al. (1957) used dehydrated fish products as supplementary proteins to cereals. They found that addition of lysine to a commercial fish meal raised its value.

Morrison (1956) recommends that cereal grains be supplemented with good quality protein such as fish meal, meat scrap, tankage or peanut oil meal.

Gupta et al. (1958) found a considerable difference in values for biological availability of the lysine in different purified protein.

#### SUPPLEMENTING WITH PURIFIED AMINO ACIDS

Rama Rao et al. (1960) found that rats grew normally when fed a complete L-amino acid diet containing all the amino acids at their minimal requirement levels in a 10 percent conventional protein (N X 6.25) ration.

Findings of Bressani et al. (1960) showed that when a cereal diet was supplemented with all of the limiting amino acids according to the pattern of the F.A.O. reference protein, a sustained nitrogen retention sometimes similar to that obtained with milk feeding was observed.

Rosenberg and Rohdenberg (1952) obtained significant growth responses in weanling rats with the addition of increasing amounts of lysine to diets of dried bread supplemented with fat, salt and vitamins. They found a supplement of 0.5 percent DL-lysine HCl, corresponding to a 0.2 percent L-lysine, to a bread diet improved the average gain in weight after 5 weeks from 32 percent to about 75 percent of the average gain on the stock diet. If sufficient lysine were added to bring the total L-lysine content of the diet to about 0.8 percent, or more, a growth response similar to that obtained with the stock diet was observed.

Brunegar et al. (1949) fed experimental diets containing 0.34 percent, 0.42 percent, 0.50 percent, 0.58 percent and 0.74 percent pure L-lysine. The first four levels of lysine were fed to 3 pigs each and the 0.74 level



was fed to 2 pigs. The pigs weighed 10 Kg. each. The averages of the grams weight gain per gram of protein consumed were 2.60, 2.85, 3.12, 3.47 and 3.49 for each of the respective lysine levels. The average biological values for the corresponding lysine levels were: 52, 51, 61, 73 and 72.

Another experiment was conducted by Brunegar et al. (1960) using a basal diet of corn and barley. The diet, consisting of 21.1 percent protein, contained 0.57 percent lysine, and was supplemented with histidine and methionine. This diet was fed to weanling pigs for four weeks. Experimental diets were made to contain 0.57, 0.75, 0.97, 1.07, 1.32 and 1.63 percent pure lysine. Each increased lysine level up to 1.07 percent improved the growth rate and feed efficiency. In another trial rations containing 21.3 percent protein were supplemented with methionine, histidine and tryptophan. Lysine levels of 0.96, 1.00, 1.20 and 1.40 percent were each fed to five pigs. Increases in growth rate and feed efficiency were noted up to the 1.20 percent lysine level. The data of these two experiments show that with diets containing approximately 22 percent protein weanling pigs require approximately 1.20 percent L-lysine in the ration. Lyman et al. (1956) found the lysine requirements of the young pig to be 3.45-3.65 percent of the crude protein by microbiological assay.

An experiment supplementing Teff with 0.4 percent lysine monohydrochloride (LMH) was conducted by Jansen et al. (1957). Their findings indicated that adding LMH to Teff raised the 4 week weight gain and P.E.R. from 50.3 grams and 1.95 to 125 grams and 3.27 respectively. Similarly, supplementation of pear millet with 0.50 percent of LMH increased weight gain and P.E.R. from 3.62 grams and 1.83 to 118 grams and 3.28,

respectively.

Hale and Lyman (1961) added 0.62 percent lysine to sorghum grain-cottonseed meal rations for growing-fattening pigs. Their results showed pigs in all groups receiving the ration containing added lysine made significantly greater ( $P < 0.01$ ) daily gain. Their findings also showed that lysine additions to the basal rations significantly improved feed efficiency.

Pond et al. (1953) supplemented corn and milo rations with amino acids for growing pigs. They obtained a significant improvement in growth rate and feed efficiency by adding lysine to the basal diet in one trial and the improvement approached significance in another trial.

Larson et al. (1960) used lysine supplementation of oat rations for weanling pigs. Findings in the first trial showed the younger and smaller pigs (20 lb.) responded to 0.3 percent supplemental lysine whereas for the heavier pigs (28 lb.) the 0.1 percent level of lysine was most beneficial. In both trials, the best rate of gain obtained on the lysine supplemented rations was similar to that obtained on the 10 percent soybean meal rations. In the second trial, the lower level of lysine supplementation (0.1 percent) seemed to be the most desirable.

Sure (1955) supplemented pearled barley with amino acids. Supplementing the protein in pearled barley, fed at an 8 percent level of protein, with 0.4 percent L-lysine, resulted in 57.2 percent increased growth and 50.0 percent increase in P.E.R. The further addition of 0.5 percent D-L threonine was followed by a 78.6 percent additional gain in body weight and 118.4 percent further increase in protein efficiency. The supplementation

of pearled barley with L-lysine, D-L threonine and 0.5 percent D-L methionine resulted in 15.3 percent additional growth and 56.3 percent increase in protein utilization.

When supplementing barley rations with lysine Dinnuson et al. (1958) found no difference in final feed conversion, however, large differences were noted before the pigs reached 100 pounds. The addition of lysine, at all levels studied and in all trials, gave beneficial results in average daily gain.

Reisen et al. (1946) fed rats diets containing 8, 18 and 50 percent casein. They found the growth of rats receiving 8 percent casein was increased with additional intake of methionine or cystine. Their results further showed that an increased intake of both methionine and cystine resulted in retarded growth when rats received 8 or 50 percent casein, but not with those receiving 18 percent casein.

When studying the effect of methionine supplementation of a soybean oil meal-purified ration for growing pigs, fed at the 10 percent level of protein, Bell et al. (1950) found that the protein from soybean oil meal was less efficiently utilized by growing pigs and had significantly lower biological value than whole egg protein. The addition of methionine to the soybean oil meal protein to equal the amount in the whole egg protein made the two proteins equal.

Kade et al. (1948) found that better growth was obtained when using an 8 percent casein diet supplemented with 1.5 percent D-L methionine than when using the basal diet without additional methionine. Methionine added at levels of 2, 2.5 and 3 percent of the diet definitely inhibited growth

and protein utilization.

Methionine or lysine was found to be the first limiting essential amino acid in commercial mixed feeds for swine by Rosenberg (1957). He further found that successful supplementation of a feed consisted of adding the first limiting essential amino acid to the feed in such a manner as to achieve a balance with the second limiting essential amino acid as any amount in excess of that needed for proper balance was lost.

Lewis (1962) conducted a feeding trial with pigs using high nitrogen barley as the sole major constituent of the diet. The pigs were divided into four groups: a control group receiving a typical standard ration, a basal group given only barley, a basal barley group with the addition of two amino acids and a basal barley group with the addition of 5 amino acids. A batch of barley of lower total nitrogen (equivalent to about 11 percent protein) was used for the finisher phase. When the pigs were given the ration of barley only, supplemented with amino acids and minor constituents, the performance was equivalent to that with a good standard ration. Assessment was made in terms of growth, feed conversion ratios, nitrogen retention, and carcass composition.

#### UTILIZATION OF D AND L FORMS OF AMINO ACIDS

When supplementing with purified amino acids some factors must be taken into consideration in relation to availability. One of these factors is the utilization of D and L forms of the amino acids. Jackson and Block (1953) found that D methionine, as well as the naturally occurring L methionine, stimulated growth in rats ingesting a cystine-methionine deficient diet.

Berg (1936) found D lysine unable to promote growth when fed to rats as a supplement in a lysine deficient diet. Van Pulsum et al. (1950) found rats fed the L forms of the ten essential amino acids as components of a D-L mixture constituting 22.4 percent of the diet grew less well than control rats fed only the L isomers at a dietary level of 11.2 percent protein. When allowance was made for the growth promoting capacities of the D components of the D-L mixture, and only half as much D-L phenylalanine, tryptophan, methionine, and arginine and an intermediate level of D-L histidine were included, the resulting 18.6 percent of D-L amino acids promoted as good growth as that attained on the L mixture. The growth retardation was traced to excess methionine. Comparative tests showed that the growth retardation produced by the natural L isomer of methionine was greater than that produced by either the D-L or the D modification.

#### TIME FACTOR

Another consideration is the influence of time of ingestion of essential amino acids upon utilization in tissue synthesis. Cannon et al. (1947) working on this problem found that for effective tissue synthesis all essential amino acids must be available to the tissues practically simultaneously; otherwise the first group absorbed is not stored long enough to enable its essential amino acids to combine with those of the second group for the synthesis of complete tissue proteins. This occurred even when the two incomplete rations were offered at alternate hours over a 14 hour period followed by the non-protein basal ration for the remainder of the 24 hour period. The two incomplete rations combined contained all of the ten essential amino acids.

A report by Geiger (1947) supports the view that "incomplete" amino acid mixtures are not stored in the body but are irreversibly further metabolized. It was shown that with delayed supplementation of the lacking amino acids the missing tryptophan, methionine or lysine, when fed several hours after feeding the "incomplete" mixture did not promote growth.

Elman (1947) found the injection of tryptophan (and methionine) 6 hours after an injection of an incomplete mixture of amino acids, lacking only tryptophan, failed to induce positive nitrogen balance, whereas the injection of tryptophan (and methionine) simultaneously succeeded in doing so. He concluded that retention of nitrogen is facilitated when all of the complete mixture of amino acids is present to the tissues at the same time.

Yang et al. (1961), however, found growth data and the biological value obtained with the lysine supplement administered apart from the diet, either immediately or 4, 8, 12 or 16 hours after the 4-hour feeding period, were not different from those observed with the lysine supplement incorporated in the diet.

#### EFFECT OF LYSINE SUPPLEMENTATION ON CARCASS QUALITY

Vipperman et al. (1961) found an increase of total muscle mass with lysine supplementation of swine rations. The carcass specific gravity increased reaching a maximum at the 0.9 percent lysine level. The yield of skinned ham, Boston butt, picnic, and trim loin increased, and the total lean yield increased ( $P < 0.01$ ).

Seerley (1962) supplemented milo rations for weanling pigs with 0.1, 0.2, and 0.3 percent L-lysine. Slaughter data collected were average backfat thickness, carcass length, loin eye area and percent lean cuts.

Results of slaughter data showed that carcasses may be improved by lysine supplementation. As the level of lysine increased backfat thickness decreased and the loin eye area and percent lean cuts increased. Comparison of carcasses from pigs fed rations without lysine and 0.3 percent lysine were 1.64 vs. 1.46 inches backfat, 3.35 vs. 3.78 square inches loin eye, and 50.24 vs. 52.84 percent lean cuts, respectively.

## RAT EXPERIMENTS

### EXPERIMENTAL ENVIRONMENT

#### Experimental animals

Both male and female rats were used in all studies and were approximately 21 days of age at the beginning of the trials. Rats were housed in the Animal Industry small animal research room in the Medical Science Building. This room was heated by a central heating system and, as a result, the temperature varied considerably. Variations as great as 20° F were observed during the trials. The room was also inadequate in ventilation, becoming very stuffy at times. No artificial light was provided at any time during the trials except when someone was working in the room.

#### General care of the animals

Rats were weighed and earmarked at the initiation of the trial so each rat could be identified. Rats were fed and watered in individual cages. Feed and water were supplied ad libitum. The feeders were refilled twice weekly and fresh water was provided as needed. The feeders were placed in crocks to minimize the spilling of feed and facilitated a reasonably accurate weigh back of feed. The experimental period lasted 28 days. The animals were weighed at weekly intervals.

#### Basal ration

The basal ration consisted of 80 percent corn starch, 10 percent corn oil, 5 percent non-nutritive cellulose, 4 percent U.S.P. #14 salt mix, and 1 percent vitamin diet fortification mixture from Nutritional Biochemical Corporation. The barley was substituted for the corn starch in the various trials to obtain the desired protein content for the ration. The rations were not analyzed chemically.



Lotting

The rats were allotted to the various treatments maintaining an equal litter distribution. A uniform sex ratio was also maintained throughout the various treatments.

Protein efficiency ratio (P.E.R.)

P.E.R. values were calculated according to the method of Chapman et al. (1959) by dividing the weight gained in grams by the grams of protein consumed. A correction factor was obtained by using the formula

$\frac{2.5}{\text{P.E.R. for casein reference standard casein. } \frac{1}{\text{P.E.R. actually received from reference standard casein diet for the trial being considered.}}$  The figure 2.5 is a determined constant P.E.R. of

The P.E.R. values of all except the casein diet were multiplied by the correction factor to convert each to a common basis for comparison with the standard casein diet.

1/ A.N.R.C. Reference Casein. Sheffield Chemical. Norwich, N. Y.

METHODS AND PROCEDURES

Rat Trial I

Trial I was conducted to determine the effect of supplementing rations containing high and low protein barley (13.3 and 17.0 percent respectively), with lysine and/or methionine. The composition of the rations is shown in Table I.

In this trial 6 rats (3 males and 3 females) were allotted to each treatment. The lots with their respective treatment are shown in Table II.

Table I. Rat Trial I. Composition of the Rations.<sup>1/</sup>

<u>Rations</u>	<u>I</u> <sup>2/</sup>	<u>II</u> <sup>3/</sup>	<u>III</u> <sup>4/</sup>
<b>Ingredients</b>			
Casein	---	---	11.13%
Barley	58.80%	75.20	---
Corn oil	10.00	10.00	10.00
Cellulose	5.00	5.00	5.00
Salt Mix #14	4.00	4.00	4.00
Vitamins	1.00	1.00	1.00
Corn starch	21.20	4.80	68.87

<sup>1/</sup> All rations corrected to 10 percent protein before the addition of amino acids.

<sup>2/</sup> 17.0 percent protein barley.

<sup>3/</sup> 13.3 percent protein barley.

<sup>4/</sup> Reference casein.

Table II. Rat Trial I. Experimental Treatments. <sup>1/</sup>

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Lot 1	Ration I <sup>2/</sup>
Lot 2	Ration II <sup>3/</sup>
Lot 3	Ration I plus Lysine <sup>4/</sup>
Lot 4	Ration II plus Lysine <sup>4/</sup>
Lot 5	Ration I plus Methionine <sup>4/</sup>
Lot 6	Ration II plus Methionine <sup>4/</sup>
Lot 7	Ration I plus Lysine and Methionine <sup>4/</sup>
Lot 8	Ration II plus Lysine and Methionine <sup>4/</sup>
Lot 9	Ration III

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<sup>1/</sup> All rations corrected to 10 percent protein before addition of amino acids.

<sup>2/</sup> 17.0 percent protein barley.

<sup>3/</sup> 13.3 percent protein barley.

<sup>4/</sup> L-lysine HCl and/or D-L Methionine.

Rat Trial II

In Trial II the procedures outlined by Chapman et al. (1959) were altered so the protein of the various rations were corrected to a 15.9 percent level. As a result, the composition of the barley ration, with respect to corn oil and cellulose, was altered somewhat to facilitate the 15.9 percent protein level. Methionine, lysine or the combination of the two were added to the basal rations. The composition of the rations is shown in Table III.

Six rats (3 males and 3 females) were used per treatment. The lots with their respective treatments are shown in Table IV.

Table III. Rat Trial II. Composition of the Rations.

<u>Ration</u>	<u>I</u>	<u>II <sup>1/</sup></u>
Ingredients		
Casein	17.4%	---
Barley	---	93.0%
Corn oil	2.0	2.0
Cellulose	5.0	---
Salt mix #14	4.0	4.0
Vitamins	1.0	1.0
Corn starch	70.6	---

1/ 17.0 percent protein barley used in the ration.

Table IV. Rat Trial II. Experimental Treatments.

Lot 1	Ration I
Lot 2	Ration II <sup>1/</sup>
Lot 3	Ration II plus 0.44 percent D-L Methionine
Lot 4	Ration II plus 0.52 percent L-lysine HCl
Lot 5	Ration II plus 0.44 percent D-L Methionine and 0.52 percent L-lysine HCl

1/ 17.0 percent protein barley used in the ration.

Rat Trial III

In Trial III a regimen was devised to approach the problem of finding the optimum levels of lysine and methionine which should be added to a 17.0 percent protein barley ration. Two supplemental levels of lysine were used with 4 different levels of methionine added to each lysine level.

The rations in this trial were also corrected to 15.9 percent protein rather than the 10 percent protein correction used by Chapman. The rations are shown in Table V.

Six rats (3 males and 3 females) were allotted to each treatment. The lots with their respective treatments are shown in Table VI.

Table V. Rat Trial III. Composition of Rations.

<u>Ration</u>	<u>I</u>	<u>II <sup>1/</sup></u>
<b>Ingredients</b>		
Barley	---	93.0%
Casein	17.4%	---
Corn oil	2.0	2.0
Cellulose	5.0	---
Salt mix #14	4.0	4.0
Vitamins	1.0	1.0
Corn starch	70.6	---

<sup>1/</sup> 17.0 percent protein barley

Table VI. Rat Trial III. Experimental Treatments. <sup>1/</sup>

<u>Levels of Methionine</u>	<u>0.4% Lysine</u>	<u>0.6% Lysine</u>
0.3%	Lot II	Lot VI
0.4	Lot III	Lot VII
0.5	Lot IV	Lot VIII
0.6	Lot V	Lot IX

<sup>1/</sup> All rations contain 17.0 percent protein barley.  
Lot I fed the casein ration.

RESULTS AND DISCUSSION

Rat Trial I

The average daily gain, feed per gram gained, P.E.R. and corrected P.E.R. are shown in Table VII. The P.E.R. values were the only result analyzed statistically. The casein ration was fed to obtain a correction factor for the P.E.R. This was calculated by using the formula

$\frac{2.5}{\text{P.E.R. for casein}}$ . The correction factor obtained for this experiment was 0.86. All rations were corrected to 10 percent protein before the addition of the amino acids.

Table VII. Results of Rat Experiment I.

Lot	A.D.G.	Feed/ Gm. Gain	P.E.R.	Corrected P.E.R.
I Ration I <u>1/</u>	Grams 1.75	Grams 6.12	1.64	1.41
II Ration II + Methionine <u>2/</u>	1.86	5.83	1.74	1.50
III Ration I + Lysine <u>3/</u>	2.56	4.58	2.24	1.91
IV Ration II + Lysine	2.56	4.55	2.21	1.90
V Ration I + Methionine	1.58	6.32	1.59	1.37
VI Ration II + Methionine	1.70	5.70	1.78	1.53
VII Ration I + Lysine and Methionine	2.68	4.55	2.23	1.92
VIII Ration II + Lysine and Methionine	2.68	4.57	2.20	1.89
IX Reference Casein	3.32	3.49	2.92	----

1/ 17 percent protein barley.

2/ 13.3 percent protein barley.

3/ L-lysine HCl and D-L Methionine both added at 0.2 percent of the ration.

There was a variation of approximately 8 grams between lots in average initial weights when the rats were placed on experiment. All animals were within 3 days of the same age.

The rats in lots receiving lysine supplementation definitely had improved P.E.R.'s. The addition of methionine had no appreciable effect. The two sources of barley, containing 13.3 and 17.0 percent protein, respectively, responded equally well with lysine and gave about equal P.E.R. values when supplemented. This is not in agreement with Mitchell (1924) and Unpublished Data (Montana State College) where findings showed that biological values were lower at higher protein contents of the feed.

The analysis of variance showed a highly significant difference ( $P < 0.01$ ) due to rations. When Duncan's New Multiple Range Test (Duncan, 1955) was applied to the results of this trial, a highly significant difference ( $P < 0.01$ ) was found between the rations containing lysine (Lot III, IV, VII, VIII) and those not receiving supplemental lysine (Lot I, III, V, and VI).

#### Rat Trial II

The average daily gains, feed per gram gain, P.E.R. and corrected P.E.R. are shown in Table VIII. Only the Protein Efficiency Ratios were used for statistical analysis. The correction factor used in this trial was 1.26.

The rations in this trial contained 15.9 percent protein before the addition of the purified amino acids.

There was a variation of 2 grams in average lot weights when the rats were placed on experiment. The rats were approximately the same age

(± 1 day).

The addition of lysine increased the protein efficiency ratios, whereas supplemental methionine gave results about equal to those of barley with no amino acids added. Methionine added with lysine gave results somewhat greater in P.E.R. than those with lysine added alone. These differences were not statistically significant.

An analysis of variance, showed a significant difference ( $<0.05$ ) due to sex. Males, in this trial, utilized lysine additions more efficiently than females.

Table VIII. Results of Rat Experiment II.

Lot	Av. Daily Gain	Feed/ Gm. Gain	P.E.R.	Corrected P.E.R.
	Grams	Grams		
I Ration I <sup>1/</sup>	3.51	3.18	1.99	----
II Ration II <sup>2/</sup>	3.06	4.24	1.49	1.89
III Ration II + 0.44% Methionine	3.01	4.31	1.47	1.85
IV Ration II + 0.52% Lysine	3.45	3.77	1.68	2.12
V Ration II + 0.44% Methionine and 0.52% Lysine	3.76	3.54	1.79	2.26

<sup>1/</sup> Reference casein.

<sup>2/</sup> 17.0 percent protein barley.

#### Rat Trial III

The average daily gain, feed per gram of gain, P.E.R. and corrected P.E.R. are shown in Table IX. The factor for correcting P.E.R. in this trial was 1.20.

All rations contained 15.9 percent protein before the addition of the amino acids.



Table IX. Results of Rat Experiment III.

Lot		Av. Daily Gain	Feed/ Gm. Gain	P.E.R.	Corrected P.E.R.
I	Ration I <u>1/</u>	4.17	3.09	2.09	----
II	Ration II + 0.4% Lysine 0.3% Methionine <u>2/</u>	4.00	3.47	1.85	2.22
III	Ration II + 0.4% Lysine 0.4% Methionine	3.98	3.46	1.83	2.20
IV	Ration II + 0.4% Lysine 0.5% Methionine	4.15	3.46	1.87	2.24
V	Ration II + 0.4% Lysine 0.6% Methionine	3.82	3.46	1.84	2.21
VI	Ration II + 0.6% Lysine 0.3% Methionine	4.16	3.37	1.90	2.28
VII	Ration II + 0.6% Lysine 0.4% Methionine	3.87	3.48	1.86	2.23
VIII	Ration II + 0.6% Lysine 0.5% Methionine	4.06	3.48	1.83	2.20
IX	Ration II + 0.6% Lysine 0.6% Methionine	3.76	3.55	1.79	2.15

1/ Reference casein.

2/ 17.0 percent protein barley.

The P.E.R. values are similar for all levels of supplementation. It appears that all rations are adequate in quality of protein for all compare quite favorably with casein for rat growth. There does, however, seem to be a trend with the 0.6% lysine level for P.E.R. values to progressively decrease with increasing levels of methionine. It would appear that the increasing levels of methionine might have a toxic effect. This would agree with work conducted by Elvehjem (1956) in which he found that the addition of 0.4 percent of methionine to an 18 percent casein diet caused

growth depression. It would be interesting to repeat this trial having a barley ration with no added amino acids to serve as a control.

An analysis of variance showed no significant differences for any of the variables.

### SUMMARY RAT EXPERIMENTS

Three feeding trials were conducted with rats using barley as the sole source of protein in the ration. The barley rations were compared to a control ration using reference casein as the only source of protein. Lysine, methionine or various combinations of the two were added to the barley rations to study the subsequent effect on Protein Efficiency Ratio (P.E.R.).

Experiment I was designed to study the effect of adding lysine, methionine or both to rations containing either a high (17.0%) or low (13.3%) protein barley. All rations were corrected to 10 percent protein before the addition of the amino acids. Lysine and methionine were added at one level (0.2% of the ration).

Results indicated that low protein barley had slightly greater (not significant) P.E.R. values when compared to the high protein barley. When lysine was added to the rations, the P.E.R. values for the two sources of barley were very similar. The addition of lysine to rations containing either the high or low protein barley resulted in greater P.E.R. values ( $P < 0.01$ ). Supplemental methionine appeared to have little effect on the P.E.R. values. Lysine and methionine added together resulted in approximately the same P.E.R. values as when lysine alone was added.

The barley ration fed to rats in Experiment II contained 17.0 percent protein barley. The rations in this experiment were corrected to 15.9 percent protein before the addition of lysine and methionine. Lysine was added at 0.52 percent and methionine at 0.44 percent of the ration.

Results of the experiment indicated P.E.R. values were greater when

lysine was added to the basal barley ration. Supplemental methionine appeared to have little effect on P.E.R. values, however, when lysine and methionine were both added to a barley ration P.E.R. values were slightly greater than with lysine added alone. The small differences observed in this experiment were not statistically significant.

In Experiment III, lysine was added to a ration containing 17.0 percent protein barley at two levels, 0.4 and 0.6 percent of the ration. To the rations containing each of the two levels of lysine, four levels of methionine were added, 0.3, 0.4, 0.5 and 0.6 percent of the ration respectively. The rations all contained 15.9 percent protein before the addition of the amino acids.

The results of the experiment indicated little difference in P.E.R. for any of the combinations of added lysine and methionine. It would appear the addition of all supplemental combinations resulted in rations with biological values approaching the biological value of casein.

A slight trend was observed for P.E.R. values to decrease with increasing levels of methionine. The analysis of variance showed no significant differences for any of the variables.

## SWINE EXPERIMENTS

### EXPERIMENTAL ENVIRONMENT

Two trials were conducted with swine to determine the effects of supplementing barley and barley soybean rations with lysine. Trial I was conducted during the summer of 1961 and Trial II the winter of 1961-62.

#### Experimental animals

Hamprace X Duroc X Yorkshire crossbred pigs from the Montana State College herd were used in both experiments.

The pigs were weaned at approximately 7 weeks of age. Previous to weaning, the male pigs were castrated. All pigs received a creep ration previous to weaning and were held on the ration until the initiation of the experiment. The first experiment had antibiotics in the creep ration but the second experiment did not. All pigs were vaccinated against erysipelas and treated with a piperazine compound to control worms.

#### Lotting

The lotting of pigs was accomplished by stratifying according to weight within sex and allotting at random to one of eight treatments.

#### Weighing

Individual initial weights were obtained at the initiation of the experiment in both trials. The pigs in Trial I were not weighed at any regular interval, except, when approaching 125 or 200 pounds, then were weighed weekly. The pigs in Trial II were weighed at two week intervals from the time of the initiation of the experiment, and after approaching 125 or 200 pounds, then they were weighed weekly. The pigs were changed to finisher rations when the lot averaged approximately 125 pounds, and removed from the experiment when they individually weighed 200 pounds or

more. When the lot had only two pigs remaining, both pigs were removed from the experiment when the heaviest pig reached 200 pounds. All weights were obtained without shrinking.

#### Feeding and watering

The rations were fed in pelleted form in self feeders. All excess feed in the feeders was weighed back at the conclusion of the grower and finisher phases of the experiment. The grower ration was formulated with 13.3 percent protein Betzes barley, whereas the finisher ration contained mill run barley. Samples of feed were taken periodically and these were analyzed by the Montana State College Chemistry Department.

Water was provided in troughs, presenting some complications. During the heat of the summer, the pigs lay in the troughs and it was difficult to keep water before them. Pipes were welded from end to end in the troughs and to help alleviate the problem. In the winter trial, during the extremely cold weather, the problem of freezing was quite pronounced. To alleviate this problem, the pigs were watered several times during the day to insure ample water supply.

METHODS AND PROCEDURES (SWINE)

Trial I

Trial I was initiated June 27, 1961, using 64 pigs with 8 pigs per lot (four barrows and four gilts). The grower ration, shown in Table X contained 81 percent barley and 10 percent soybean meal resulting in a ration with a protein content of approximately 17 percent by chemical analysis (Table XI). The finisher ration (Table XII) contained no soybean meal and had a protein content of approximately 13 percent by chemical analysis. Table XIII shows the chemical analysis of the finisher ration.

Lysine, in both phases of the experiment, was provided from two sources L-lysine HCl and Lyamine.<sup>1/</sup> Both were added at levels to provide the same quantity of additional lysine. Each source provided 3 levels of additional lysine, 0.1, 0.2 and 0.3 percent of the ration.

Upon removal from the experiment, 3 barrows and 3 gilts from each treatment were probed for backfat and then slaughtered. It was not possible to slaughter all 8 pigs because 1 female from each lot was saved by the college for breeding purposes. To maintain an equal number of each sex, only the first 3 males reaching the desired weight were slaughtered.

Three backfat probes were taken on the live hog, one at the first rib, one at the last rib and one between the 3rd and 4th vertebrae. These probes were made approximately one inch from the middle of the back. The average of the three probes was used for computations.

The slaughtering was conducted in the Montana State College Meats

<sup>1/</sup> Lyamine is the trade name of a Merck produced product. Lyamine contains 20% lysine.

Table X. Swine Experiment I. Specifications of Rations for Growing Swine Utilizing Barley and Lysine.

MSC Formula No.	187	188	189	190	191	192	193	194
Ingredients:	<u>Pounds per ton</u>							
Barley	1215.00	1215.00	1215.00	1215.00	1215.00	1215.00	1215.00	1215.00
Soybean meal	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Salt	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Rock Phos. Defl.	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
Limestone	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
Trace mineral <sup>1/</sup>	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
B vitamin <sup>2/</sup>	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
B <sub>12</sub> vitamin <sup>3/</sup>	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Vitamin A and D <sup>4/</sup>	X	X	X	X	X	X	X	X
Molasses	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Antibiotics <sup>5/</sup>	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
L-lysine HCl	0	1.87	3.75	5.62	0	0	0	0
Lyamine	0	0	0	0	0	7.50	15.00	22.50
Wheat mixed feed	22.50	20.63	18.75	16.88	22.50	15.00	7.50	0
	<u>1500.00</u>	<u>1500.00</u>	<u>1500.00</u>	<u>1500.00</u>	<u>1500.00</u>	<u>1500.00</u>	<u>1500.00</u>	<u>1500.00</u>

<sup>1/</sup> High zinc trace mineral.

<sup>2/</sup> 4000 mg. riboflavin; 8000 mg. pantothenic acid and 18,000 mg. niacin per lb.

<sup>3/</sup> 6 mg. vitamin B<sub>12</sub> per lb.

<sup>4/</sup> To provide 500 I.U. vitamin A and 60 I.U. vitamin D per pound of complete feed.

<sup>5/</sup> Add 20 grams per ton of antibiotic (Pro-strep). Potency of Pro-strep -- 10 grams per lb.

Size of pellets: 3/16 inch.



Table XI. Swine Experiment I. Chemical Analysis of Growing Ration Utilizing Barley Plus Lysine or Lyamine.

		Moisture	Protein	Ether Extract	Ash	Crude Fiber	Phosphorus	Calcium
Ration No.:								
187	Basal	3.3	16.7	2.5	5.5	4.9	0.55	1.10
188	Basal + 0.1% lysine <u>1/</u>	4.0	17.4	2.2	4.5	3.9	0.52	0.92
189	Basal + 0.2% lysine <u>1/</u>	3.8	17.0	2.3	5.1	3.9	0.52	1.00
190	Basal + 0.3% lysine <u>1/</u>	3.5	17.2	2.1	3.4	4.4	0.52	0.92
191	Basal	3.4	17.2	2.1	5.0	4.1	0.54	1.00
192	Basal + 0.1% lysine <u>2/</u>	2.2	17.3	2.2	5.0	4.1	0.52	0.79
193	Basal + 0.2% lysine <u>2/</u>	7.3	17.3	2.3	5.4	4.2	0.53	1.00
194	Basal + 0.3% lysine <u>2/</u>	7.3	18.0	2.3	5.2	4.2	0.53	0.92

1/ From L-lysine HCl.

2/ From Lyamine.

Table XII. Swine Experiment I. Specifications of Rations for Fattening Swine Utilizing Barley, Lysine and Lyamine.

MSC Formula No.	197	198	199	200	201	202	203	204
Ingredients:	Pounds per ton							
Barley	1825.00	1825.00	1825.00	1825.00	1825.00	1825.00	1825.00	1825.00
Salt	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Rock Phos. Defl.	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Limestone	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Trace mineral <sup>1/</sup>	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
B vitamin <sup>2/</sup>	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B <sub>12</sub> vitamin <sup>3/</sup>	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin A and D <sup>4/</sup>	X	X	X	X	X	X	X	X
Molasses	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Antibiotics <sup>5/</sup>	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L-lysine HCl	0	2.50	5.00	7.50	0	0	0	0
Lyamine	0	0	0	0	0	10.00	20.00	30.00
Wheat mixed feed	30.00	27.50	25.00	22.50	30.00	20.00	10.00	0
	<u>1999.00</u>	<u>1999.00</u>	<u>1999.00</u>	<u>1999.00</u>	<u>1999.00</u>	<u>1999.00</u>	<u>1999.00</u>	<u>1999.00</u>

<sup>1/</sup> High zinc trace mineral.

<sup>2/</sup> 4000 mg. riboflavin; 8000 mg. pantothenic acid and 18,000 mg. niacin per lb.

<sup>3/</sup> 6 mg. vitamin B<sub>12</sub> per lb.

<sup>4/</sup> To provide 500 I.U. vitamin A and 60 I.U. vitamin D per pound of complete feed.

<sup>5/</sup> Add 10 grams per ton of antibiotic (Pro-strep). Potency of Pro-strep -- 10 grams per lb.

Size of pellets: 3/8 inch.

Table XIII. Swine Experiment I. Chemical Analysis of Finishing Ration Utilizing Barley Plus Lysine or Lyamine.

		Moisture	Protein	Ether Extract	Ash	Crude Fiber	Phosphorus	Calcium
Ration No.:								
197	Basal	7.3	12.3	2.2	5.1	6.5	0.41	0.88
198	Basal + 0.1% lysine <u>1/</u>	7.3	12.1	2.2	5.6	6.7	0.41	1.00
199	Basal + 0.2% lysine <u>1/</u>	7.3	16.0	2.2	5.2	5.7	0.50	0.71
200	Basal + 0.3% lysine <u>1/</u>	7.3	17.5	2.2	5.1	5.7	0.54	0.88
201	Basal	5.1	12.3	2.4	5.4	7.6	0.41	0.83
202	Basal + 0.1% lysine <u>2/</u>	4.8	12.6	2.5	5.3	6.9	0.40	0.92
203	Basal + 0.2% lysine <u>2/</u>	5.1	12.1	2.4	5.6	8.9	0.39	0.83
204	Basal + 0.3% lysine <u>2/</u>	5.3	14.9	2.2	5.3	6.1	0.45	0.79

1/ From L-lysine HCl.

2/ From Lyamine.

Laboratory and followed the procedure of Cole (1951). The pigs were dressed packer style. After slaughter, the following data were collected (following the procedure of Strong, 1951): 1) backfat thickness, 2) specific gravity of the carcass, 3) length of the carcass, 4) weight of each wholesale cut and 5) ribeye tracings. A description of how each was obtained will follow: 1) Backfat thickness of the carcass was measured opposite the first rib, last rib, and between the 3rd and 4th lumbar vertebrae. These values were averaged to obtain the value used in the results. 2) The specific gravity was taken after the carcasses were completely cooled (approximately 36 hours). The carcasses were immersed in water (approximately 40° F) and readings obtained. Each half of the carcass was immersed, and an average for the two halves taken as the specific gravity for the whole carcass. 3) The length of the carcass was determined by measuring from anterior edge of the first rib to the anterior edge of the aitch bone. 4) The carcass was cut into wholesale cuts. A three rib shoulder was used and hams were skinned. 5) Altering the procedure outlined by Strong, the cut for the ribeye area was made between the 10th and 11th ribs. The ribeyes were traced on acetate paper and the areas determined by a planimeter. Three measurements were made of each ribeye, and if they were within 0.03 of an inch, the three were averaged and used as the value for the ribeye area. If they were not within this tolerance, more measurements were made until the desired accuracy was obtained.

#### Trial II

This trial was initiated December 15, 1961, and involved 40 pigs with 5 pigs per lot (2 barrows and 3 gilts). Two different samples of Betzes

barley were used for this experiment, one having 17.0 percent protein (Table XIV) and the other 13.3 percent protein (Table XV). The rations containing the 13.3 percent protein barley also contained soybean meal in the growing phase but not in the fattening phase. The rations containing 17.0 percent protein barley did not have soybean meal in either the growing or fattening phase. The grower rations using both barley sources contained approximately 15 percent protein by chemical analysis. The fattening rations using the 13.3 percent protein barley contained approximately 12 percent protein (Table XVI) and those having the 17.0 percent protein barley had an approximate protein content of 15 percent (Table XVII). An analysis of the barley samples is shown in Table XVIII.

Lysine was supplemented at three levels to provide 0.05, 0.10 and 0.15 percent additional L-lysine for each of the barley samples. This added lysine was in the form of Lyamine.

Following removal from the experiment, each pig was probed for back-fat. No carcass data were obtained from this group of pigs.

Table XIV. Swine Experiment II. Specifications for Rations for Growing and Fattening Swine Utilizing 17 Percent Protein Barley and Lyamine.

MSC Formula No.	219	220	221	222	223	224	225	226
	Growing				Fattening			
Ingredients:	Pounds per ton							
Barley	1820	1820	1820	1820	1820	1820	1820	1820
Salt	10	10	10	10	10	10	10	10
Rock Phos. Defl.	13	13	13	13	13	13	13	13
Limestone	20	20	20	20	20	20	20	20
Trace mineral <u>1/</u>	2	2	2	2	2	2	2	2
B vitamin <u>2/</u>	2	2	2	2	2	2	2	2
B <sub>12</sub> vitamin <u>3/</u>	2	2	2	2	2	2	2	2
Vitamin A and D <u>4/</u>	X	X	X	X	X	X	X	X
Molasses	100	100	100	100	100	100	100	100
Antibiotics <u>5/</u>	2	2	2	2	2	2	2	2
Lyamine	0	5	10	15	0	5	10	15
Wheat mixed feed	<u>30</u>	<u>25</u>	<u>20</u>	<u>15</u>	<u>30</u>	<u>25</u>	<u>20</u>	<u>15</u>
	2001	2001	2001	2001	2001	2001	2001	2001

1/ High zinc trace mineral.

2/ 2000 mg. riboflavin; 4000 mg. pantothenic acid and 9000 mg. niacin per lb.

3/ 6 mg. vitamin B<sub>12</sub> per lb.

4/ To provide 500 I.U. of vitamin A and 60 I.U. of vitamin D per pound of complete feed.

5/ Add 20 grams per ton of antibiotic (Pro-strep). Potency of Pro-strep -- 10 grams per lb.

Size of pellets: 1/4 inch.

Table XV. Swine Experiment II. Specifications for Rations for Growing and Fattening Swine Utilizing 13.3 Percent Protein Barley and Lyamine.

MSC Formula No.	211	212	213	214	215	216	217	218
	Growing				Fattening			
Ingredients:								
	<u>Pounds per ton</u>							
Barley	1610	1610	1610	1610	1820	1820	1820	1820
S.B.O.M. (45%)	210	210	210	210	---	---	---	---
Salt	10	10	10	10	10	10	10	10
Rock Phos. Defl.	12	12	12	12	12	12	12	12
Limestone	20	20	20	20	20	20	20	20
Trace mineral <u>1/</u>	2	2	2	2	2	2	2	2
B vitamin <u>2/</u>	2	2	2	2	2	2	2	2
B <sub>12</sub> vitamin <u>3/</u>	2	2	2	2	2	2	2	2
Vitamin A and D <u>4/</u>	X	X	X	X	X	X	X	X
Molasses	100	100	100	100	100	100	100	100
Antibiotics <u>5/</u>	2	2	2	2	2	2	2	2
Lyamine	0	5	10	15	0	5	10	15
Wheat mixed feed	<u>30</u>	<u>25</u>	<u>20</u>	<u>15</u>	<u>30</u>	<u>25</u>	<u>20</u>	<u>15</u>
	2000	2000	2000	2000	2000	2000	2000	2000

1/ High zinc trace mineral.

2/ 2000 mg. riboflavin; 4000 mg. pantothenic acid and 9,000 mg. niacin per lb.

3/ 6 mg. vitamin B<sub>12</sub> per lb.

4/ To provide 500 I.U. of vitamin A and 60 I.U. of vitamin D per pound of complete feed.

5/ Add 20 grams per ton of antibiotic (Pro-strep). Potency of Pro-strep -- 10 grams per lb.

Size of pellets: 1/4 inch.

Table XVI. Swine Experiment II. Chemical Analysis of Rations for Growing and Fattening Swine Utilizing 13.3 Percent Protein Barley and Lyamine.

	Moisture %	Protein %
<u>Growing Ration No.</u>		
211 Basal	8.1	15.8
212 Basal + 0.25% Lyamine	7.0	15.9
213 Basal + 0.50% Lyamine	7.3	15.1
214 Basal + 0.75% Lyamine	7.2	15.1
<u>Finishing Ration No.</u>		
215 Basal	7.3	12.1
216 Basal + 0.25% Lyamine	7.4	11.7
217 Basal + 0.50% Lyamine	7.4	11.6
218 Basal + 0.75% Lyamine	7.2	11.8

Table XVII. Swine Experiment II. Chemical Analysis of Rations for Growing and Fattening Swine Utilizing 17.0 Percent Protein Barley and Lyamine.

	Moisture %	Protein %
<u>Growing Ration No.</u>		
219 Basal	7.0	15.0
220 Basal + 0.25% Lyamine	7.2	15.1
221 Basal + 0.50% Lyamine	7.9	15.3
222 Basal + 0.75% Lyamine	7.2	15.3
<u>Finishing Ration No.</u>		
223 Basal	7.1	15.6
224 Basal + 0.25% Lyamine	7.2	15.3
225 Basal + 0.50% Lyamine	7.2	15.3
226 Basal + 0.75% Lyamine	7.0	15.4



Table XVIII. Swine Experiment II. Physical and Chemical Composition of Barley Samples. <sup>1/</sup>

Protein	13.3%	17.0%
Test weight	50.0 lb.	44.0 lb.
Moisture	8.6%	8.0%
Skinned and broken	5.3%	3.0%
Broken	1.8%	0.0%
Plump	33.6%	21.2%
Thin	20.0%	42.8%
Dockage	00.0	00.0
Grain grade	#1 two rowed barley	#3 two rowed barley
Screen size - top	6/64	6/64
Screen size - through	5.5/64	5.5/64

<sup>1/</sup> Information obtained from the Montana State College Grain Laboratory.

## RESULTS AND DISCUSSION

### Growing phase -- Swine Experiment I

All lots were on the growing ration for a period of 28 days. The results of this phase of the experiment are shown in Table XIX. Source of lysine appeared to have a slight effect on rate of gain. Pigs fed L-lysine HCl tended to gain faster than the pigs fed Lyamine; however, little difference was observed in feed efficiency. Supplemental L-lysine HCl added to the ration at the 0.2 and 0.3 percent levels appeared to increase average daily gains and improve feed efficiency. Supplemental Lyamine seemed to be beneficial only at the 0.2 percent level. These differences were not statistically significant.

Duncan's New Multiple Range Test applied to the results showed the 0.1 percent level of supplemented lysine decreased average daily gain ( $P < 0.05$ ) when compared to all other levels. Results further showed a highly significant difference ( $P < 0.01$ ) between the 0.1 and 0.2 percent supplemented levels. The depressed average daily gain at the 0.1 percent level (Lots 2 and 6) should, however, be discussed further before forming any conclusions. These lots had a greater standard deviation than the other lots due to 1 pig in each lot with a depressed average daily gain. All other pigs in the two lots appeared to compare favorably in gaining ability with the pigs in the control groups. One would suspect, as a result, that the depressed gains observed with Lots 2 and 6 would be due to chance rather than to the added lysine at the 0.1 percent level.

The initial weight of lots of all pigs were quite high at the start of the experiment. Further investigations seem necessary to determine the

Table XIX. Swine Experiment I. Summary of the Growing Phase of an Experiment to Evaluate the Use of Lysine in a Barley-Soybean Ration for Swine.

Lot	Ration	Average Init. Wt.	Average Final Wt.	Average Gain	Days on Feed	Average Daily Gn.	Standard Deviation	Feed Cons.	Feed Effic.
1	187 Basal	70.2	126.5	56.0	28	2.01	.20	152.5	2.71
2	188 Basal + 0.1% lysine <u>1/</u>	72.1	124.3	52.3	28	1.87	.37	141.8	2.71
3	189 Basal + 0.2% lysine <u>1/</u>	71.7	131.8	60.0	28	2.14	.18	161.1	2.69
4	190 Basal + 0.3% lysine <u>1/</u>	71.9	130.1	58.3	28	2.08	.18	149.4	2.56
5	191 Basal	69.0	124.5	55.0	28	1.98	.18	144.8	2.61
6	192 Basal + 0.1% lysine <u>2/</u>	69.5	119.9	50.4	28	1.80	.33	131.3	2.61
7	193 Basal + 0.2% lysine <u>2/</u>	73.5	131.2	57.7	28	2.06	.31	148.1	2.56
8	194 Basal + 0.3% lysine <u>2/</u>	73.6	127.1	54.0	28	1.95	.13	144.1	2.64

1/ From L-lysine HCl.

2/ From Lyamine.

response of pigs to supplemental lysine using pigs with a lighter initial weight.

#### Fattening phase -- Swine Experiment I

The results of the fattening phase are shown in Table XX. The pigs fed L-lysine HCl appeared to have a greater average daily gain and improved feed efficiency when compared to the pigs fed Lyamine. The 0.2 and 0.3 percent levels of L-lysine HCl supplementation both resulted in increased average daily gains, whereas the 0.1 percent level was less than the controls. The depressed gain observed for the lot receiving the 0.1 percent level of added L-lysine HCl appeared to be the result of the poor performance of one pig in the lot. It was interesting to note that the pigs in the lot receiving the 0.1 percent level of Lyamine showed an increased gain in the fattening phase of the experiment. The 0.3 percent level of Lyamine resulted in the most favorable gain for that source of lysine. These differences were not significant statistically.

Ration 199 and 200 had a greater protein content than the other rations as shown in the first chemical analysis (Table X). A second chemical analysis was conducted and the results of this analysis resulted in protein content values more in agreement with the other rations, though still slightly greater. This increased protein content may have had an effect on the increased average daily gains observed for the pigs in these two lots.

#### Summary of Swine Experiment I

The summary of Swine Experiment I (Table XXI) indicated feeding pigs L-lysine HCl may have a beneficial effect on average daily gain and feed

Table XX. Swine Experiment I. Summary of the Fattening Phase of an Experiment to Evaluate the Use of Lysine in a Barley-Soybean Ration for Swine.

Lot	Ration	Average Init. Wt.	Average Final Wt.	Average Gain	Average Av. Days on Feed	Average Daily Gn.	Standard Deviation	Feed Cons.	Feed Effic.
1	197 Basal	126.5	204.9	78.4	35.0	2.24	.16	276.9	3.53
2	198 Basal + 0.1% lysine <u>1/</u>	124.5	205.4	81.0	42.0	1.92	.42	300.4	3.71
3	199 Basal + 0.2% lysine <u>1/</u>	131.7	208.2	76.5	33.2	2.30	.23	266.9	3.49
4	200 Basal + 0.3% lysine <u>1/</u>	130.1	208.6	78.5	34.1	2.30	.15	268.0	3.41
5	201 Basal	124.5	204.0	79.5	37.6	2.11	.36	302.7	3.81
6	202 Basal + 0.1% lysine <u>2/</u>	119.9	209.9	90.0	41.1	2.19	.30	329.1	3.66
7	203 Basal + 0.2% lysine <u>2/</u>	131.2	205.1	73.9	36.7	2.01	.23	300.0	4.06
8	204 Basal + 0.3% lysine <u>2/</u>	127.1	206.9	79.7	35.9	2.22	.20	285.2	3.58

1/ From L-lysine HCl.

2/ From Lyamine.

Table XXI. Swine Experiment I. Summary of an Experiment to Evaluate the Use of Lysine in a Barley-Soybean Ration for Growing and Fattening Swine.

Lot	Ration	Average Init. Wt.	Average Final Wt.	Average Gain	Av. Days on Feed	Average Daily Gn.	Standard Deviation	Average Feed Cons.	Feed Effic.
1	Basal	70.2	204.9	134.6	63.0	2.14	.10	429.4	3.19
2	Basal + 0.1% lysine <u>1/</u>	72.1	205.4	133.2	70.0	1.90	.42	442.1	3.32
3	Basal + 0.2% lysine <u>1/</u>	71.7	208.2	136.5	61.2	2.23	.20	428.0	3.14
4	Basal + 0.3% lysine <u>1/</u>	71.9	208.6	136.7	62.1	2.20	.13	417.4	3.05
5	Basal	69.0	204.0	135.0	65.6	2.06	.26	447.5	3.31
6	Basal + 0.1% lysine <u>2/</u>	69.5	209.9	140.4	69.1	2.03	.28	460.4	3.28
7	Basal + 0.2% lysine <u>2/</u>	73.5	205.1	131.6	64.7	2.03	.25	448.1	3.40
8	Basal + 0.3% lysine <u>2/</u>	72.6	206.9	134.2	63.9	2.10	.24	429.4	3.20

1/ From L-lysine HCl.

2/ From Lyamine.

efficiency when compared to Lyamine. The 0.2 and 0.3 percent levels of L-lysine HCl resulted in an increased average daily gain and feed efficiency. The 0.1 percent level of L-lysine HCl resulted in decreased gains when compared to the controls. This decrease in gain was partly attributed to the poor performance of one pig in the lot. Lyamine at the 0.3 percent level of supplementation produced the most favorable results for that source of lysine.

As a result of the increased gain, the 0.2 and 0.3 L-lysine HCl supplemental levels and 0.3 Lyamine level reached the desired weight in fewer days than the controls and with a decrease in pounds of feed required per pound of gain.

#### Carcass data Swine Experiment I

The summary of the carcass data is shown in Table XXII. Source of lysine appeared to have little effect on fat content of the carcass. Live backfat probes indicated a slight decrease in backfat thickness with supplemental Lyamine, when compared to the pigs receiving added L-lysine HCl. This difference was not significant statistically.

Levels of added lysine did not produce any consistent trends when considering the fat content of the carcass. It is of interest to note the carcasses from the pigs receiving the 0.2 percent level of Lyamine had a decreased backfat thickness, which was indicated by all fat measurements. The pigs in Lot 3, however, having the same level of added lysine, produced carcasses with a considerable amount of fat.

The three methods of measuring fat content (live probe, carcass backfat measurement and specific gravity) employed in this trial all produced

Table XXII. Swine Experiment I. Summary of the Carcass Data From an Experiment to Evaluate Lysine in a Barley Ration for Swine. <sup>1/</sup>

Lot	Ration	Average Backfat Probe (live)	Average Backfat Thickness (carcass)	Average Specific Gravity of Carcass	Average Length of Carcass	Ham	Belly	Shoulder	Loin	Butt	Fat	Lean Trim	Loin Area
1	Basal	1.5	1.6	1.0408	30.7	23.91	16.56	14.22	20.53	6.58	36.83	8.75	2.62
2	Basal + 0.1% Lysine <sup>2/</sup>	1.5	1.5	1.0432	30.0	24.92	16.54	14.71	21.98	6.88	36.04	9.21	2.91
3	Basal + 0.2% Lysine <sup>2/</sup>	1.6	1.7	1.0407	30.4	24.92	17.25	14.75	21.67	6.54	38.13	9.21	3.06
4	Basal + 0.3% Lysine <sup>2/</sup>	1.6	1.6	1.0406	30.5	24.33	17.74	14.49	21.93	7.02	36.31	8.60	2.98
5	Basal	1.5	1.6	1.0425	30.4	24.18	16.29	14.02	20.53	6.60	35.62	8.68	2.76
6	Basal + 0.1% Lysine <sup>3/</sup>	1.5	1.6	1.0416	30.7	24.57	17.07	14.77	22.13	7.04	37.38	9.38	3.14
7	Basal + 0.2% Lysine <sup>3/</sup>	1.4	1.4	1.0474	31.1	25.13	16.10	14.59	21.98	7.17	32.32	9.29	3.00
8	Basal + 0.3% Lysine <sup>3/</sup>	1.5	1.7	1.0400	30.0	23.77	17.00	14.28	20.92	6.97	37.01	8.67	2.82
	Av. Male		1.7	1.0387		23.55	17.42	14.10	20.71	6.56	38.65	8.81	2.70
	Av. Female		1.5	1.0458		25.34	16.22	14.85	22.20	7.14	29.55	9.14	3.08

<sup>1/</sup> Data are the average of three gilts and three barrows from each lot.

<sup>2/</sup> From L-lysine HCl.

<sup>3/</sup> From Lyamine.



similar results. This would indicate live backfat probes might be used with reasonable accuracy to predict the degree of fatness of swine to be used for breeding purposes.

The length of the carcass did not appear to be influenced by adding lysine to the basal ration and was one of the two measurements not affected by sex when analyzed statistically (the other measurement was live backfat probes).

Results were very interesting when considering the effect of sex on the various measurements. Gilt carcasses produced a greater weight, highly significant ( $P < 0.01$ ), of ham, shoulder, loin, butt, lean trim and the area of the ribeye was increased ( $P < 0.01$ ). In addition gilt carcasses contained less fat as shown by specific gravity values ( $P < 0.01$ ) and by carcass backfat measurements ( $P < 0.05$ ). Barrow carcasses contained heavier bacons, and more fat trim than gilts ( $P < 0.01$ ).

The two measurements, loin weight and ribeye area, were affected by both L-lysine HCl and Lyamine. The pigs receiving the 0.1 and 0.2 percent levels of supplemental lysine had carcasses with larger ribeye area ( $P < 0.08$ ). Carcass loin weights were also greater from pigs receiving the 0.1 and 0.2 percent levels of supplemental lysine ( $P < 0.09$ ).

#### Growing phase -- Swine Experiment II

The results of the growing phase, Table XXIII, indicated a trend for slightly greater gains with the rations containing the low protein barley (13.3% protein) when compared to the rations containing the high protein barley (17.0% protein). The rations containing the high protein barley did not have the S.O.M. added, whereas the rations containing the low

Table XXIII. Swine Experiment II. Summary of Growing Phase of an Experiment to Evaluate the Use of Lyamine in a Barley, Barley-Soybean Ration for Swine.

Lot	Ration	Average Init. Wt.	Average Final Wt.	Average Gain	Days on Feed	Average Daily Gn.	Average Feed Cons.	Feed Eff.
1	211 Basal <u>1/</u>	63.6	125.8	62.2	35	1.78	212.0	3.41
2	212 Basal + 0.25% Lyamine <u>1/</u>	58.2	123.8	65.6	35	1.87	198.0	3.02
3	213 Basal + 0.50% Lyamine <u>1/</u>	59.4	124.8	65.4	35	1.87	214.0	3.27
4	214 Basal + 0.75% Lyamine <u>1/</u>	63.0	129.8	66.8	35	1.91	204.8	3.07
5	219 Basal <u>2/</u>	63.0	123.4	60.4	35	1.73	202.0	3.34
6	220 Basal + 0.25% Lyamine <u>2/</u>	63.4	126.2	62.8	35	1.79	210.8	3.36
7	221 Basal + 0.50% Lyamine <u>2/</u>	59.0	121.2	62.2	35	1.78	200.0	3.22
8	222 Basal + 0.75% Lyamine <u>2/</u>	63.6	125.4	61.8	35	1.77	200.8	3.25

1/ 13.3 percent barley.

2/ 17.0 percent barley.

protein barley did. All rations contained approximately 15.3 percent protein. It would appear from the results of this experiment that pigs fed a ration containing high protein barley will do reasonably well without high protein supplements added. The differences observed in gains due to source of protein were not significant.

The addition of Lyamine to the basal rations appeared to increase rate of gain. This increase was more pronounced when Lyamine was added to rations containing the low protein barley, although the difference was very slight and not significant.

Supplemental Lyamine at all levels improved feed efficiency when added to the rations containing the low protein barley. When Lyamine was added to the rations containing the high protein barley the 0.50 and 0.75 percent levels resulted in a slight improvement in feed efficiency.

#### Fattening phase -- Swine Experiment II

The results of the fattening phase are shown in Table XXIV. The rations containing the low protein barley (13.3% protein) had a protein content of approximately 12 percent in this phase of the experiment. The protein content of the high protein barley rations (17.0% protein) was approximately 15.5 percent. Soybean oil meal was not added to any of the rations in this phase. Chemical analysis of the feed showed very little variation in protein content among the rations within a particular barley source.

The pigs receiving the low protein barley rations made greater gains than the pigs fed the high protein barley rations. This difference was highly significant ( $P < 0.01$ ). Feed efficiency also appeared to be improved

Table XXIV. Swine Experiment II. Summary of the Fattening Phase of an Experiment to Evaluate the Use of Lyamine in a Barley-Soybean Ration for Swine.

Lot	Ration	Average Init. Wt.	Average Final Wt.	Average Gain	Av. Days on Feed	Average Daily Gn.	Average Feed Cons.	Feed Eff.
1	215 Basal <u>1/</u>	125.8	203.4	77.6	30.8	2.52	276.0	3.56
2	216 Basal + 0.25% Lyamine <u>1/</u>	123.8	205.2	81.4	33.6	2.42	282.2	3.47
3	217 Basal + 0.50% Lyamine <u>1/</u>	124.8	209.8	85.0	30.8	2.76	292.0	3.44
4	218 Basal + 0.75% Lyamine <u>1/</u>	129.8	204.6	74.8	30.8	2.43	261.0	3.49
5	223 Basal <u>2/</u>	123.4	206.2	82.8	36.4	2.27	303.6	3.67
6	224 Basal + 0.25% Lyamine <u>2/</u>	126.2	202.8	76.6	33.6	2.28	287.6	3.75
7	225 Basal + 0.50% Lyamine <u>2/</u>	121.2	208.0	86.8	39.2	2.21	307.0	3.54
8	226 Basal + 0.75% Lyamine <u>2/</u>	125.4	201.6	76.2	35.0	2.18	264.0	3.46

1/ 13.3 percent barley.

2/ 17 percent barley.

when feeding the low protein barley rations when compared to the high protein barley rations. This difference was not analyzed statistically.

It was interesting to note that the pigs fed rations containing the low protein barley made the greatest gains. This might be due to the higher fiber content of the high protein barley (lower test weight). There is also a possibility that barley exhibits the same trends as corn (Mitchell, 1924), resulting in a decreased biological value of the protein with increases in protein content. Rat work (unpublished data Montana State College) conducted with a high and low protein barley source indicated P.E.R. values were greater for the low protein barley when all rations were corrected to 10 percent protein. It was also evident in this phase of the experiment that barley rations will give very satisfactory gains without supplemental protein.

Supplemental Lyamine did not seem to increase gains, except when the 0.5 percent level was added to the rations containing the low protein barley. A slight trend was indicated for improved feed efficiency with the addition of Lyamine. These differences were not significant.

#### Summary of Swine Experiment II

The summary of the results of Swine Experiment II is shown in Table XXV. Pigs fed low protein barley rations (13.3% protein) had a greater average daily gain ( $P < 0.01$ ) than pigs fed the high protein barley rations (17.0% barley).

Pigs fed the 0.50 percent level of supplemental Lyamine added to the low protein barley had slightly greater gains (not significant). The gains for pigs fed all other supplemental levels added to both sources of barley

Table XXV. Swine Experiment II. Summary of an Experiment to Evaluate the Use of Lyamine in a Barley, Barley-Soybean Ration for Growing and Fattening Swine.

Lot	Ration	Average Init. Wt.	Average Final Wt.	Average Gain	Av. Dys. on Feed	Average Daily Gn.	Feed Cons.	Feed Eff.	Backfat Probe
1	Basal <u>1/</u>	63.6	203.4	129.8	65.8	2.12	488.0	3.49	1.61
2	Basal + 0.25% Lyamine <u>1/</u>	58.2	205.2	147.0	68.6	2.14	480.2	3.27	1.66
3	Basal + 0.50% Lyamine <u>1/</u>	59.4	209.8	150.4	65.8	2.29	506.0	3.36	1.62
4	Basal + 0.75% Lyamine <u>1/</u>	63.0	204.6	141.6	65.8	2.15	465.8	3.29	1.61
5	Basal <u>2/</u>	63.0	206.2	143.2	71.4	2.01	505.6	3.53	1.73
6	Basal + 0.25% Lyamine <u>2/</u>	63.4	202.8	139.4	68.6	2.03	498.4	3.57	1.60
7	Basal + 0.50% Lyamine <u>2/</u>	59.0	207.8	148.8	74.2	2.01	507.0	3.41	1.62
8	Basal + 0.75% Lyamine <u>2/</u>	63.6	201.6	138.0	70.0	1.97	464.8	3.37	1.58

1/ 13.3 percent protein barley. Soybean oil meal in grower but not in finisher.

2/ 17.0 percent protein barley.

were similar.

Feed efficiency was improved when Lyamine was added to the rations containing the low protein barley. A slight improvement in feed efficiency was also observed when adding Lyamine at the 0.50 and 0.75 percent levels to the high protein barley rations.

As a result of greater gains, the pigs fed the low protein barley reached the desired weight in fewer days than pigs fed the high protein barley rations.

The backfat probes, taken when the pigs were removed from the experiment appeared to be similar when comparing rations containing different protein levels and also when comparing levels of supplemental Lyamine.

Results of the trial would indicate supplemental Lyamine produced greater effect on gain and feed efficiency in the growing phase than in the fattening period. These results would indicate that continued work is necessary starting the experimental work when the pigs were weaned. Protein quality seems to be most critical when the pigs are small.

When comparing the rat and swine data rats utilize supplemental lysine added to barley rations more efficiently than swine. These rations were not of the same protein content, so comparisons could be due to this factor.

### SUMMARY SWINE EXPERIMENTS

Two swine trials were conducted to determine the effects of supplementing barley and barley-soybean rations with lysine. Hamprace X Duroc X Yorkshire crossbred pigs were used in both experiments. The pigs were first placed on a growing ration, changed to a fattening ration when the lot averaged approximately 125 pounds, and removed from the experiment when they individually weighed 200 pounds or more. Rations were supplemented with vitamins and minerals and fed in a pelleted form.

Trial I used 64 pigs with 8 pigs per lot (four gilts and four barrows). The grower ration contained 81 percent barley and 10 percent S.O.M. The protein content of the grower ration was approximately 17.0 percent. The finisher ration contained no S.O.M. and had a protein content of approximately 13.0 percent. Lysine was provided from two sources, L-lysine HCl and Lyamine. Each source provided 3 levels of additional lysine, 0.1, 0.2 and 0.3 percent of the ration.

In the growing phase of Trial I, pigs fed L-lysine HCl tended to gain faster than pigs fed Lyamine. This difference was not significant statistically. Supplemental L-lysine HCl added to the ration at the 0.2 and 0.3 percent levels of the ration appeared to increase average daily gain of pigs and improve feed efficiency. The 0.1 level of supplemental lysine, however, decreased average daily gain ( $P < 0.05$ ), when compared to all other levels. Results showed a highly significant difference ( $P < 0.01$ ) between the 0.1 and 0.2 percent supplemental levels.

Pigs fed L-lysine HCl, in the fattening phase of Trial I, appeared to have greater average daily gains and improved feed efficiency when compared



to pigs fed Lyamine. The 0.1 and 0.3 percent levels of L-lysine HCl supplementation both resulted in greater average daily gains, whereas the 0.1 percent level was slightly less than the control. The 0.3 percent Lyamine supplementation resulted in the most favorable gain for that source of lysine. These differences were not statistically significant.

When the results of the two phases were combined, L-lysine HCl seemed to have a beneficial effect on average daily gain and feed efficiency when compared to Lyamine. The 0.2 and 0.3 percent levels of L-lysine HCl resulted in an increased average daily gain and feed efficiency. Lyamine added at the 0.3 percent level produced the most favorable results. These differences were not statistically significant.

Source of lysine or levels did not seem to affect the fat content of the carcass. The pigs receiving the 0.1 and 0.2 percent levels of supplemental lysine had carcasses with a larger ribeye area ( $P < 0.08$ ) and loin weights were heavier ( $P < 0.09$ ) when compared to the control. Little difference was observed in the other measurements. Gilt carcasses produced a greater weight ( $P < 0.01$ ) of ham, shoulder, loin, butt, lean trim and the area of the ribeye was greater. In addition, gilt carcasses contained less fat as shown by specific gravity values ( $P < 0.01$ ) and by carcass backfat measurement ( $P < 0.05$ ). Barrow carcasses contained heavier bacons and more fat trim than the gilts ( $P < 0.01$ ).

Swine Trial II involved 40 pigs with 5 pigs per lot (2 barrows and 3 gilts). Two different samples of Betzes barley were used for this experiment, one having 13.3 percent protein and the other 17.0 percent protein. The rations containing the 13.3 percent protein barley also contained S.O.M.

in the growing phase but not in the fattening phase. The grower rations using both barley sources contained approximately 15.0 percent protein. The fattening rations using the 13.3 percent protein barley contained approximately 12.0 percent protein, and those having the 17.0 percent protein barley had approximately 15.5 percent protein. Lyamine was supplemented at three levels to provide 0.05, 0.10 and 0.15 percent additional L-lysine. Following removal from the experiment each pig was probed for backfat.

The results of the growing phase indicated a trend for slightly greater gains with the 13.3 percent protein barley. Feed efficiency and average daily gain appeared to increase with lyamine supplementation. These differences were not statistically significant.

In the fattening phase, a definite increase in gain and feed efficiency was observed for the rations containing 13.3 percent protein barley, when compared with the rations containing the 17.0 percent protein barley. This difference was highly significant statistically ( $P < 0.01$ ).

When the results of the two phases were combined, the pigs fed the rations containing the 13.3 percent protein barley had a greater average daily gain ( $P < 0.01$ ) than pigs fed the rations containing the 17.0 percent protein barley. The average daily gains and feed efficiency appeared to be slightly improved by addition of lyamine, especially to the rations containing the 13.3 percent protein barley. The differences observed were not significant statistically.

The backfat probes indicated a slight decrease in backfat thickness with the higher protein ration. Various levels of supplementation appeared to have little effect on backfat thickness.

**APPENDIX**

APPENDIX TABLE I. RAT EXPERIMENT I. <sup>1/</sup> INDIVIDUAL PERFORMANCE DATA.

Sex	Rat No.	Initial	Final	Total	Average	Protein	P.E.R.	Corrected P.E.R.
		Weight	Weight	Gain	Daily	Con-		
		Grams	Grams	Grams	Grams	sumed		
						Grams		
				<u>Lot 1.</u>	<u>Ration I</u>	<sup>2/</sup>		
F	11	57	108	51	1.82	30.6	1.67	1.44
M	12	41	82	40	1.43	25.4	1.57	1.35
F	13	45	92	47	1.68	29.7	1.58	1.36
F	14	47	101	54	1.93	32.7	1.65	1.42
M	15	56	111	55	1.96	32.9	1.67	1.44
M	16	39	85	46	1.64	27.5	1.65	1.42
	Average	47.5	96.5	49.0	1.75	29.8	1.64	1.41
				<u>Lot 2.</u>	<u>Ration II</u>	<sup>3/</sup>		
M	21	57	112	55	1.96	31.9	1.72	1.48
F	22	48	104	56	2.00	31.2	1.79	1.54
F	23	44	97	53	1.89	33.7	1.57	1.35
M	24	40	77	37	1.32	23.9	1.55	1.33
F	25	39	90	51	1.82	29.3	1.74	1.50
M	26	32	84	52	1.86	26.2	1.99	1.71
	Average	41.8	94.0	52.2	1.86	29.4	1.74	1.50
				<u>Lot 3.</u>	<u>Ration I + 0.2% L-lysine HCl</u>			
M	31	49	96	47	1.68	27.7	1.70	1.46
F	32	39	116	77	2.75	31.8	2.42	2.08
M	33	50	121	71	2.53	34.2	2.08	1.79
M	34	38	110	72	2.57	28.8	2.50	2.15
F	35	35	112	77	2.75	33.3	2.31	1.99
F	36	36	123	87	3.10	37.7	2.31	1.99
	Average	41.5	113.0	71.5	2.56	32.2	2.22	1.91
				<u>Lot 4.</u>	<u>Ration II + 0.2% L-lysine HCl</u>			
F	41	45	116	71	2.54	32.5	2.18	1.87
M	42	45	116	71	2.54	32.3	2.20	1.89
F	43	49	123	74	2.64	37.0	2.00	1.72
F	44	40	115	75	2.68	32.8	2.29	2.00
M	45	36	119	83	2.96	34.8	2.39	2.06
M	46	45	125	80	2.86	37.0	2.16	1.86
	Average	43.3	119.0	75.7	2.70	34.4	2.21	1.90

APPENDIX TABLE I. (CONTINUED)

Sex	Rat No.	Initial Weight Grams	Final Weight Grams	Total Gain Grams	Average Daily Gain Grams	Protein Consumed Grams	P.E.R.	Corrected P.E.R.
<u>Lot 5. Ration I + 0.2% D-L Methionine</u>								
M	51	50	94	44	1.57	36.2	1.68	1.44
F	52	53	111	58	2.07	35.2	1.64	1.41
F	53	46	100	54	1.93	35.4	1.53	1.32
M	54	41	82	41	1.46	23.6	1.74	1.50
F	55	32	72	40	1.43	22.6	1.77	1.52
M	56	34	63	29	1.04	23.0	1.26	1.08
	Average	42.7	87.0	44.3	1.58	27.7	1.59	1.37
<u>Lot 6. Ration II + 0.2% D-L Methionine</u>								
M	61	52	97	45	1.61	24.5	1.84	1.58
F	62	34	78	44	1.57	25.8	1.71	1.47
F	63	49	106	57	2.04	33.8	1.69	1.45
M	64	42	80	38	1.35	24.6	1.54	1.32
F	65	35	81	46	1.64	25.4	1.81	1.56
M	66	40	96	56	2.00	27.9	2.01	1.73
	Average	42.0	89.7	47.7	1.70	27.0	1.78	1.53
<u>Lot 7. Ration I + 0.2% L-lysine HCl and 0.2% D-L Methionine</u>								
F	71	51	122	71	2.54	34.2	2.08	1.79
F	72	41	103	62	2.21	27.5	2.25	1.94
F	73	51	115	64	2.29	35.0	1.83	1.57
M	74	44	121	77	2.75	33.1	2.33	2.00
M	75	35	123	88	3.14	35.1	2.51	2.16
M	76	39	114	75	2.68	31.9	2.35	2.02
	Average	41.3	116.3	72.8	2.68	32.8	2.23	1.92
<u>Lot 8. Ration II + 0.2% L-lysine HCl and 0.2% D-L Methionine</u>								
F	81	49	122	73	2.61	34.7	2.10	1.81
M	82	32	91	59	2.11	27.4	2.15	1.85
M	83	49	124	75	2.68	36.7	2.04	1.75
F	84	39	108	69	2.46	33.2	2.08	1.79
F	85	34	111	77	2.75	32.8	2.35	2.02
M	86	35	132	97	3.46	39.5	2.46	2.12
	Average	39.7	114.6	75.0	2.68	34.1	2.20	1.89

APPENDIX TABLE I. (CONTINUED)

Sex	Rat No.	Initial	Final	Total	Average	Protein	P.E.R.	Corrected P.E.R.
		Weight	Weight	Gain	Daily	Con-		
		Grams	Grams	Grams	Grams	sumed		
						Grams		
				Lot 9.	Ration III	<sup>4/</sup>		
F	91	40	126	86	3.07	30.0	2.87	----
F	92	48	135	87	3.11	32.0	2.72	----
F	93	47	128	81	2.89	31.9	2.54	----
M	94	39	118	79	2.82	31.5	2.51	----
M	95	36	156	120	4.29	34.3	3.49	----
M	96	30	135	105	3.75	31.4	3.34	----
	Average	40.0	133.0	90.0	3.32	31.8	2.92	----

- 1/ Experimental period 28 days. Protein of ration 10%.  
2/ 17.0% protein Betzes barley.  
3/ 13.3% protein Betzes barley.  
4/ A.N.R.C. reference casein.

APPENDIX TABLE II. RAT EXPERIMENT II. 1/ INDIVIDUAL PERFORMANCE DATA.

Sex	Rat No.	Initial Weight Grams	Final Weight Grams	Total Gain Grams	Average	Protein	P.E.R.	Corrected P.E.R.
					Daily Gain Grams	Con- sumed Grams		
<u>Lot 1. Ration I <u>2/</u></u>								
F	51	43	139	96	3.43	50.9	1.89	----
M	52	41	173	132	4.71	57.4	2.30	----
M	53	30	91	61	2.18	35.7	1.71	----
M	54	59	185	126	4.50	56.6	2.23	----
F	55	58	135	77	2.75	45.5	1.69	----
Average		46.2	144.6	98.4	3.51	49.5	1.99	----
<u>Lot 2. Ration II <u>3/</u></u>								
F	61	44	142	98	3.50	58.8	1.67	2.10
M	62	47	157	110	3.93	61.1	1.80	2.27
F	63	36	109	73	2.61	54.5	1.34	1.69
M	64	55	117	62	2.21	52.3	1.19	1.50
M	65	54	139	85	3.04	59.7	1.42	1.79
Average		47.2	132.8	85.6	3.06	57.4	1.49	1.89
<u>Lot 3. Ration II + 0.44% D-L Methionine</u>								
M	71	42	127	85	3.04	55.5	1.53	1.93
M	72	39	127	88	3.14	56.9	1.55	1.95
F	73	41	113	72	2.57	57.0	1.26	1.59
F	74	56	128	72	2.57	54.5	1.32	1.66
M	75	56	160	104	3.71	62.7	1.66	2.09
Average		46.8	131.0	84.2	3.01	57.4	1.47	1.85
<u>Lot 4. Ration II + 0.52% L-lysine HCl</u>								
F	81	45	135	90	3.21	55.9	1.61	2.03
M	82	41	172	131	4.68	60.4	2.17	2.73
M	83	38	120	82	2.93	56.2	1.46	1.84
M	84	52	141	89	3.18	53.4	1.67	2.10
F	85	54	146	92	3.29	62.7	1.47	1.85
Average		46	143.0	96.8	3.46	57.7	1.68	2.12

APPENDIX TABLE II. (CONTINUED)

Sex	Rat No.	Initial	Final	Total	Average	Protein	P.E.R.	Corrected
		Weight	Weight	Gain	Daily	Con-		P.E.R.
		Grams	Grams	Grams	Grams	sumed		P.E.R.
		Lot 5. Ration II + 0.52% L-lysine HCl and 44% D-L Methionine						
M	91	46	173	127	4.54	61.5	2.07	2.61
M	92	48	172	124	4.43	60.8	2.04	2.57
F	93	33	115	82	2.93	58.8	1.39	1.75
M	94	62	182	120	4.29	62.9	1.91	2.41
F	95	51	125	74	2.64	50.4	1.47	1.85
Average		48.0	153.4	105.4	3.76	58.9	1.79	2.26

1/ Experimental period 28 days. Protein of ration 15.9%.

2/ A.N.R.C. reference casein.

3/ 17.0% protein barley.



APPENDIX TABLE III. RAT EXPERIMENT III. <sup>1/</sup> INDIVIDUAL PERFORMANCE DATA.

Sex	Rat No.	Initial	Final	Total	Average	Protein	P.E.R.	Corrected
		Weight	Weight	Gain	Daily	Con-		P.E.R.
		Grams	Grams	Grams	Grams	sumed		P.E.R.
						Grams		
				Lot 1.	Ration I <sup>2/</sup>			
F	1	42	153	111	3.96	50.9	2.18	----
F	2	63	160	97	3.46	50.6	1.92	----
M	3	68	199	131	4.68	53.7	2.44	----
M	4	54	156	102	3.64	62.3	1.64	----
F	5	52	171	119	4.25	57.7	2.06	----
M	6	70	211	141	5.04	62.1	2.27	----
Average		58.2	175.0	116.8	4.17	56.2	2.09	----
				Lot 2.	Ration II + 0.4% L-lysine HCl and 0.3% D-L Methionine <sup>3/</sup>			
F	7	47	154	107	3.82	56.4	1.90	2.28
M	8	68	202	134	4.79	66.4	2.02	2.42
F	9	64	171	107	3.82	60.5	1.77	2.12
F	10	52	186	134	4.79	62.1	2.16	2.59
M	11	49	148	99	3.54	59.3	1.67	2.00
M	12	65	156	91	3.25	57.8	1.57	1.88
Average		57.5	169.5	112.0	4.00	60.4	1.85	2.22
				Lot 3.	Ration II + 0.4% L-lysine HCl and 0.4% D-L Methionine			
F	13	45	147	102	3.64	53.6	1.90	2.28
M	14	67	195	128	4.57	66.8	1.92	2.30
F	15	63	163	100	3.57	57.8	1.73	2.08
M	16	55	162	107	3.82	62.1	1.72	2.06
M	17	51	153	102	3.64	55.3	1.84	2.21
F	18	73	203	130	4.64	69.8	1.86	2.23
Average		59.0	170.5	111.5	3.98	60.9	1.83	2.20
				Lot 4.	Ration II + 0.4% L-lysine HCl and 0.5% D-L Methionine			
M	19	48	200	152	5.43	66.2	2.30	2.76
F	20	64	178	114	4.07	62.7	1.82	2.18
F	21	45	159	114	4.07	58.6	1.95	2.34
F	22	57	197	140	5.00	69.0	2.03	2.44
M	23	51	139	88	3.14	51.4	1.71	2.05
M	24	70	159	89	3.18	62.4	1.43	1.72
Average		55.8	172.0	116.1	4.15	61.7	1.87	2.24

APPENDIX TABLE III. (CONTINUED)

Sex	Rat No.	Initial Weight Grams	Final Weight Grams	Total Gain Grams	Average Daily Gain Grams	Protein Consumed Grams	P.E.R.	Corrected P.E.R.
<u>Lot 5. Ration II + 0.4% L-lysine HCl and 0.6% D-L Methionine</u>								
M	25	44	176	132	4.71	61.9	2.13	2.56
F	26	67	178	111	3.96	62.6	1.77	2.12
F	27	66	173	107	3.82	59.4	1.80	2.16
F	28*	--	---	---	----	----	----	----
M	29	49	147	98	3.50	54.2	1.81	2.17
M	30	73	160	87	3.11	51.4	1.69	2.03
Average		59.8	166.8	107.0	3.82	57.9	1.84	2.21
<u>Lot 6. Ration II + 0.6% L-lysine HCl and 0.3% D-L Methionine</u>								
F	31	45	151	106	3.79	54.4	1.95	2.34
M	32	71	214	143	5.11	72.0	1.99	2.39
F	33	64	177	113	4.04	62.1	1.82	2.18
M	34	49	155	106	3.79	51.2	2.07	2.48
F	35	57	186	129	4.61	61.9	2.08	2.50
M	36	72	173	101	3.61	67.0	1.51	1.81
Average		59.7	176.0	116.3	4.16	61.4	1.90	2.28
<u>Lot 7. Ration II + 0.6% L-lysine HCl and 0.4% D-L Methionine</u>								
M	37	51	196	145	5.18	60.7	2.39	2.87
F	38	58	148	90	3.21	51.2	1.76	2.11
F	39	50	148	98	3.50	56.4	1.74	2.09
F	40	57	190	133	4.75	62.1	2.14	2.57
M	41	50	141	91	3.25	60.0	1.52	1.82
M	42	69	162	93	3.33	56.9	1.63	1.96
Average		55.8	164.3	108.3	3.87	57.9	1.86	2.23
<u>Lot 8. Ration II + 0.6% L-lysine HCl and 0.5% D-L Methionine</u>								
F	43	49	149	100	3.57	55.6	1.80	2.16
M	44	72	220	148	5.29	71.9	2.06	2.47
F	45	45	153	108	3.86	55.5	1.95	2.34
M	46	54	165	111	3.96	68.4	1.62	1.94
M	47	52	145	93	3.32	54.5	1.71	2.05
F	48	74	196	122	4.36	65.9	1.85	2.22
Average		57.7	171.3	113.7	4.06	61.9	1.83	2.20

APPENDIX TABLE III. (CONTINUED)

Sex	Rat No.	Initial Weight Grams	Final Weight Grams	Total Gain Grams	Average Daily Gain Grams	Protein Consumed Grams	P.E.R.	Corrected P.E.R.
<u>Lot 9. Ration II + 0.6% L-lysine HCl and 0.6% D-L Methionine</u>								
M	49	48	168	120	4.29	62.1	1.93	2.32
F	50	56	140	84	3.00	49.9	1.68	2.02
F	51	48	156	108	3.86	56.2	1.92	2.30
M	52	48	150	102	3.64	60.7	1.68	2.02
M	53	50	150	100	3.57	59.3	1.69	2.03
F	54	75	192	117	4.18	63.7	1.85	2.22
Average		54.1	159.3	105.1	3.76	58.7	1.79	2.15

1/ Experimental period 28 days. Protein of ration 15.9%.

2/ A.N.R.C. reference casein.

3/ 17.0 percent protein barley.

\* Rat removed from experiment due to sickness.

APPENDIX TABLE IV. SWINE EXPERIMENT I. INDIVIDUAL PERFORMANCE DATA ---  
GROWING PHASE.

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 1. Ration 187 -- Basal</u>								
M	1-3-9	86	148	62	28	2.21		
M	1-1-6	65	119	54	28	1.93		
F	1-5-1	73	125	52	28	1.86		
F	2-4-7	70	130	60	28	2.14		
F	2-8-3	69	130	61	28	2.18		
F	3-3-1	75	120	45	28	1.61		
M	3-1-8	72	130	58	28	2.07		
M	3-2-5	52	110	58	28	2.07		
	Average	--	---	56.3	28	2.01	152.5	2.71
<u>Lot 2. Ration 188 -- Basal + 0.1% L-lysine</u>								
M	1-9-3	79	135	56	28	2.00		
M	1-1-10	72	138	66	28	2.36		
F	1-1-1	79	131	52	28	1.86		
F	2-4-6	69	112	43	28	1.54		
F	2-3-2	70	121	51	28	1.82		
F	3-1-1	74	108	34	28	1.21		
M	3-2-4	69	131	62	28	2.21		
M	3-1-9	65	119	54	28	1.93		
	Average	--	---	52.3	28	1.87	141.8	2.71
<u>Lot 3. Ration 189 -- Basal + 0.2% L-lysine 1/</u>								
M	1-5-6	75	138	63	28	2.25		
M	1-6-6	66	123	57	28	2.04		
F	1-1-4	88	150	62	28	2.21		
F	2-7-7	71	123	52	28	1.86		
F	2-5-2	66	123	57	28	2.04		
F	3-3-7	75	145	70	28	2.50		
M	3-6-3	67	127	60	28	2.14		
M	3-1-10	66	125	59	28	2.11		
	Average	--	---	60.0	28	2.14	161.1	2.69

APPENDIX TABLE IV. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 4. Ration 190 -- Basal + 0.3% L-lysine <sup>1/</sup></u>								
M	1-3-5	76	139	63	28	2.25		
M	1-14-4	71	137	66	28	2.36		
F	1-3-1	80	137	57	28	2.04		
F	2-3-5	72	127	55	28	1.96		
F	2-2-3	72	122	50	28	1.79		
F	3-3-2	81	142	61	28	2.18		
M	3-7-5	71	131	60	28	2.14		
M	3-1-5	52	106	54	28	1.93		
Average		--	---	58.3	28	2.08	149.4	2.56
<u>Lot 5. Ration 191 -- Basal</u>								
M	1-6-5	60	115	55	28	1.96		
M	1-8-7	70	125	55	28	1.96		
F	1-5-2	78	136	58	28	2.07		
F	2-1-3	74	132	58	28	2.07		
F	2-5-3	63	109	46	28	1.64		
F	3-7-2	74	123	49	28	1.75		
M	3-7-4	79	140	61	28	2.30		
M	3-2-6	54	116	62	28	2.21		
Average		--	---	55.5	28	1.98	144.8	2.61
<u>Lot 6. Ration 192 -- Basal + 0.1% L-lysine <sup>2/</sup></u>								
M	1-1-7	73	133	60	28	2.14		
M	1-14-10	65	123	58	28	2.07		
F	1-1-3	76	117	41	28	1.46		
F	2-1-4	69	121	52	28	1.86		
F	2-2-4	67	111	44	28	1.57		
F	3-7-1	76	115	39	28	1.39		
M	3-2-7	66	129	63	28	2.25		
M	3-7-3	64	110	46	28	1.64		
Average		--	---	50.4	28	1.80	131.3	2.61

APPENDIX TABLE IV. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 7. Ration 193 -- Basal + 0.2% L-lysine <sup>2/</sup></u>								
M	1-2-6	90	165	75	28	2.68		
M	1-12-3	71	131	60	28	2.14		
F	1-3-4	84	139	55	28	1.96		
F	2-2-2	82	128	46	28	1.64		
F	2-8-1	67	131	64	28	2.29		
F	3-1-2	67	122	55	28	1.96		
M	3-6-6	63	118	55	28	1.96		
M	3-2-9	64	116	54	28	1.93		
Average		--	---	58.0	28	2.07	148.1	2.56

<u>Lot 8. Ration 194 -- Basal + 0.3% L-lysine <sup>2/</sup></u>								
M	1-1-8	76	132	56	28	2.00		
M	1-3-6	74	127	53	28	1.89		
F	1-6-1	78	128	50	28	1.79		
F	2-3-3	80	138	58	28	2.07		
F	2-4-4	68	116	48	28	1.71		
F	3-3-6	81	139	58	28	2.07		
M	3-6-7	65	122	57	28	2.04		
M	3-1-7	59	115	56	28	2.00		
Average		--	---	54.5	28	1.95	144.1	2.64

1/ From L-lysine HCl.

2/ From lysamine

APPENDIX TABLE V. SWINE EXPERIMENT I. INDIVIDUAL PERFORMANCE DATA --  
FATTENING PHASE.

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 1. Ration 197 -- Basal</u>								
M	1-3-9	148	212	64	28	2.29		
M	1-1-6	119	200	81	35	2.31		
F	1-5-1	125	202	77	35	2.20		
F	2-4-7	130	213	83	42	1.98		
F	2-8-3	130	202	72	35	2.06		
F	3-3-1	120	201	81	35	2.31		
M	3-1-8	130	200	70	28	2.50		
M	3-2-5	110	202	92	42	2.19		
Average		---	---	77.5	35.0	2.22	276.88	3.53
<u>Lot 2. Ration 198 -- Basal 0.1% L-lysine <math>\frac{1}{2}</math></u>								
M	1-9-3	135	208	73	35	2.09		
M	1-1-10	138	212	74	28	2.64		
F	1-1-1	131	208	77	42	1.83		
F	2-4-6	112	200	88	56	1.57		
F	2-3-2	121	204	83	42	1.98		
F	3-1-1	108	184	76	56	1.36		
M	3-2-4	131	214	83	35	2.37		
M	3-1-9	119	213	94	42	2.24		
Average		---	---	81.0	42.0	1.93	300.38	3.71
<u>Lot 3. Ration 199 -- Basal + 0.2% L-lysine <math>\frac{1}{2}</math></u>								
M	1-5-6	138	200	62	28	2.21		
M	1-6-6	123	208	85	42	2.02		
F	1-1-4	150	202	52	21	2.48		
F	2-7-7	123	209	86	42	2.05		
F	2-5-2	123	207	84	35	2.40		
F	3-3-7	145	220	75	28	2.68		
M	3-6-3	127	214	87	35	2.49		
M	3-1-10	125	206	81	35	2.31		
Average		---	---	76.5	33.3	2.30	266.88	3.49

APPENDIX TABLE V. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 4. Ration 200 -- Basal + 0.3% L-lysine <sup>1/</sup></u>								
M	1-3-5	139	202	63	28	2.25		
M	1-14-4	137	206	69	28	2.46		
F	1-3-1	137	201	64	28	2.29		
F	2-3-5	127	209	82	35	2.34		
F	2-2-3	122	208	86	42	2.05		
F	3-3-2	142	217	75	35	2.14		
M	3-7-5	131	214	83	35	2.37		
M	3-1-5	106	212	106	42	2.52		
	Average	---	---	78.5	34.1	2.31	268.00	3.41
<u>Lot 5. Ration 201 -- Basal</u>								
M	1-6-5	115	213	98	49	2.00		
M	1-8-7	125	208	83	35	2.37		
F	1-5-2	136	208	72	35	2.06		
F	2-1-3	132	207	75	35	2.14		
F	2-5-3	109	179	70	49	1.43		
F	3-7-2	123	202	79	35	2.26		
M	3-7-4	140	214	74	28	2.64		
M	3-2-6	116	201	85	35	2.43		
	Average	---	---	79.5	37.6	2.11	302.75	3.81
<u>Lot 6. Ration 202 -- Basal + 0.1% L-lysine <sup>2/</sup></u>								
M	1-1-7	133	203	70	28	2.50		
M	1-14-10	123	211	88	35	2.51		
F	1-1-3	117	206	89	49	1.82		
F	2-1-4	121	206	85	42	2.02		
F	2-2-4	111	207	96	49	1.96		
F	3-7-1	115	214	99	49	2.02		
M	3-2-7	129	220	91	35	2.60		
M	3-7-3	110	212	102	42	2.43		
	Average	---	---	90.0	41.1	2.19	329.13	3.66



APPENDIX TABLE V. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 7. Ration 203 -- Basal + 0.2% L-lysine <sup>2/</sup></u>								
M	1-2-6	165	216	51	21	2.43		
M	1-12-3	131	211	80	35	2.29		
F	1-3-4	139	202	63	35	1.80		
F	2-2-2	128	204	76	42	1.81		
F	2-8-1	131	200	69	35	1.97		
F	3-1-2	122	203	81	42	1.93		
M	3-6-6	118	203	85	42	2.02		
M	3-2-9	116	202	86	42	2.05		
Average		---	---	73.9	36.8	2.01	300.00	4.06

<u>Lot 8. Ration 204 -- Basal + 0.3% L-lysine <sup>2/</sup></u>								
M	1-1-8	132	212	80	35	2.29		
M	1-3-6	127	205	78	35	2.23		
F	1-6-1	128	213	85	42	2.02		
F	2-3-3	138	210	72	28	2.57		
F	2-4-4	116	201	85	42	2.02		
F	3-3-6	139	205	66	28	2.36		
M	3-6-7	122	209	87	42	2.07		
M	3-1-7	115	200	85	35	2.43		
Average		---	---	79.8	35.9	2.22	285.25	3.58

<sup>1/</sup> From L-lysine HCl.

<sup>2/</sup> From lysamine.

APPENDIX TABLE VI. SWINE EXPERIMENT I. INDIVIDUAL PERFORMANCE DATA -- SUMMARY.

Sex	Pit No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 1. Ration -- Basal</u>								
M	1-3-9	86	212	126	56	2.25		
M	1-1-6	65	200	135	63	2.14		
F	1-5-1	73	202	129	63	2.05		
F	2-4-7	70	213	143	70	2.07		
F	2-8-3	69	202	133	63	2.11		
F	3-3-1	75	201	126	63	2.00		
M	3-1-8	72	200	128	56	2.29		
M	3-2-5	52	202	150	70	2.14		
	Average	--	---	133.8	63.0	2.12	429.38	3.19
<u>Lot 2. Ration -- Basal + 0.1% L-lysine <sup>1/</sup></u>								
M	1-9-3	79	208	129	63	2.05		
M	1-1-10	72	212	140	56	2.50		
F	1-1-1	79	208	129	70	1.84		
F	2-4-6	69	200	131	84	1.56		
F	2-3-2	70	204	134	70	1.91		
F	3-1-1	74	184	110	84	1.31		
M	3-2-4	69	214	145	63	2.30		
M	3-1-9	65	213	148	70	2.11		
	Average	--	---	133.2	70	1.90	442.13	3.32
<u>Lot 3. Ration -- Basal + 0.2% L-lysine <sup>1/</sup></u>								
M	1-5-6	75	200	125	56	2.23		
M	1-6-6	66	208	142	70	2.03		
F	1-1-4	88	202	114	49	2.33		
F	2-7-7	71	209	138	70	1.97		
F	2-5-2	66	207	141	63	2.24		
F	3-3-7	75	220	145	56	2.59		
M	3-6-3	67	214	147	63	2.33		
M	3-1-10	66	206	140	63	2.22		
	Average	--	---	136.5	61.3	2.23	428.00	3.14

APPENDIX TABLE VI. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 4. Ration -- Basal + 0.3% L-lysine <sup>1/</sup></u>								
M	1-3-5	76	202	126	56	2.25		
M	1-14-4	71	206	135	56	2.41		
F	1-3-1	80	201	121	56	2.16		
F	2-3-5	72	209	137	63	2.17		
F	2-2-3	72	208	136	70	1.94		
F	3-3-2	81	217	136	63	2.16		
M	3-7-5	71	214	143	63	2.27		
M	3-1-5	52	212	160	70	2.29		
	Average	--	---	136.7	62.1	2.20	417.38	3.05
<u>Lot 5. Ration -- Basal</u>								
M	1-6-5	60	213	153	77	1.99		
M	1-8-7	70	208	138	63	2.19		
F	1-5-2	78	208	130	63	2.06		
F	2-1-3	74	207	133	63	2.11		
F	2-5-3	63	179	116	77	1.51		
F	3-7-2	74	202	128	63	2.03		
M	3-7-4	79	214	135	56	2.41		
M	3-2-6	54	201	147	63	2.33		
	Average	--	---	135.0	65.6	2.06	447.50	3.31
<u>Lot 6. Ration -- Basal + 0.1% L-lysine <sup>2/</sup></u>								
M	1-1-7	73	203	130	56	2.32		
M	1-14-10	65	211	146	63	2.32		
F	1-1-3	76	206	130	77	1.69		
F	2-1-4	69	206	137	70	1.96		
F	2-2-4	67	207	140	77	1.82		
F	3-7-1	76	214	138	77	1.79		
M	3-2-7	66	220	154	63	2.44		
M	3-7-3	64	212	148	70	2.11		
	Average	--	---	140.3	69.1	2.03	460.38	3.28

APPENDIX TABLE VI. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 7. Ration -- Basal + 0.2% L-lysine <sup>1/</sup></u>								
M	1-2-6	90	216	126	49	2.57		
M	1-12-3	71	211	140	63	2.22		
F	1-3-4	84	202	118	63	1.87		
F	2-2-2	82	204	122	70	1.74		
F	2-8-1	67	200	133	63	2.11		
F	3-1-2	67	203	136	70	1.94		
M	3-6-6	63	203	140	70	2.00		
M	3-2-9	64	202	138	70	1.97		
Average		--	---	132.0	64.8	2.03	448.13	3.40
<u>Lot 8. Ration -- Basal + 0.3% L-lysine <sup>1/</sup></u>								
M	1-1-8	76	212	136	63	2.16		
M	1-3-6	74	205	131	63	2.08		
F	1-6-1	78	213	135	70	1.93		
F	2-3-3	80	210	130	56	2.32		
F	2-4-4	68	201	133	70	1.90		
F	3-3-6	81	205	124	56	2.21		
M	3-6-7	65	209	144	70	2.06		
M	3-1-7	59	200	141	63	2.24		
Average		--	---	134.2	63.9	2.10	429.38	3.20

<sup>1/</sup> From L-lysine HCl.

<sup>2/</sup> From lysamine.

APPENDIX TABLE VII. SWINE EXPERIMENT I. INDIVIDUAL CARCASS DATA.

Pig No.	Shrunk Weight	Av. Backfat Probe Live	Specific Gravity	Chilled Total Wt.	Backfat Measurement	Length of Carcass	Ham	Belly	Picnic Shoulder	Loin	Butt	Fat	Lean Trim	Loin Area
<u>Lot 1. Ration -- Basal</u>														
1-3-9	198	1.6	1.0416	139.5	1.5	31.5	24.00	16.00	14.75	22.25	6.00	38.50	9.00	2.29
1-1-6	186	1.9	1.0348	137.0	1.7	28.8	21.50	18.50	12.75	19.50	5.75	39.75	8.75	2.55
2-4-7	197	1.5	1.0418	148.5	1.6	30.3	26.00	17.75	14.50	21.25	6.50	40.00	10.50	2.81
2-8-3	188	1.3	1.0461	139.0	1.5	31.1	26.00	15.00	15.00	20.50	7.00	35.20	9.00	2.59
3-3-1	185	1.6	1.0325	138.0	1.7	30.8	22.20	17.10	13.80	19.20	6.00	40.50	7.50	2.60
3-1-8	181	1.3	1.0481	128.5	1.4	31.4	23.75	15.00	14.50	20.50	8.25	27.00	7.75	2.87
Average		1.5	1.0408	138.4	1.6	30.6	23.91	16.56	14.22	20.53	6.58	36.83	8.75	2.62
<u>Lot 2. Ration -- Basal + 0.1% L-lysine <math>\frac{1}{2}</math></u>														
1-9-3	188	1.8	1.0427	137.0	1.5	31.1	23.25	17.25	14.00	21.75	6.00	35.00	9.50	2.86
1-1-10	192	1.6	1.0347	142.0	1.7	29.2	23.00	18.00	13.50	18.75	6.00	43.50	8.75	2.36
2-4-6	198	1.1	1.0542	145.0	1.2	30.0	30.00	14.00	16.25	26.25	8.25	28.25	10.00	3.20
2-3-2	193	1.7	1.0395	145.0	1.7	30.2	24.25	17.75	15.25	21.10	7.50	40.00	9.25	2.67
3-1-1	182	1.2	1.0552	132.5	1.2	30.5	27.00	13.00	15.50	24.75	7.00	24.50	9.25	3.83
3-2-4	194	1.8	1.0327	144.5	1.9	29.0	22.00	19.25	13.75	19.25	6.50	45.00	8.50	2.51
Average		1.5	1.0432	141.0	1.5	30.0	24.92	16.54	14.71	21.98	6.88	36.04	9.21	2.91

APPENDIX TABLE VII. (CONTINUED)

Pig No.	Shrunk Weight	Av. Backfat Probe Live	Specific Gravity	Chilled Total Wt.	Backfat Measurement	Length of Carcass	Ham	Belly	Picnic Shoulder	Loin	Butt	Fat	Lean Trim	Loin Area
<u>Lot 3. Ration -- Basal + 0.2% L-lysine <math>\frac{1}{1}</math></u>														
1-5-6	190	1.7	1.0425	139.0	1.6	31.8	24.50	16.25	14.00	21.00	5.50	37.75	8.50	2.32
1-6-6	195	1.5	1.0399	148.5	1.6	30.0	26.25	16.75	16.75	22.50	7.00	36.50	10.75	3.04
2-7-7	198	1.4	1.0472	144.5	1.8	30.0	26.50	16.75	15.75	22.00	7.25	34.75	10.00	3.38
2-5-2	190	1.4	1.0389	142.0	1.5	29.6	24.50	17.00	14.00	21.00	6.25	40.75	8.50	2.83
3-3-7	196	1.7	1.0367	146.5	1.9	30.3	23.25	18.75	14.00	22.50	7.25	41.25	8.00	2.84
3-6-3	191	1.9	1.0393	142.0	1.7	30.7	24.50	18.00	14.00	21.00	6.00	37.75	9.50	2.96
Average		1.6	1.0407	143.8	1.7	30.4	24.92	17.25	14.75	21.67	6.54	38.13	9.21	3.06
<u>Lot 4. Ration -- Basal + 0.3% L-lysine <math>\frac{1}{1}</math></u>														
1-3-5	185	1.8	1.0434	136.0	1.7	30.0	22.75	16.50	13.25	19.75	6.75	37.25	8.75	2.69
1-14-4	190	1.6	1.0359	139.5	1.7	31.0	22.25	18.25	14.25	21.75	6.75	38.50	8.00	2.73
2-3-5	189	1.6	1.0389	143.5	1.7	29.6	23.50	17.00	14.25	22.00	7.00	30.50	8.75	3.13
2-2-3	196	1.3	1.0498	145.5	1.4	30.4	29.00	17.10	15.60	23.60	7.60	31.10	10.10	3.58
3-3-2	200	1.4	1.0427	147.0	1.5	32.1	25.00	18.10	15.10	23.25	7.25	37.50	8.00	3.05
3-7-5	196	1.8	1.0328	148.0	1.8	29.7	23.50	19.50	14.50	21.25	6.75	43.00	8.00	2.68
Average		1.6	1.0406	143.2	1.6	30.5	24.33	17.74	14.49	21.93	7.02	36.31	8.60	2.98

APPENDIX TABLE VII. (CONTINUED)

Pig No.	Shrunk Weight	Av. Backfat Probe Live	Specific Gravity	Chilled Total Wt.	Backfat Measurement	Length of Carcass	Ham	Belly	Picnic Shoulder	Loin	Butt	Fat	Lean Trim	Loin Area
<u>Lot 5. Ration -- Basal</u>														
1-6-5	197	1.4	1.0444	145.0	1.5	31.8	26.50	17.00	15.50	24.25	7.25	34.70	9.75	2.72
1-8-7	192	1.7	1.0355	144.5	1.8	29.5	23.75	18.00	14.10	19.40	6.60	43.25	8.10	2.77
2-1-3	192	1.6	1.0458	138.0	1.8	30.8	24.60	15.25	14.50	20.25	7.25	35.25	9.25	2.75
2-5-3	165	1.2	1.0519	118.0	1.4	31.2	23.25	13.00	12.50	20.25	6.25	23.75	9.25	2.58
3-7-2	187	1.5	1.0379	138.5	1.6	29.6	23.00	17.25	13.75	20.00	6.25	39.25	8.25	3.13
3-7-4	197	1.6	1.0396	133.5	1.8	29.7	24.00	17.25	13.75	19.00	6.00	37.50	7.50	2.62
Average		1.5	1.0425	136.3	1.6	30.4	24.18	16.29	14.02	20.53	6.60	35.62	8.68	2.76
<u>Lot 6. Ration -- Basal + 0.1% L-lysine <sup>2/</sup></u>														
1-1-7	184	1.8	1.0367	136.0	1.6	29.5	21.50	15.75	13.00	20.25	6.50	39.25	9.25	2.66
1-14-10	193	1.6	1.0407	143.0	1.7	31.0	23.75	18.00	14.10	21.20	7.30	39.00	8.50	3.17
2-1-4	191	1.1	1.0523	138.5	1.5	31.5	25.75	15.50	15.50	22.25	7.25	30.75	9.50	3.02
2-2-4	195	1.3	1.0488	144.0	1.5	31.7	26.50	16.25	16.00	24.00	7.50	32.80	10.25	3.60
3-7-1	200	1.4	1.0446	150.0	1.7	30.9	26.50	17.00	15.50	25.25	7.50	37.50	9.00	3.53
3-2-7	200	1.7	1.0305	147.5	1.9	29.8	23.40	19.90	14.50	19.80	6.20	45.00	9.80	2.83
Average		1.5	1.0416	143.2	1.6	30.7	24.57	17.07	14.77	22.13	7.04	37.38	9.38	3.14

APPENDIX TABLE VII. (CONTINUED)

Pig No.	Shrunk Weight	Av. Backfat Probe Live	Specific Gravity	Chilled Total Wt.	Backfat Measurement	Length of Carcass	Ham	Belly	Picnic Shoulder	Loin	Butt	Fat	Lean Trim	Loin Area
<u>Lot 7. Ration -- Basal + 0.2% L-lysine <sup>2/</sup></u>														
1-2-6	205	1.7	1.0379	140.2	1.8	30.6	22.85	17.20	14.80	20.30	7.50	40.25	8.75	2.85
1-12-3	195	1.4	1.0421	142.0	1.6	31.8	25.50	16.75	13.75	22.50	6.50	37.00	9.75	2.47
2-2-2	190	1.0	1.0580	137.5	1.0	31.0	28.00	14.75	16.25	24.00	8.00	24.25	9.50	3.36
2-8-1	183	1.2	1.0510	134.0	1.4	30.7	25.00	15.50	15.00	21.00	7.00	29.50	8.50	3.07
3-1-2	187	1.2	1.0527	136.0	1.4	31.8	26.00	15.50	14.75	23.50	7.50	27.50	10.00	3.48
3-6-6	188	1.5	1.0457	137.0	1.4	30.4	23.40	16.90	13.00	20.60	6.50	35.40	9.25	2.74
Average		1.4	1.0474	137.8	1.4	31.1	25.13	16.10	14.59	21.98	7.17	32.32	9.29	3.00
<u>Lot 8. Ration -- Basal + 0.3% L-lysine <sup>2/</sup></u>														
1-1-8	194	2.0	1.0252	147.0	2.0	28.5	22.60	20.00	13.40	18.00	5.80	50.30	7.00	2.38
1-3-6	189	1.5	1.0343	138.0	1.4	30.6	22.75	17.25	13.50	21.50	6.75	37.25	8.75	2.37
2-3-3	194	1.3	1.0367	143.2	1.9	30.1	23.25	18.00	15.50	20.75	7.25	40.25	8.75	2.78
2-4-4	188	1.4	1.0526	141.5	1.6	29.9	26.26	16.50	14.75	22.50	7.25	33.50	9.25	3.02
3-3-6	184	1.5	1.0440	134.0	1.6	31.8	22.75	15.50	13.50	21.75	7.50	31.50	9.00	3.08
3-1-7	182	1.4	1.0476	131.5	1.7	29.3	25.00	14.75	15.00	21.00	7.25	29.25	9.25	3.27
Average		1.5	1.0400	139.1	1.7	30.0	23.77	17.00	14.28	20.92	6.97	37.01	8.67	2.82
Average Males			1.0387		1.7		23.55	17.42	14.10	20.71	6.56	38.65	8.81	2.70
Average Females			1.0458		1.5		25.34	16.22	14.85	22.20	7.14	29.55	9.14	3.08

<sup>1/</sup> From L-lysine HCl.

<sup>2/</sup> From lysamine.



APPENDIX TABLE VIII. SWINE EXPERIMENT II. INDIVIDUAL PERFORMANCE DATA -- GROWING PHASE.

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 1. Ration 211 -- Basal</u>								
M	10-9	62	129	67	35	1.91		
M	10-12	58	118	60	35	1.71		
F	6-1	76	143	67	35	1.91		
F	7-6	67	114	47	35	1.34		
F	12-2	55	125	70	35	2.00		
Average		63.6	125.8	62.2	35	1.78	212.0	3.41
<u>Lot 2. Ration 212 -- Basal + 0.25% Lyamine <sup>1/</sup></u>								
M	10-5	58	124	66	35	1.89		
M	10-10	44	102	58	35	1.66		
F	3-7	74	151	77	35	2.20		
F	7-2	65	130	65	35	1.86		
F	11-5	50	112	62	35	1.77		
Average		58.2	123.8	65.6	35	1.87	198.0	3.02
<u>Lot 3. Ration 213 -- Basal + 0.50% Lyamine <sup>1/</sup></u>								
M	12-7	61	132	71	35	2.03		
M	11-10	45	105	60	35	1.71		
F	5-3	72	141	69	35	1.97		
F	7-5	65	128	63	35	1.80		
F	11-6	54	118	64	35	1.83		
Average		59.4	124.8	65.4	35	1.87	214.0	3.27
<u>Lot 4. Ration 214 -- Basal + 0.75% Lyamine <sup>1/</sup></u>								
M	10-6	66	134	68	35	1.94		
M	11-7	50	115	65	35	1.86		
F	7-1	73	141	68	35	1.94		
F	7-4	69	134	65	35	1.86		
F	10-2	57	125	68	35	1.94		
Average		63.0	129.8	66.8	35	1.91	204.8	3.07

APPENDIX TABLE VIII. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 5. Ration 219 -- Basal <sup>2/</sup></u>								
M	12-5	57	120	63	35	1.80		
M	10-7	57	116	59	35	1.69		
F	7-7	70	137	67	35	1.91		
F	7-8	70	131	61	35	1.74		
F	10-1	61	113	52	35	1.49		
Average		63.0	123.4	60.4	35	1.73	202.0	3.34
<u>Lot 6. Ration 220 -- Basal + 0.25% Lyamine <sup>2/</sup></u>								
M	7-12	63	128	65	35	1.86		
M	12-3	51	115	64	35	1.83		
F	2-2	73	136	63	35	1.80		
F	7-3	69	123	54	35	1.54		
F	12-1	61	129	68	35	1.94		
Average		63.4	126.2	62.8	35	1.79	210.8	3.36
<u>Lot 7. Ration 221 -- Basal + 0.50% Lyamine <sup>2/</sup></u>								
M	12-4	63	136	73	35	2.09		
M	10-4	47	112	65	35	1.86		
F	5-4	76	141	65	35	1.86		
F	6-5	59	114	55	35	1.57		
F	11-3	50	103	53	35	1.51		
Average		59.0	121.2	62.2	35	1.78	200.0	3.22
<u>Lot 8. Ration 222 -- Basal + 0.75% Lyamine <sup>2/</sup></u>								
M	10-8	58	118	60	35	1.71		
M	12-6	54	99	45	35	1.29		
F	4-1	74	145	71	35	2.03		
F	2-1	70	131	61	35	1.74		
F	10-3	62	134	72	35	2.06		
Average		63.6	125.4	61.8	35	1.77	200.8	3.25

<sup>1/</sup> 13.3 percent protein Betzes barley.

<sup>2/</sup> 17.0 percent protein Betzes barley.

APPENDIX TABLE IX. SWINE EXPERIMENT II. INDIVIDUAL PERFORMANCE DATA -- FINISHING PHASE.

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 1. Ration 215 -- Basal <math>\frac{1}{2}</math></u>								
M	10-9	129	204	75	28	2.68		
M	10-12	118	205	87	35	2.49		
F	6-1	143	203	60	21	2.86		
F	7-6	114	197	83	35	2.37		
F	12-2	125	208	83	35	2.37		
Average		125.8	203.4	77.6	30.8	2.52	276.0	3.56
<u>Lot 2. Ration 216 -- Basal + 0.25% Lyamine <math>\frac{1}{2}</math></u>								
M	10-5	124	202	78	35	2.23		
M	10-10	102	207	105	42	2.50		
F	3-7	151	212	61	21	2.90		
F	7-2	130	202	72	28	2.57		
F	11-5	112	203	91	42	2.17		
Average		123.8	205.2	81.4	33.6	2.42	282.2	3.47
<u>Lot 3. Ration 217 -- Basal + 0.50% Lyamine <math>\frac{1}{2}</math></u>								
M	12-7	132	222	90	28	3.21		
M	11-10	105	190	85	35	2.43		
F	5-3	141	203	62	21	2.95		
F	7-5	128	217	89	35	2.54		
F	11-6	118	217	99	35	2.83		
Average		124.8	209.8	85.0	30.8	2.76	292.0	3.44
<u>Lot 4. Ration 218 -- Basal + 0.75% Lyamine <math>\frac{1}{2}</math></u>								
M	10-6	134	206	72	28	2.57		
M	11-7	115	194	79	35	2.26		
F	7-1	141	217	76	28	2.71		
F	7-4	134	205	71	28	2.53		
F	10-2	125	201	76	35	2.17		
Average		129.8	204.6	74.8	30.8	2.43	261.0	3.49

APPENDIX TABLE IX. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency
<u>Lot 5. Ration 223 -- Basal <sup>2/</sup></u>								
M	12-5	120	206	86	35	2.46		
M	10-7	116	208	92	42	2.19		
F	7-7	137	205	68	28	2.42		
F	7-8	131	212	81	35	2.31		
F	10-1	113	200	87	42	2.07		
Average		123.4	206.2	82.8	36.4	2.27	303.6	3.67
<u>Lot 6. Ration 224 -- Basal + 0.25% Lyamine <sup>2/</sup></u>								
M	7-12	128	209	81	35	2.31		
M	12-3	115	203	88	35	2.51		
F	2-2	136	212	76	35	2.17		
F	7-3	123	186	63	35	1.80		
F	12-1	129	204	75	28	2.67		
Average		126.2	202.8	76.6	33.6	2.28	287.6	3.75
<u>Lot 7. Ration 225 -- Basal + 0.50% Lyamine <sup>2/</sup></u>								
M	12-4	136	215	79	28	2.82		
M	10-4	112	215	103	42	2.45		
F	5-4	141	200	59	28	2.10		
F	6-5	114	206	92	49	1.87		
F	11-3	103	204	101	49	2.06		
Average		121.2	208.0	86.8	39.2	2.21	307.0	3.54
<u>Lot 8. Ration 226 -- Basal + 0.75% Lyamine <sup>2/</sup></u>								
M	10-8	118	210	92	42	2.19		
M	12-6	99	181	82	42	1.95		
F	4-1	145	207	62	28	2.21		
F	2-1	131	204	73	35	2.08		
F	10-3	134	206	72	28	2.57		
Average		125.4	201.6	76.2	35	2.18	264.0	3.46

<sup>1/</sup> 13.3 percent protein Betzes barley.

<sup>2/</sup> 17.0 percent protein Betzes barley.

APPENDIX TABLE X. SWINE EXPERIMENT II. INDIVIDUAL PERFORMANCE DATA -- SUMMARY.

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency	Back-fat Probe
<u>Lot 1. Ration -- Basal <math>\frac{1}{2}</math></u>									
M	10-9	62	204	142	63	2.25			1.46
M	10-12	58	205	147	70	2.10			1.80
F	6-1	76	203	127	56	2.27			1.50
F	7-6	67	197	130	70	1.86			1.73
F	12-2	55	208	153	70	2.19			1.56
Average		63.6	203.4	139.8	66.0	2.12	488.0	3.49	1.61
<u>Lot 2. Ration -- Basal + 0.25% Lyamine <math>\frac{1}{2}</math></u>									
M	10-5	58	202	144	70	2.06			1.77
M	10-10	44	207	163	77	2.33			1.93
F	3-7	74	212	138	56	2.45			1.35
F	7-2	65	202	137	63	2.16			1.53
F	11-5	50	203	153	77	1.99			1.71
Average		58.2	205.2	147.0	68.6	2.14	480.2	3.27	1.66
<u>Lot 3. Ration -- Basal + 0.50% Lyamine <math>\frac{1}{2}</math></u>									
M	12-7	61	222	161	63	2.56			1.43
M	11-10	45	190	145	70	2.07			1.67
F	5-3	72	203	131	56	2.34			1.50
F	7-5	65	217	152	70	2.17			1.73
F	11-6	54	217	163	70	2.33			1.77
Average		59.4	209.8	150.4	65.8	2.29	506.0	3.36	1.62
<u>Lot 4. Ration -- Basal + 0.75% Lyamine <math>\frac{1}{2}</math></u>									
M	10-6	66	206	140	63	2.22			1.53
M	11-7	50	194	144	70	2.06			1.80
F	7-1	73	217	144	63	2.29			1.57
F	7-4	69	205	136	63	2.16			1.60
F	10-2	57	201	144	70	2.06			1.57
Average		63.0	204.6	141.6	65.8	2.15	465.8	3.29	1.61

APPENDIX TABLE X. (CONTINUED)

Sex	Pig No.	Initial Weight	Final Weight	Gain	Days	Average Daily Gain	Average Feed Consumption	Feed Efficiency	Back-fat Probe
<u>Lot 5. Ration -- Basal <sup>2/</sup></u>									
M	12-5	57	206	149	70	2.13			1.63
M	10-7	57	208	151	77	1.96			1.87
F	7-7	70	205	135	63	2.14			1.53
F	7-8	70	212	142	70	2.03			1.77
F	10-1	61	200	139	77	1.81			1.83
Average		63.0	206.2	143.2	71.4	2.01	505.6	3.53	1.73
<u>Lot 6. Ration -- Basal + 0.25% Lyamine <sup>2/</sup></u>									
M	7-12	63	209	146	70	2.09			1.73
M	12-3	51	203	152	70	2.17			1.47
F	2-2	73	212	139	70	1.99			1.73
F	7-3	69	186	117	70	1.67			1.67
F	12-1	61	204	143	63	2.27			1.40
Average		63.4	202.8	139.4	68.6	2.03	498.4	3.57	1.60
<u>Lot 7. Ration -- Basal + 0.50% Lyamine <sup>2/</sup></u>									
M	12-4	63	215	152	63	2.41			1.57
M	10-4	47	215	168	77	2.18			1.87
F	5-4	76	200	124	63	1.97			1.37
F	6-5	59	206	147	84	1.75			1.70
F	11-3	50	204	154	84	1.83			1.60
Average		59.0	207.8	148.8	74.2	2.03	507.0	3.41	1.62
<u>Lot 8. Ration -- Basal + 0.75% Lyamine <sup>2/</sup></u>									
M	10-8	58	210	152	77	1.97			1.80
M	12-6	54	181	127	77	1.65			1.37
F	4-1	74	207	133	63	2.11			1.43
F	2-1	70	204	134	70	1.91			1.67
F	10-3	62	206	144	63	2.29			1.63
Average		63.6	201.6	138.0	70.0	1.97	464.8	3.37	1.58

<sup>1/</sup> 13.3 percent protein Betzes barley.

<sup>2/</sup> 17.0 percent protein Betzes barley.

APPENDIX TABLE XI. ANALYSIS OF VARIANCE OF P.E.R. RAT TRIAL I.

Variation	df	ss	ms	F
Ration (R)	7	2.58	.37	18.50**
Sex (S)	1	0.01	.01	.50
R X S	7	0.22	.03	1.50
Error	32	0.81	.02	----
Total	47	3.62	---	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XII. COMPARISON OF RATIONS AS SHOWN BY DUNCAN'S MULTIPLE RANGE TEST. RAT TRIAL I.

Ration No.	V	I	II	VI	VIII	IV	III	VII
Mean	<u>1.37</u>	<u>1.41</u>	<u>1.50</u>	<u>1.53</u>	<u>1.89</u>	<u>1.90</u>	<u>1.91</u>	<u>1.92</u>

1/ Rations that are underlined are not significantly different from each other but are significantly different from the rations that are not underlined on the same line.

APPENDIX TABLE XIII. ANALYSIS OF VARIANCE OF P.E.R. RAT TRIAL II.

Variation	df	ss	ms	F
Ration (R)	3	0.54	.18	2.50
Sex (S)	1	0.53	.57	7.63*
R X S	3	0.37	.12	1.71
Error	12	0.86	.07	----
Total	19	2.30	---	----

\* Significant ( $P < 0.05$ ).

APPENDIX TABLE XIV. ANALYSIS OF VARIANCE OF P.E.R. RAT TRIAL III.

Variation	df	ss	ms	F
Lysine (L)	1	0.001	0.001	0.01
Methionine (M)	3	0.035	0.012	0.15
Sex (S)	1	0.060	0.060	0.76
L X S	1	0.029	0.029	0.37
L X M	3	0.034	0.011	0.14
M X S	3	0.072	0.024	0.30
L X M X S	3	0.035	0.012	0.15
Error	31	2.463	0.079	----
Total	47	2.699	-----	----

APPENDIX TABLE XV. SWINE TRIAL I. GROWING PHASE. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN.

	df	ss	ms	F
Source	1	0.085	0.085	1.74
Levels	3	0.630	0.210	4.31**
Source X Levels	3	0.029	0.009	0.20
Sex	1	0.780	0.780	16.03**
Sex X Source	1	0.007	0.007	0.15
Levels X Sex	3	0.387	0.129	2.65
Sex X Levels X Source	3	0.072	0.024	0.50
Error	48	2.337	0.049	----
Total	63	4.329	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XVI. COMPARISON OF AVERAGE DAILY GAIN AS SHOWN BY DUNCAN'S MULTIPLE RANGE TEST.

Levels of Lysine	0.1	0.0	0.3	0.2
Mean of A.D.G.	<u>1.83</u>	<u>2.00</u>	<u>2.01</u>	<u>2.11</u>
				<u>1</u> **
-----				
Levels of Lysine	0.1	0.0	0.3	0.2
Mean of A.D.G.	<u>1.83</u>	<u>2.00</u>	<u>2.01</u>	<u>2.11</u>
				<u>1</u> *

\* Significant ( $P < 0.05$ ).

\*\* Highly significant ( $P < 0.01$ ).

1/ Rations that are underlined are not significantly different from each other but are significantly different from the rations that are not underlined on the same line.



APPENDIX TABLE XVII. SWINE TRIAL I. FATTENING PHASE. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN.

Variation	df	ss	ms	F
Source	1	0.035	0.035	0.84
Levels	3	0.193	0.064	1.53
Sex	1	1.166	1.166	27.80**
Source X Levels	3	0.532	0.177	4.23
Sex X Source	1	0.038	0.038	0.91
Levels X Sex	3	0.687	0.229	5.46**
Sex X Levels X Source	3	0.264	0.087	2.08
Error	48	2.014	0.049	----
Total	63	4.928	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XVIII. SUMMARY SWINE TRIAL I. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN.

Variation	df	ss	ms	F
Source	1	0.052	0.052	1.60
Level	3	0.246	0.082	2.53
Sex	1	0.955	0.955	29.49**
Source X Levels	3	0.186	0.062	1.91
Sex X Source	1	0.016	0.016	0.50
Level X Sex	3	0.483	0.161	4.97**
Sex X Levels X Source	3	0.167	0.056	1.72
Error	42	1.553	0.032	----
Total	63	3.660	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XIX. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF BACKFAT PROBES. (LIVE).

Variation	df	ss	ms	F
Source	1	0.137	0.137	3.66
Levels	3	0.043	0.014	0.38
Sex	1	0.919	0.919	2.46
Source X Levels	3	0.103	0.034	0.92
Sex X Source	1	0.006	0.006	0.16
Levels X Sex	3	0.131	0.044	1.19
Sex X Levels X Source	3	0.028	0.009	0.24
Error	32	1.193	0.037	----
Total	47	2.561	-----	----

APPENDIX TABLE XX. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF SPECIFIC GRAVITY.

Variation	df	ss	ms	F
Source	1	0.041	0.041	1.05
Levels	3	0.103	0.034	0.87
Sex	1	0.611	0.611	15.74**
Source X Levels	3	0.124	0.041	1.05
Sex X Source	1	0.077	0.077	2.00
Levels X Sex	3	0.177	0.059	1.51
Sex X Levels X Source	3	0.062	0.021	0.54
Error	32	1.242	0.039	----
Total	47	2.438	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXI. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF BACKFAT MEASUREMENT. (CARCASS).

Variation	df	ss	ms	F
Source	1	-----	-----	----
Levels	3	0.074	0.025	0.69
Sex	1	0.182	0.182	5.01*
Source X Levels	3	0.262	0.087	2.40
Sex X Source	1	0.007	0.009	0.25
Levels X Sex	3	0.092	0.031	0.86
Sex X Levels X Source	3	0.209	0.070	1.94
Error	32	1.165	0.036	----
Total	47	1.993	-----	----

\* Significant ( $P < 0.05$ ).

APPENDIX TABLE XXII. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF CARCASS LENGTH.

Variation	df	ss	ms	F
Source	1	0.040	0.040	0.49
Levels	3	0.155	0.052	0.63
Sex	1	0.176	0.176	2.14
Source X Levels	3	0.319	0.106	1.29
Sex X Source	1	0.128	0.128	1.56
Levels X Sex	3	0.282	0.094	1.15
Sex X Levels X Source	3	0.043	0.014	0.17
Error	32	2.637	0.082	----
Total	47	3.780	-----	----

APPENDIX TABLE XXIII. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF HAM WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.001	0.001	0.04
Levels	3	0.088	0.029	1.12
Sex	1	0.364	0.364	13.84**
Source X Levels	3	0.015	0.005	0.19
Sex X Source	1	0.021	0.021	0.81
Levels X Sex	3	0.214	0.071	2.71
Sex X Levels X Source	3	0.142	0.047	1.81
Error	32	0.840	0.026	----
Total	47	1.687	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXIV. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF BACON WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.020	0.020	0.91
Levels	3	0.058	0.019	0.86
Sex	1	0.172	0.172	7.70**
Source X Levels	3	0.046	0.015	0.68
Sex X Source	1	0.016	0.016	0.73
Levels X Sex	3	0.066	0.022	1.00
Sex X Levels X Source	3	0.082	0.027	1.23
Error	32	0.713	0.022	----
Total	47	1.172	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXV. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF SHOULDER WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.020	0.020	0.26
Levels	3	0.293	0.098	1.29
Sex	1	0.682	0.682	8.96**
Source X Levels	3	0.015	0.005	0.65
Sex X Source	1	-----	-----	----
Levels X Sex	3	0.659	0.219	2.88
Sex X Levels X Source	3	0.385	0.128	1.68
Error	32	2.437	0.076	----
Total	47	4.490	-----	----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXVI. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF LOIN WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.002	0.002	0.09
Level	3	0.162	0.054	2.43
Sex	1	0.268	0.268	12.06**
Source X Levels	3	0.032	0.011	0.50
Sex X Source	1	-----	-----	-----
Levels X Sex	3	0.292	0.097	4.39**
Sex X Levels X Source	3	0.020	0.007	0.32
Error	32	0.709	0.022	-----
Total	47	1.486	-----	-----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXVII. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF BUTT WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.043	0.043	1.16
Levels	3	0.118	0.039	1.05
Sex	1	0.405	0.405	11.08**
Source X Levels	3	0.083	0.028	0.76
Sex X Source	1	0.003	0.003	0.08
Levels X Sex	3	0.220	0.073	2.01
Sex X Levels X Source	3	0.035	0.012	0.32
Error	32	1.170	0.037	-----
Total	47	2.078	-----	-----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXVIII. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF FAT TRIM WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.018	0.018	0.64
Levels	3	0.017	0.006	0.21
Sex	1	0.288	0.288	10.35**
Source X Levels	3	0.094	0.031	1.11
Sex X Source	1	0.046	0.046	1.64
Levels X Sex	3	0.090	0.030	1.07
Sex X Levels X Source	3	0.138	0.046	1.64
Error	32	0.889	0.028	-----
Total	47	1.581	-----	-----

\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXIX. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF LEAN TRIM WEIGHTS.

Variation	df	ss	ms	F
Source	1	0.005	0.005	0.07
Levels	3	0.434	0.145	1.99
Sex	1	0.132	0.132	1.81
Source X Levels	3	0.009	0.003	0.04
Sex X Source	1	0.006	0.006	0.08
Levels X Sex	3	0.184	0.061	0.83
Sex X Levels X Source	3	0.048	0.062	0.85
Error	32	2.325	0.073	----
Total	47	3.144	-----	----

APPENDIX TABLE XXX. SWINE EXPERIMENT I. ANALYSIS OF VARIANCE OF RIBEYE AREA.

Variation	df	ss	ms	F
Source	1	0.074	0.074	0.80
Levels	3	0.719	0.240	2.62
Sex	1	1.763	1.763	19.23**
Source X Levels	3	0.254	0.084	0.91
Sex X Source	1	-----	-----	----
Levels X Sex	3	0.352	0.117	1.27
Sex X Levels X Source	3	0.177	0.059	0.64
Error	32	2.935	0.092	----
Total	47	6.275	-----	----

\*\*\* Highly significant ( $P < 0.01$ ).

APPENDIX TABLE XXXI. GROWING PHASE SWINE EXPERIMENT II. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAINS.

Variation	df	ss	ms	F
Protein (P)	1	0.082	0.082	2.15
Lysine (L)	3	0.051	0.017	0.44
Sex (S)	1	0.002	0.002	0.05
P X S	1	0.002	0.002	0.05
P X L	3	0.011	0.003	0.07
L X S	3	0.199	0.067	1.76
P X L X S	3	0.211	0.070	1.84
Error	24	0.906	0.038	----
Total	39	1.464	-----	----

APPENDIX TABLE XXXII. FATTENING PHASE SWINE EXPERIMENT II. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAINS.

Variation	df	ss	ms	F
Protein (P)	1	0.939	0.939	12.36**
Lysine (L)	3	0.216	0.072	0.95
Sex (S)	1	0.041	0.041	0.54
P X S	1	0.097	0.097	1.28
P X L	3	0.180	0.060	0.79
L X S	3	0.282	0.094	1.24
P X L X S	3	0.204	0.068	0.89
Error	24	1.833	0.076	----
Total	39	3.792	-----	----

\*\* Highly significant ( $P < 0.01$ )

APPENDIX TABLE XXXIII. SUMMARY SWINE EXPERIMENT II. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAINS.

Variation	df	ss	ms	F
Protein (P)	1	0.322	0.322	9.94**
Lysine (L)	3	0.053	0.018	0.50
Sex (S)	1	0.026	0.026	0.72
P X S	1	0.014	0.014	0.39
P X L	3	0.019	0.006	0.02
L X S	3	0.197	0.066	1.83
P X L X S	3	0.153	0.051	1.42
Error	24	0.858	0.036	----
Total	39	1.642	-----	----

\*\* Highly significant ( $P < 0.01$ )

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