PART I. NUTRITIONAL STUDIES WITH DISEASE-FREE SWINE

PART II. UTILIZATION OF D-AMINO ACIDS BY SWINE

By

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INTRODUCTION

Swine production has been seriously hampered in recent years by several insidious and costly diseases. Many herds encountering these disorders contain valuable breeding stock and to dispose of these herds in an attempt to eliminate these diseases would result in severe losses to the swine industry. It is also very difficult at times to replace valuable breeding stock with any certainty of freedom from these diseases. Various treatments have been used successfully in alleviating symptoms in afflicted animals, yet none have been proven to be effective in completely eliminating the disease conditions in the herds. These diseases have also seriously handicapped experimental studies in swine nutrition and breeding. In many instances conclusions have been made on what must be regarded as diseased rather than normal pigs.

In 1950 an experiment was started in which baby pigs were delivered aseptically by Caesarian section and raised in an environment entirely isolated from other swine-raising operations. It was desired in this study to evaluate the possibility of eliminating a digestive disturbance in the young pigs that had existed in the parent stock, and also to study the nutritive requirements of swine raised in this manner.

REVIEW OF LITERATURE

The published literature on this subject is so voluminous that no attempt will be made to give a complete review. Only those reports which are pertinent to this study will be considered.

Use of Purified Rations for Baby Pigs

Wintrobe (1939) employed a "synthetic" diet in studying the nutritive requirements of young pigs. He found that a diet composed of casein, 9.5 grams; lard, 4.0; cod liver oil, 0.5; sucrose, 21.0; minerals, 2.2; plus 3 grams of yeast per kilogram of body weight daily produced the most rapid growth.

McRoberts and Hogan (1944) fed pigs, which had nursed the sow for two days, a diet consisting of: acid-washed casein, 30 percent; sucrose, 30; corn starch, 5; lard, 30; mineral mixture, 5; and all the then-known vitamins. Of the initial 34 pigs, 15 died with pneumonia and pericarditis; the remaining 19 failed to respond normally and developed a severe diarrhea. The pigs were given either extracts of liver or yeast. The ones receiving the liver extract recovered from the diarrhea and grew in a normal manner.

Anderson and Hogan (1947) reported the results from an experiment in which baby pigs were allowed to nurse the sow for three days. The pigs were then transferred to a synthetic diet containing all known nutrients but no crude carriers of unknown substances. At first they had diarrhea but gained at nearly a normal rate and averaged 35.8 pounds at 56 days of age. One gilt was fed the synthetic diet through a reproductive cycle and farrowed eleven normal pigs, but she became anemic, stopped lactating, and died on the 55th day after farrowing. Five pigs survived and were raised on a synthetic diet without any difficulty until 56 days of age.

After the isolation of B_{12}, Anderson and Hogan (1950) reported successful reproduction in two gilts fed a purified ration supplemented with this nutrient. Two reproductive cycles were completed. Other workers, Johnson et al. (1948), Russell et al. (1948), Lehrer, et al. (1949), and Neuman et al. (1950), have successfully raised baby pigs on a purified diet after the pigs nursed the sow for two days.

Attempts to raise pigs from birth to eight weeks of age on a purified diet without access to colostrum have been less successful. Bustad et al. (1948) removed pigs from the sow at birth and fed a purified diet which contained all known nutrients. The diet consisted of casein, 39.6 percent; sucrose or lactose, 25.5; lard, 28.7; and salt mixture, 6.2. Blood serum and plasma were used as colostrum substitutes. In this experiment pigs removed from the dam at birth failed to survive longer than 22 days. A severe diarrhea developed in all pigs fed the synthetic milk, and the following therapeutic agents were of no benefit in prolonging life: penicillin, sulfathalidine, sulfamethazine, and Kaopectate. These workers concluded that the diet was inadequate even though crude casein, 1-20 liver powder, and an anti-pernicious anemia liver extract were added to the experimental diet.

Young and Underdahl (1951), however, reported raising baby pigs from birth to 90 days without the pigs receiving colostrum. The diet consisted of modified cow's milk containing a whole egg and 5 ml. of a salt mixture per quart of homogenized milk. Healthy pigs were obtained by placing a sterile cloth bag against the buttocks of the sow and catching the new-born pig.

Value of Various Fats for Pre-Weanling Young

Gullickson et al. (1942) reported the value of the following oils and fats from feeding trials with dairy calves: soybean oil, corn oil, cottonseed oil, coconut oil, lard, beef tallow, and butter fat. These fats and oils were added to skim milk at a level of 3.5 percent and were emulsified with the milk by homogenization. The calves were fed on the respective rations for a three- to four-month period, starting at approximately seven to fourteen days of age. They found that the calves receiving the vegetable oils made average daily gains as follows: coconut oil, 0.96 pounds; peanut oil, 0.80; corn oil, 0.40; cottonseed oil, 0.31; soybean oil, 0.32; as compared to calves receiving whole milk, 1.43 pounds; butter fat, 1.22; lard, 1.17; tallow, 1.24. The incidence of diarrhea was more frequent in the calves receiving the vegetable oils than the calves receiving the animal fats.

Jacobson et al. (1949) compared the nutritive value of butter fat, crude soybean oil, and hydrogenated soybean oil in a dried milk ration for dairy calves. These workers found that the calves receiving the ration containing hydrogenated soybean oil gained as rapidly as the calves receiving the ration containing butter fat. However, the calves receiving the ration containing crude soybean oil scoured severely and made slow gains.

Boutwell et al. (1943) reported no difference was found between the nutritive value of vegetable oils and animal fats when fed to day-old pigs.

Gestation-Lactation Performance of Swine Fed Natural Rations

Hogan and Johnson (1940) reported that sows fed a ration consisting of corn, linseed meal, alfalfa meal, tankage, minerals, and cod liver oil failed to reproduce in a normal manner. The percentage of pigs weaned was approximately 40 percent. If 2 percent buttermilk solids were added to the basal ration, 74 percent of the pigs born alive were weaned. The addition of wheat bran, yeast, and liver to the basal ration also improved the reproductive performance. Some of the symptoms observed in the pigs were goose stepping, diarrhea, sudden collapse, skin lesions, and scabs.

Ross et al. (1942) in a series of experiments with swine and rats fed a basal ration of 76.35 percent of ground yellow corn, 17.5 percent soybean meal, 5 percent alfalfa meal, 0.5 percent iodized salt, and 0.65 percent calcium carbonate. They concluded that the ration was inadequate for normal reproduction and lactation. Gilts raised in dry lot on this ration failed to suckle their litters to allow normal growth; many pigs died before weaning while others became emaciated. These same findings were also substantiated in the rat experiments. Normal reproduction and lactation could be obtained with both swine and rats if 10 percent alfalfa meal was added to the basal ration.

In a later report, Ross et al. (1944) found that the addition of wheat bran, middlings, tankage, yeast, and certain B-vitamins to the basal ration from ten days prior to parturition to twenty days following parturition did not correct these embryological abnormalities or stimulate lactation sufficiently to raise the pigs to weaning.

Cunha et al. (1944) continued the experiments initiated by Ross et al., to determine if certain vitamins or commercial preparations would adequately supplement an all-plant basal ration. These workers were unable to show any supplement or vitamin, other than 10 percent alfalfa meal added to the basal ration, that would permit normal reproduction and lactation of swine and rats fed all-plant rations.

Fairbanks *et al.* (1945) fed gilts a basal ration of corn, soybean meal, fish meal, tankage, limestone, steamed bone meal, salt, and cod liver oil. This basal ration was supplemented with either corn distillers solubles, alfalfa meal, or all known B-vitamins. These workers found that the basal ration was inadequate for normal gestation but was adequate for lactation. If the different supplements were added to the basal ration, normal gestation and lactation could be obtained. These workers concluded that the nutrient requirements of a sow were most critical during the gestation period.

Heidebrecht *et al.* (1950) designed three experiments to determine the adequacy of a corn-soybean meal ration for reproduction and lactation of swine and to determine the supplementary effect of certain nutrients when added to such a swine ration. Two basal rations were used in the three experiments. Basal ration A was composed of ground yellow corn, 82.85 percent; expeller soybean meal, 11; alfalfa meal, 5; iodized salt, 0.5; ground limestone, 0.65; and 6000 I. U. of carotene per pound of feed. Basal ration B consisted of ground yellow corn, 82 percent; expeller soybean meal, 11; alfalfa meal, 5; salt, 0.5; and steamed bone meal, 1.5. Supplements added to these basal rations included fish solubles, vitamin A, carotene, alfalfa meal, liver extract, APF, and iodine. These workers observed, with data collected from 70 sows on 15 different treatments, that reproduction performances of sows fed the basal rations were essentially normal but that the weaning weights of the pigs were suboptimal. Survival rates of pigs from gilts or sows fed the basal rations fortified with fish solubles were greater than survival rates of pigs from sows fed the basal ration. In two experiments the addition of fish solubles to the basal rations increased the weaning weights of the pigs. Supplementation of the basal rations with alfalfa meal, liver extract, iodine, or vitamin A was without effect on reproduction or lactation. In Experiment 3, one lot of sows fed the basal ration and housed in concrete pens that were washed daily raised fewer pigs than those sows fed the same ration but whose pens were washed twice weekly. Slightly lower weaning weights were also obtained.

Aureomycin in Rations for Swine

Cunha et al. (1949) demonstrated that Lederle APF (aureomycin residue) supplement contained some growth factor or factors other than vitamin B_{12} that gave a marked growth response in young pigs on a corn-peanut meal basal ration. Jukes et al. (1950) reported data indicating that the antibiotic aureomycin was a constituent of Lederle APF supplement, and that in pure form aureomycin would produce a growth response in swine.

Leucke et al. (1950) observed a growth response in weanling pigs by supplementing a corn-soybean meal basal ration with 10 milligrams of aureomycin per pound of feed. Terrill and Krider (1950) also observed that weanling pigs in dry lot made faster gains when a corn-soybean meal basal ration was supplemented with APF or aureomycin.

Heidebrecht et al. (1951) fed unthrifty pigs a basal ration containing the following feeds: ground yellow corn, soybean meal, tankage, fish meal, cottonseed meal, alfalfa leaf meal, trace mineralized salt, and steamed bone meal. This basal ration was supplemented with either aureomycin, streptomycin, penicillin, or sulfathalidine. The pigs receiving the basal ration supplemented with the antibiotics or sulfathalidine gained at a faster rate than the pigs receiving the basal ration for a

56-day experimental period.

During the past three years there has been an enormous amount of data collected at various experiment stations concerning the evaluation of APF supplements and antibiotics in swine rations. Some of the data has shown that antibiotics when fed to unthrifty pigs stimulate growth as much as 100 percent. However, in the case of apparently healthy pigs fed well-balanced rations the growth stimulation has resulted in either no response or limited growth increases.

Heidebrecht et al. (1951) fed healthy pigs a basal ration composed of yellow corn, 73.25 percent; tankage, 5.0; expeller soybean meal, 5.0; cottonseed meal, 5.0; fish meal, 3.0; dried skim milk, 2.0; alfalfa meal, 5.0; brewers yeast, 0.25; trace mineralized salt, 0.5; steamed bone meal, 1.0; and Delsterol, 9 grams per 100 pounds of feed. These healthy pigs were divided into three lots, six pigs per lot. Lot 1 received the basal ration. Lot 2 was fed the basal ration, plus 0.75 grams of aureomycin per 100 pounds of feed, and Lot 3 received the basal ration, plus 0.75 grams of aureomycin per 100 pounds of feed from the beginning of the experiment until the pigs reached an average weight of 125 pounds. During the remainder of the experiment the pigs in Lot 3 were fed the basal ration. These workers found that excellent growth was obtained in all lots. The average daily gain and feed efficiency were not in favor of the lots receiving supplementations of aureomycin. It was suggested from these data that the response of pigs to antibiotics depends upon the health of the animal and the adequacy of the ration with respect to various nutrients.

Speers et al. (1950) reported an experiment in which healthy pigs were fed a corn-soybean meal basal ration, supplemented with either aureomycin, liquid APF, or dry APF. The pigs receiving the APF supplement, either liquid or dry, gained at a faster rate than the pigs receiving the basal ration. Supplementation of the basal ration with either 5 or 10 milligrams of aureomycin per pound of feed produced gains of the same magnitude as those gains made by pigs receiving the basal ration.

B-Vitamins in Rations for Swine

Chick et al. (1938) reported the curative action of nicotinic acid on pigs suffering from the effects of a diet consisting largely of corn. Various extractions from yeast had been given the pigs, but they still refused to eat. When 100 milligrams of nicotinic acid were injected intramuscularly for three days and 60 milligrams given daily in the feed, the results were striking. Appetite returned within 24 hours, and the pigs gained 93 pounds in 90 days. Since then, Hughes (1940), Hughes and Ittner (1942), Hughes and Squibb (1942), and Hughes (1943) have shown that nicotinic acid, riboflavin, pyridoxine, and pantothenic acid are required in the ration of the growing pig.

During the past two years several reports have praised the growth stimulation in swine caused by the addition of vitamins of the B- complex group. Leucke et al. (1950) showed that the addition of thiamine, riboflavin, nicotinic acid, pyridoxine, choline, and pantothenic acid to an all-plant basal ration improved the rate of gain 100 percent over that produced by the basal ration.

Briggs and Beeson (1950) studied the supplementary value of riboflavin, calcium pantothenate, and niacin in a practical mixed animal and plant protein ration containing B_{12} and aureomycin for weanling pigs in dry lot. These workers found that the addition of riboflavin, niacin, and pantothenic acid to the basal ration increased the average daily gains of the pigs 0.17 pounds, as compared to the average daily gains of the pigs receiving the basal ration.

Hillier and Whitehair (1952) found that the addition of B-vitamins to a low protein ration improved the rate of gain slightly; however, the addition of these vitamins to a higher protein ration improved the rate of gain 10 percent and the economy of gain 5 percent.

EXPERIMENTAL

Pre-Weanling Phase

General procedures. - Twenty-three purebred Chester White pigs were delivered by Caesarian section from four selected gilts of the Animal Husbandry Department swine herd. All of the gilts and two boars from each litter were selected for this study. The baby pigs were delivered shortly after the gilts had let down their milk. Upon delivery they were wrapped in sterile cheese cloth and transferred immediately to clean individual metabolism pens located in a room maintained at a constant temperature of 90° F. The pigs were fed an artificial milk containing 20 percent solids, the composition of which is shown in Ration 1, Table 1. The milk was prepared by dissolving lactose in warm distilled water and homogenizing the mixture with melted butter by means of a small mechanical homogenizer. The casein, salts, and vitamins were then added and the mixture was suspended with the aid of a Waring blender. The milk was refrigerated until used, at which time small amounts were resuspended by warming and blending. One whole egg and one-half pint of heifer colostrum were added per 800 ml. of milk and fed to certain pigs for the first three days as a source of unidentified nutrients. Each of the pigs received 10 ml. of Ration 1 shortly after being placed in the metabolism pens. Thereafter the pigs were fed every four hours starting at 7:00 A. M. and ending at 11:00 P. M. After six days on this feeding schedule the 11:00 P. M. feeding was omitted. Crocks from which the pigs ate were washed and sterilized after each feeding. The pens were washed daily with warm soapy water. The temperature of the room was lowered five degrees each week until a constant temperature of 78° F. was attained. The pigs were weighed at two-day intervals.

Trial 1 - Two separate growth trials were conducted. In the first trial eight pigs twelve days of age from two litters were allotted on the basis of weight, sex, and litter to Rations 1, 2, or 3 and fed for the succeeding twenty-one days. The essential difference between these rations was in the fat constituent. These rations were prepared by mixing either melted butter, corn oil, or cottonseed oil with lactose, casein, salts, and vitamins by means of a small feed mixer. A portion of this mixture was weighed before each feeding and suspended in warm water with the aid of the blender. Each pig was offered all the food he could consume in fifteen minutes.

Trial 2 - This trial was essentially a repetition of Trial 1. The trial began with an adjustment period of approximately twelve days, during which the pigs were fed Ration 1. Seven pigs were fed Ration 1 unsupplemented with whole egg or colostrum. The pigs were then allotted on the basis of weight, sex, and litter to Rations 1, 2 or 3 which were prepared as described in Trial 1.

Table 1

Rations Used in Fat Studies*

Ingredients	Ration Number 1	2	3
Vitamin free casein	60 gms.	60 gms.	60 gms.
Butter	84		
Cottonseed oil		84	
Corn oil			84
Lactose	46	46	46
Salts**	10	10	10

* Vitamins added per 200 gms. of dry ration: thiamine 1.1 mg.; riboflavin 1.8 mg.; niacin 10.1 mg.; inositol 26.8 mg.; choline 26.0 mg.; para-amino benzoic acid 5.0 mg.; folic acid 0.13 mg.; biotin 0.025 mg.; pyridoxine 2.0 mg.; calcium pantothenate 7.1 mg.; ascorbic acid 130 mg.; vitamin B_{12} 10 mcg.; vitamin A 900 I.U.; vitamin D 120 I.U.; menadione 0.29 mg.; alpha tocopherol acetate 1.5 mg.

** Johnson, B. C. et al., Jour. Ani. Sci. (1948) 7:486.

Table 2

Response of Young Pigs to Various Types of Fats

Trial 1 (Duration 21 Days)

	Lot 1 Butter	Lot 2 Corn Oil	Lot 3 Cottonseed Oil
Number of pigs	2	3	3
Average initial weight	3.3 lbs.	3.9 lbs.	4.0 lbs.
Average final weight	14.8	15.3	16.2
Average gain	11.5	11.4	12.2
Average daily gain	0.55	0.54	0.58

Trial 2 (Duration 21 Days)

	Lot 1 Butter	Lot 2 Corn Oil	Lot 3 Cottonseed Oil
Number of pigs[1]	4	1	3
Average initial weight	3.8 lbs.	4.7 lbs.	4.0 lbs.
Average final weight	16.0	15.9	14.3
Average gain	12.2	11.2	10.3
Average daily gain	0.58	.53	.49

[1] Includes only pigs which completed the trial.

Results and Discussion

Seventeen of the 23 baby pigs that were fed rations previously described were successfully raised. Four of these were raised on diets unsupplemented with a source of unidentified growth factors. An examination of the data in Table 2 reveals no marked differences as determined by growth in the nutritive value of the three different fats, although slightly faster growth was obtained with the pigs receiving butter fat. These findings are in agreement with Jacobson et al. (1949) in which no differences were obtained with dairy calves when hydrogenated soybean oil was substituted for butter fat. Also, in the report of Boutwell et al. (1943) no difference was found between the nutritive value of vegetable oils and animal fats when fed to day-old pigs.

In Trial 2, two pigs on the corn oil and one on the cottonseed oil diet died before the trial was completed. These three pigs were fed Ration 1 unsupplemented with whole egg and colostrum for the first twelve days. These deaths apparently were not due to nutritional causes. The individual performance of each pig is presented in Table 1, appendix.

Post-Weanling Phase

Trial 1, Effect of aureomycin supplementation - When the eight pigs in Trial 1, pre-weanling phase reached approximately five weeks of age, the artificial type of ration was gradually replaced with one composed of corn, soybean meal, alfalfa leaf meal, dried skim milk solids, brewers yeast, steamed bone meal, and salt. At this time the pigs were transferred to an isolated area that had not previously maintained any swine. The equipment, such as feeders, waterers, houses, and fence, was either new or had never been used in swine-raising operations.

As soon as the pigs were accustomed to this type of ration they were divided into two lots according to weight, sex and litter. The pigs in Lot 1 were self-fed the basal ration; the pigs in Lot 2 were self-fed the basal ration plus 10 mg. crystalline aureomycin per pound of feed. This trial was conducted for 23 days. Water was offered ad libitum.

Trial 2 - Trial 2 was a repetition of Trial 1. Nine pigs approximately five weeks of age were removed from Trial 2, pre-weanling phase and transferred to the isolated area. They were divided into two lots and received the same treatment as the pigs in Trial 1. This trial was conducted for 32 days. At the conclusion of the experiment testing the value of aureomycin, all pigs were continued on the basal ration with slight modifications of the protein levels until breeding age.

Results and Discussion

The rations fed during the post-weanling phase are presented in Table 3. A summary of each trial is presented in Table 4. An examination of the data in Trial 1 shows that the pigs receiving the supplementation of aureomycin made gains slightly faster than the pigs receiving the basal ration. In Trial 2 the situation is reversed, for the pigs receiving the basal ration gained at a slightly faster rate. While this experiment was of short duration and a rather limited number of pigs were used, the weighted averages of both trials would indicate that pigs raised in this manner did not benefit from the addition of aureomycin to their ration. At no time was there any evidence in any of these pigs of a digestive disturbance although such had existed in the parent stock.

Some of the pigs became sick in Trial 1 after they had been on the experiment 23 days. This was thought to be due to spraying the lots for fly control. As a result, the last ten days of the trial has been omitted. The individual performance of each pig is shown in Table 2, appendix.

Table 3

Experimental Rations Used in Growth Studies

Ingredients	Lot 1	Lot 2
Corn (ground yellow)	66.0 percent	66.0 percent
Soybean meal	25.0	25.0
Alfalfa leaf meal	5.0	5.0
Dried skim milk solids	2.0	2.0
Steamed bone meal	1.0	1.0
Dried brewers yeast	0.5	0.5
Salt (iodized)	0.5	0.5
Aureomycin HCl (mg/lb.)		10.0

Table 4

Summary of the Average Daily Gain and Feed Efficiency of Pigs Fed a Basal Ration, and a Basal Ration Plus Aureomycin

	Lot 1 Basal	Lot 2 Basal Plus Aureomycin
	Trial 1	
Days on experiment	23	23
Number of pigs per lot	4	4
Average initial weight (lbs.)	53.8	54.2
Average final weight (lbs.)	86.8	89.0
Average daily gain (lbs.)	1.43	1.51
Feed per lb. gain (lbs.)	2.88	2.88
	Trial 2	
Days on experiment	32	32
Number of pigs per lot	4	5
Average initial weight (lbs.)	55	48
Average final weight (lbs.)	99.5	89.8
Average daily gain (lbs.)	1.39	1.31
Feed per lb. gain (lbs.)	2.88	2.72

Gestation-Lactation Phase

Nine gilts from the above trials were moved to a clean lot 75 feet wide and 200 feet long. The gilts were bred and divided into two lots. The gilts in Lot 1 were hand-fed a basal ration composed of corn, soybean meal, ground alfalfa hay, steamed bone meal, and salt. The gilts in Lot 2 were hand-fed the same ration with the exception that two percent skim milk solids replaced the soybean meal. The gilts remained in these lots until approximately one week prior to farrowing. They were then washed with warm soapy water and moved to a clean lot. Starting eight days after farrowing the sows were self-fed their respective rations until the pigs were 56 days of age. At this time they were moved to clean soil, and the feed was restricted three or four days until they had ceased lactating. The sows were then placed on full feed for a three-week period and bred. After conception the sows were hand-fed furing the gestation period. Again, approximately five days before farrowing the sows were washed with warm soapy water and moved to clean farrowing quarters. Five days prior to farrowing and five days after farrowing, 10 percent of ground alfalfa hay was added to each sow's ration replacing 10 percent of corn. Eight days after farrowing the sows were self-fed their respective rations until the pigs were 56 days of age. Water was supplied *ad libitum*.

Results and Discussion

The rations fed are presented in Table 5. All of the nine gilts bred during the fall of 1951 farrowed in the spring of 1952. Six of the sows bred during the spring of 1952 weaned litters in the fall. A summary of the reproductive performance for both spring and fall is shown in Table 6. The individual performance of each sow is presented in Table 3, appendix.

No unusual disturbances were encountered in the first six gilts nor in the last gilt to farrow. However, two gilts which farrowed the first of April had difficulty. Number 12, Lot 1, farrowed a litter of eight normal pigs, but they all died of starvation two days after farrowing. Number 5, Lot 2, farrowed ten pigs, seven of which died of starvation the first week. The other three were removed from the sow at 28 days of age so the sow could be rebred. It should be noted that both experimental treatments were involved. Two sows died during the summer of 1952 from heat prostration.

Except for the two cases mentioned above, satisfactory reproduction and lactation performances were obtained from the sows in both lots. This is in agreement with the work of Heidebrecht *et al.* (1950) and contrary to the observations of Ross *et al.* (1942) and (1944). Supplementation of the all-plant basal ration with dried skim milk solids resulted in no change in weaning weights nor the percentage of pigs weaned, as compared to the sows on the basal ration.

Table 5

Rations Fed to Sows During Gestation-Lactation

	Lot 1 Basal	Lot 2 Basal Plus Skim Milk Solids
Ground yellow corn	75.0 Percent	75.0 Percent
Soybean meal (41% expeller)	18.0	16.3
Ground alfalfa hay	5.0	5.0
Skim milk solids		2.0
Steamed bone meal	1.5	1.5
Salt (iodized)	0.5	0.5

Table 6

Summary of the Reproductive Performance

	Lot 1	Lot 2
Number of sows farrowed[1]	6	6
Number of pigs farrowed	46	42
Number of pigs dead at birth	4	4
Average birth weight of pigs (lbs.)	2.4	2.6
Number of pigs weaned	35	32
Average weaning weight (lbs.)	28.9	29.1
Percent of pigs weaned	83.3	84.2

[1] Includes only sows which completed two reproductive cycles.

Growth-Fattening Phase

Twenty-eight weanling pigs averaging approximately 30 pounds were divided into four lots on the basis of weight, sex, and litter. The boar pigs had been castrated when five weeks of age. All pigs had access before weaning to the self-feeder from which the sows ate. The pigs in Lot 1 were self-fed a ration composed of corn, soybean meal, alfalfa leaf meal, steamed bone meal, and salt. The pigs in Lot 2 received the same ration plus 10 mg. of crystalline aureomycin per pound of feed. The pigs in Lot 3 received the basal ration plus seven of the B-complex vitamins, while those in Lot 4 received the basal plus aureomycin plus B-vitamins. The basal ration contained approximately 18.6 percent protein and the amounts of corn and soybean meal were adjusted so that the protein content was reduced to 15.2 percent when the pigs reached 120 pounds. The pigs remained on their respective rations until they weighed approximately 200 pounds.

The second growth trial was essentially a repetition of the first trial. Twenty-four weanling pigs weighing approximately 30 pounds were equalized into four lots according to weight, sex, and litter, then allotted at random to individual pens in the Animal Husbandry experimental barn. The pigs were self-fed the same type of ration as presented in Trial 1. All pigs were weighed at 14-day intervals. Water was offered *ad libitum*.

The results were analyzed by analysis of variance according to Snedecor (1946).

Results and Discussion

The chemical composition of the feeds is shown in Table 7. The percentage composition of the rations fed is given in Table 8. The summary of the average daily gains and feed efficiency of the pigs in Trial 1 is given in Table 9 and the individual data are shown in Table 17, appendix. Statistical analysis (Table 10) of the average daily gain of the pigs over the entire trial shows that difference among treatments approached significance at the 5 percent level. Orthogonal comparisons revealed that this difference was due to the gains made by the pigs receiving B-vitamins as compared to the gains made by the pigs which received no additional vitamin supply. Practically no difference is noted in feed efficiency.

The summary of the average daily gains and feed efficiency of the pigs in Trial 2 is given in Table 11 and the individual data are shown in Table 17, appendix. Statistical analysis (Table 12) of the average daily gain of the pigs over a 70-day period shows that significant differences were present. Orthogonal comparisons revealed that the only significant difference was between the pigs receiving B-vitamins as compared to the pigs unsupplemented with B-vitamins. Statistical analysis (Table 13) of the feed efficiency for the pigs in Trial 2 shows that significant differences were not present.

These data confirm the findings of Heidebrecht et al. (1951) and Speers et al. (1950) in which no added growth response was obtained when crystalline aureomycin was added to the ration of growing swine. These data also confirmed the findings of Leucke et al. (1950), Briggs and Beeson (1951), and Hillier and Whitehair (1952) in which these workers showed that the addition of B-vitamins to the ration of growing swine increased the daily gains when compared to the daily gains made by swine receiving a basal ration composed mainly of corn and soybean meal unfortified with B-vitamins.

In Trial 1, representative pigs were subjected to post-mortem examination and there was no evidence of gross pathology of any kind except the presence of a few leisons in the liver presumably due to Ascaris. A few viable roundworms were also found in the intestinal tract. It is possible that these pigs could have become infected by feed or other means. Herrick (1952) states that pigs can become infected when in utero. The worms are reported by him to migrate into the liver of the foetuses and remain there until the pigs are born, then continue their migration, returning to the intestine in about two weeks.

Table 7

Percentage Chemical Composition of the Ration Used in Growth Studies

	H_2O	Protein	Fat	Fiber	N.F.E.	Ash	Ca.	P.
Corn (yellow)	12.21	9.76	3.23	2.08	71.06	1.66	0.05	0.282
Soybean (solvent extracted)	8.93	44.18	0.53	6.66	33.51	6.19	0.36	0.476
Alfalfa meal	5.61	18.22	2.31	22.24	40.66	10.96	1.37	0.195
Bone meal	1.34					64.96	27.70	9.14

Table 8

Rations Used in Growth Studies - 30-120 Pounds

	Lot 1	Lot 2	Lot 3	Lot 4
Corn (ground yellow) (%)	68.0	68.0	68.0	68.0
Soybean meal (solvent extracted) (%)	25.0	25.0	25.0	25.0
Alfalfa meal (dehydrated) (%)	5.0	5.0	5.0	5.0
Steamed bone meal (%)	1.5	1.5	1.5	1.5
Salt (stock) (%)	0.5	0.5	0.5	0.5
Aureomycin (mg./lb.)		10		10
B-vitamins*			+	+
Delsterol (gms/100 lb. feed)**	8	8	8	8

Rations Used in Growth Studies - 120-200 Pounds

	Lot 1	Lot 2	Lot 3	Lot 4
Corn (ground yellow) (%)	78.0	78.0	78.0	78.0
Soybean meal (solvent extracted) (%)	15.0	15.0	15.0	15.0
Alfalfa meal (dehydrated) (%)	5.0	5.0	5.0	5.0
Steamed bone meal (%)	1.5	1.5	1.5	1.5
Salt (stock) (%)	0.5	0.5	0.5	0.5
Aureomycin (mg/lb.)		10		10
B-vitamins*			+	+
Delsterol (gms/100 lb. feed)**	8	8	8	8

* Added B-vitamins - thiamine, 0.5; riboflavin, 1.5; niacin, 6; calcium pantothenate, 4; pyridoxine, 0.6; choline, 200 mg. per pound of ration. Vitamin B_{12}, 9 mcg. per pound of ration.

** Added only for pigs at the experimental barn.

Table 9

Summary of the Growth Performance
Summer 1952

	Lot 1	Lot 2	Lot 3	Lot 4
No. of pigs per lot	7	7*	7	7
Average initial weight (lbs.)	30.8	30.6	30.6	30.6
Average final weight (lbs.)	197.0	196.0	200.0	208.0
Average daily gain (lbs.)	1.32	1.31	1.37	1.44
Feed required per 100 lb. gain	350.0	343.0	343.0	348.0

* One pig removed 120 pounds - injury.

Table 10

Analysis of Variance of Average Daily Gain of Pigs
Summer 1952

Source of Variation	d.f.	Sum of Squares	Mean Square
Total	26	0.3527	
Treatment	3	0.0813	0.0271
Lots 1 and 3 vs. Lots 2 and 4	(1)	0.0078	
Lots 1 and 2 vs. Lots 3 and 4	(1)	0.0591	0.0591
Lots 1 and 4 vs. Lots 2 and 3	(1)	0.0144	
Error	23	0.2714	0.0118

Table 11

Summary of the Growth Performance
Winter 1952-53

	Lot 1	Lot 2	Lot 3	Lot 4
No of pigs per lot	6	6	6	6
Average initial weight (lbs.)	31.0	31.1	30.7	31.3
Average final weight (lbs.)	111.0	117.0	125.0	136.0
Average daily gains (lbs.)	1.14	1.23	1.34	1.53
Feed required per 100 lb. gain	319.0	311.0	309.0	275.0

Table 12

Analysis of Variance of Average Daily Gain of Pigs
Winter 1952-53

Source of Variation		d.f.	Sum of Squares	Mean Square
Total		23	1.0832	
Treatment		3	0.5120	0.1707*
Lots 1 and 3 vs. Lots 2 and 4	(1)		0.1120	
Lots 1 and 2 vs. Lots 3 and 4	(1)		0.3850	0.3850**
Lots 1 and 4 vs. Lots 2 and 3	(1)		0.0150	
Rows		5	0.0733	0.0147
Error		15	0.4979	0.0319

* Statistically significant at 5 percent level.

** Statistically significant at 1 percent level.

Table 13

Analysis of Variance of Feed Efficiency
Winter 1952-53

Source of Variation		d.f.	Sum of Squares	Mean Square
Total		23	25,764.0	
Treatment		3	6,960.0	2,320.0
Lots 1 and 3 vs. Lots 2 and 4	(1)		2,710.0	
Lots 1 and 2 vs. Lots 3 and 4	(1)		3,197.0	
Lots 1 and 4 vs. Lots 2 and 3	(1)		1,053.0	
Rows		5	7,850.0	1,570.0
Error		15	10,954.0	730.0

SUMMARY

Baby pigs delivered by Caesarian section were raised to five weeks of age on an artificial-type ration without receiving the sow's colostrum. Four pigs were raised on the artificial-type ration unsupplemented with sources of unidentified growth factors. Two growth trials were conducted with baby pigs to test the nutritive value of butterfat, corn oil, and cottonseed oil when fed to twelve-day-old baby pigs. When the fats were fed under the same experimental conditions, no difference was obtained as determined by the gains made of the pigs for a twenty-one day experimental period.

Two growth trials were conducted to determine the effect of crystalline aureomycin on the average daily gain and feed efficiency of growing pigs raised in an isolated area. When ten milligrams of crystalline aureomycin was added per pound of feed to an all-plant type of basal ration, no increase in average daily gain was obtained during an average of a twenty-eight day experimental period.

Gilts which were raised on an artificial-type ration to five weeks of age then transferred to an all-plant basal ration reproduced and lactated in a normal manner. The addition of two percent dried skim milk solids to the basal ration was without effect on weaning weight or percentage survival to weaning.

Two growth trials were conducted with offspring from the sows to determine the effect of crystalline aureomycin and seven of the B-vitamins on the average daily gain of pigs fed an all-plant ration. The addition of B-vitamins to the basal ration resulted in a significant increase in

the average daily gain of pigs when compared to the daily gain of pigs receiving the basal ration unfortified with B-vitamins. Aureomycin did not significantly increase the average daily gain of pigs as compared to the average daily gain of pigs unsupplemented with aureomycin. At no time was there evidence of a digestive disturbance in any of the pigs raised at the isolated area. Representative pigs were subjected to post-mortem examination and there was no evidence of gross pathology of any kind except the presence of a few lesions in the liver presumably due to ascarid infection. Viable roundworms were also found in the intestinal tract.

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APPENDIX

Table 14

Response of Baby Pigs to Different Fats
(Pounds)

Trial 1 Duration 21 Days

Pig No.	Initial	Final	Gain	Average Daily Gain	Hemoglobin gm/100 ml blood
Lot No. 1					
1	3.8	16.8	13.0	.62	13.3
6	2.8	12.7	9.9	.47	12.1
Lot No. 2					
2	4.2	16.2	12.0	.57	12.5
4	3.9	15.9	12.0	.57	12.8
8	3.6	13.9	10.3	.49	12.3
Lot No. 3					
3	5.1	20.1	15.0	.71	14.0
5	3.3	13.8	10.5	.50	12.3
9	3.7	14.6	10.9	.52	12.7
		Trial 2	Duration 21 Days		
Lot No. 1					
10	5.4	21.0	15.6	.74	12.3
14	2.6	13.5	10.9	.50	11.6
16	3.6	15.0	11.4	.54	12.4
19	3.8	14.7	10.9	.50	12.0
Lot No. 2					
11	4.7	15.9	11.2	.53	12.2
13	2.0	6.5	4.5	.20	12.2
17[1]	3.3				
20[2]	3.6				
Lot No. 3					
12	4.0	13.7	9.2	.44	11.9
15	4.0	15.2	11.2	.53	13.4
18[3]	3.3				
21	4.0	13.9	9.9	.47	11.9

[1] Pig number 17 died. Hemorrage of lungs and kidneys.

[2] Pig number 20 died. Uremic poisoning - injury.

[3] Pig number 18 died. Pneumonia and pericarditis.

Table 15

Response of Pigs to Aureomycin
(Pounds)

Trial 1 Duration 23 Days

Pig No.	Initial	Final	Gain	Average Daily Gain
Lot No. 1				
2[1]	58	92	34	1.48
3[1]	63	94	31	1.35
5	48	77	29	1.26
8	46	84	38	1.65
Lot No. 2				
1[1]	51	90	39	1.70
4[1]	59	89	30	1.30
6	47	76	29	1.26
9	60	101	41	1.78
	Trial 2 Duration 32 Days			
Lot No. 1				
11	57	104	47	1.47
12	48	88	40	1.25
15	66	114	48	1.50
19	49	92	43	1.34
Lot No. 2				
10	71	113	42	1.31
13	25	62	37	1.16
14	41	79	38	1.19
16	60	105	45	1.41
21	43	90	47	1.47

[1] Died from heat prostration, 7-21-51.

Table 16

Reproductive Performance of Individual Sows
Spring 1952

Sow No.	Pigs Far-rowed	Average Birth Weight (lbs.)	Dead or Ab-normal	Number Weaned	Average Weaning Weight	Percent Pigs Born Alive Weaned
Lot No. 1						
6	7	1.9	3	3	27.8	75.0
10	7	2.3	0	5	32.0	71.4
12[1]	8		0			
15	9	2.0	1	6	18.3	75.0
Lot No. 2						
5[2]	10	2.8	0			
11[3]	6	3.3	0			
13	7	2.9	0	7	30.9	100.0
14	7	2.3	0	5	26.9	71.4
16[4]	8	2.5	3	4	28.4	80.0
Fall 1952						
Lot No. 1						
6	8	2.8	0	7	32.4	87.5
10	6	2.8	0	5	32.4	83.3
15	9	2.5	0	9	30.1	100.0
Lot No. 2						
5	7	3.2	0	7	30.1	100.0
13	5	2.7	0	4	31.0	80.0
14	8	2.1	1	5	26.4	71.4

[1] Lost all pigs at 36 hours of age. Sow became crippled and did not breed in spring.

[2] Lost 7 pigs first week. Raised 3 until 28 days of age. They were weaned so sow could be rebred.

[3] Raised 5 pigs until 14 days of age. Pigs weaned so sow could be rebred. Sow died 5-14-52. Heat prostration due to fighting.

[4] Sow died 6-2-52. Acute cardiac congestion.

Table 17

Growth Performance of Pigs Fed an All-Plant Ration
(Pounds) Summer 1952

Pig No.	Sex	Initial Weight	70 Day Weight	Final Weight	Gain	Average Daily Gain
Lot No. 1						
1-4	M	40.0	143.0	200.0	160.0	1.43
2-6	F	37.0	138.0	208.0	171.0	1.44
3-4	F	32.0	133.0	202.0	170.0	1.43
4-3	F	20.5	92.0	168.0	147.5	1.11
4-8	M	19.0	108.0	208.0	189.0	1.42
5-4	M	27.0	116.0	198.0	171.0	1.28
6-5	M	40.0	112.0	198.0	158.0	1.19
Lot No. 2						
1-2	M	30.0	121.0	210.0	180.0	1.35
2-1	M	39.5	144.0	202.0	162.5	1.45
2-4[1]	F	32.0	120.0		88.0	1.26
3-1	M	39.0	141.0	204.0	165.0	1.39
4-6	F	19.5	101.0	178.0	158.5	1.19
6-1	F	25.5	108.0	193.0	167.5	1.26
6-4	M	29.0	114.0	190.0	161.0	1.21
Lot No. 3						
1-3	M	24.0	105.0	196.0	172.0	1.29
1-5	F	17.0	95.0	185.0	168.0	1.26
2-3	F	34.5	129.0	194.0	159.5	1.34
3-3	F	41.0	143.0	204.0	163.0	1.46
3-5	M	32.0	146.0	216.0	184.0	1.55
4-5	F	29.0	119.0	208.0	179.0	1.35
5-2	F	36.5	138.0	199.0	162.5	1.37
Lot No. 4						
1-1	M	38.5	158.0	212.0	173.5	1.64
2-2	M	37.0	136.0	198.0	161.0	1.40
3-2	M	35.5	138.0	201.0	165.5	1.44
3-6	F	29.0	111.0	214.0	185.0	1.39
4-2	F	25.5	119.0	210.0	184.5	1.39
4-4	M	16.5	104.0	208.0	191.5	1.44
5-4	M	32.0	136.0	200.0	168.0	1.46

Table 17 - continued

Growth Performance of Pigs Fed an All-Plant Ration
(Pounds) Winter 1952-53

Pig No.	Sex	Initial Weight	70 Day Weight	Gain	Average Daily Gain	Feed Required Per 100 Pound Gain
Lot No. 1						
11-2	M	35.0	105.0	70.0	1.00	344.0
12-2	F	34.0	126.0	92.0	1.31	306.0
10-6	F	32.0	119.0	87.0	1.24	351.0
10-7	F	28.0	119.0	91.0	1.30	279.0
13-3	M	31.0	91.0	60.0	.86	336.0
11-6	F	26.0	105.0	79.0	1.13	299.0
Lot No. 2						
13-2	M	34.0	103.0	69.0	.98	338.0
11-1	F	35.0	119.0	84.0	1.20	270.0
12-4	F	34.0	127.0	93.0	1.33	280.0
12-1	F	29.0	129.0	100.0	1.43	303.0
10-4	M	30.0	115.0	85.0	1.21	324.0
11-3	F	25.0	110.0	85.0	1.21	352.0
Lot No. 3						
10-5	M	34.0	134.0	100.0	1.43	331.0
11-4	F	36.0	134.0	98.0	1.40	291.0
12-7	F	31.0	131.0	100.0	1.43	348.0
10-8	F	31.0	133.0	102.0	1.46	317.0
12-3	M	30.0	116.0	86.0	1.23	305.0
13-4	F	22.0	100.0	78.0	1.11	264.0
Lot No. 4						
10-9	M	32.0	154.0	122.0	1.74	284.0
13-1	F	37.0	124.0	87.0	1.24	228.0
12-6	F	33.0	132.0	99.0	1.41	280.0
11-5	F	30.0	132.0	102.0	1.46	283.0
10-2	M	30.0	152.0	122.0	1.74	321.0
12-5[2]	M	26.0	120.0	94.0	1.59	253.0

[1] Removed weighing 120 pounds - injury.

[2] Placed on experiment 11-5-52.

PART II. UTILIZATION OF D-AMINO ACIDS BY SWINE

INTRODUCTION

The ability of various animals to use the unnatural isomer of amino acids is of practical as well as theoretical importance. Commercial production of DL-methionine is a recent accomplishment, and several other amino acids are currently being produced on pilot plant and semi-works scale. The efficiency with which the animal uses the D-isomer is an important economic concern and may well determine the practicability of supplementing natural feeds with synthetic amino acids.

It is well recognized that there is wide variation in the degree of use of the unnatural isomer of different amino acids in some species and also in the use of the same amino acid by various species (Albanese, 1947). Various methods have been employed to determine the quantitative and qualitative use of the D-isomer of an amino acid. From a practical point of view in animal feeding, it would appear that techniques involving the ability of the unnatural form to promote nitrogen retention and growth would be preferable. Such techniques have been used to measure the utilization of D-tryptophan and D-methionine in human beings, chicks, rats, and mice.

In order to determine qualitatively whether or not the D-form of tryptophan and methionine is utilized, studies were made with "baby pigs" fed prepared milks of known composition. The milks were supplemented with different amounts of either L- or DL-tryptophan or either L- or D-methionine. Growth and nitrogen retention were used as criteria to estimate the utilization of the D- form as compared to the natural isomer.

REVIEW OF LITERATURE

Tryptophan

DuVigneaud, Sealock, and Van Etten (1932) fed weanling rats a ration consisting of: acid-hydrolyzed casein, 14.7 percent; cystine, 0.3; starch, 40; sucrose, 15; Crisco, 19; cod liver oil, 5; salt mixture, 4; and agar, 2. They found that the addition of 10 milligrams of either D- or L-tryptophan per rat daily to this diet was equally effective in promoting growth. When either D- or L-tryptophan was removed the rats lost weight.

Berg (1934), using the same type of basal ration as duVigneaud, *et al.*, fed four pairs of litter-mate rats for eighty days. Each pair received either 0.1 or 0.2 percent D- or L-tryptophan the first forty days; the second forty days the D- and L- feedings were reversed. Berg found that for growth the rat used either isomer of tryptophan equally well.

More recently Oesterling and Rose (1952) found that the L-tryptophan requirement of male weanling rats was 0.15 percent of the total ration. A tendency toward better growth was obtained on 0.20 percent L-tryptophan, however. Having established the L-tryptophan requirement for the rat, the next step was to determine the effectiveness of D- and DL-tryptophan. For this, comparisons were made of gains induced by adding levels of 0.15 and 0.20 percent DL-tryptophan. A level of 0.20 percent DL-tryptophan was as effective as 0.20 percent L-tryptophan. At the 0.15 percent level the natural form permitted slightly better growth than the racemic mixture. Comparisons of the D- and the L-isomers directly gave differences of even greater magnitude. At the 0.20 percent level, the data suggested a superiority of the L-isomer, a difference of 7.1 grams, which was not significant. At the 0.15 percent level, however, the L-form was decidedly better than the D-form. At this level of intake there was a difference of 34.9 grams in average body weight at the end of 28 days. Oesterling and Rose concluded from these studies that about 75 percent of D-tryptophan is inverted biologically by the rat.

Totter and Berg (1939) fed mice a tryptophan deficient diet composed of: casein hydrolysate, 14.7: cystine, 0.3; agar, 2; salt mixture, 8; sugar, 15; starch, 36; cod liver oil, 5; and Crisco, 19 percent. This diet was supplemented with either 0.2 percent L-, 0.1 percent L- or 0.2 percent D-tryptophan. During a forty-day experimental period, 0.2 percent D-isomer supported growth but the growth rate was less than that obtained with 0.1 percent L-tryptophan.

Rose (1949) reported the essential amino acid requirement of man for maintenance. He fed male graduate students a diet which furnished 6.7 to 10 grams of nitrogen daily. The diet was composed of corn starch, sucrose, butterfat, corn oil, inorganic salts, and vitamins, supplemented with pure amino acids many of which were racemic mixtures. As a result of these studies it was concluded that eight amino acids were required by man for nitrogen equilibrium. It was necessary, in determining quantitative requirements, to determine the value in the human organisms of the D-form of the eight essential amino acids. He found that either D- or L-methionine was equally effective in maintenance of nitrogen equilibrium in man. D-phenylalanine was partially utilized; D-tryptophan was not utilized for maintenance of nitrogen equilibrium. The D- modifications of lysine, valine, leucine, isoleucine, and threonine appeared not to be utilized at all in human subjects.

Wilkening and Schweigert (1947) fed chicks a diet consisting of oxidized casein, 12; gelatin, 10; mineral mixture, 5; corn oil, 5; fish solubles, 2 (dry basis); L-cystine, 0.5; DL-methionine, 1; fortified cod liver oil, 0.75; and enough corn starch to make a total of 100 percent. The water soluble and other fat soluble vitamins plus L- or DL-tryptophan supplementation were added at the expense of the starch. Different levels of L- and DL- tryptophan were added to the basal ration. For each level of DL-tryptophan added, the apparent activity of the D-isomer was calculated from the growth data obtained with chicks receiving different levels of L-tryptophan for a fourteen-day experimental period. These workers found that from 17 to 40 percent of the D-isomer was utilized by the chick. Chicks fed the basal ration containing 0.008 percent L-tryptophan lost an average of 18 grams in fourteen days whereas chicks receiving an optimum level of 0.30 percent DL-tryptophan gained an average of 144 grams in fourteen days.

Reber, Whitehair, and MacVicar (1951) fed baby pigs a "synthetic milk" ration consisting of zein, 17.5; gelatin, 17.5; lard, 41.5; lactose, 19.0; mixed salts, 5; DL-lysine, 1.0; DL-methionine, 0.2 percent, supplemented with either 0.05 percent L- or 0.1 percent DL-tryptophan for two successive eight-day collection periods. Pigs receiving the DL-tryptophan had a better appetite and made somewhat greater weight gains. Nitrogen retention was essentially the same for each type of supplementation, averaging + 1.1 grams per day for the DL-form and + 1.0 gram for the L-isomer. Growth, however, favored the DL-mixture. A second series of two trials followed using 0.1 percent L- and 0.2 percent DL-tryptophan. Again, the nitrogen retention was nearly the same for both groups, + 1.69

grams of nitrogen and + 1.84 grams retained per day for DL- and L-tryptophan, respectively. Weight gains again favored the DL-mixture.

Shelton, Beeson and Mertz (1951) studied the quantitative DL-tryptophan requirement of the weanling pig by feeding a zein-gelatin ration which was deficient in tryptophan. The basal ration contained 0.01 percent tryptophan and 24.5 percent protein. Ten weanling pigs were divided into five lots: Lot 1 received the basal ration; Lot 2 received the basal ration plus 0.1 percent DL-tryptophan; Lot 3 received the basal ration plus 0.2 percent DL-tryptophan; Lot 4 received the basal ration supplemented with 0.3 percent DL-tryptophan; Lot 5 received the basal ration plus 0.4 percent supplementation of DL-tryptophan. Employing growth and feed efficiency as a criteria for establishing the tryptophan requirement they reported that the pigs receiving the basal ration supplemented with 0.2 percent DL-tryptophan gained as rapidly and utilized feed as efficiently as pigs receiving higher levels of DL-tryptophan.

Methionine

Jackson and Black (1938) fed young male albino rats a cystine-methionine deficient diet composed of whole milk powder, 12 percent; gelatin, 3; salt mixture, 1.5; sodium chloride, 1.0; tryptophan, 0.02; Lloyd's reagent adsorbate of vitamin "B", 0.6; lard, 25. Supplements of D- or L-methionine were added at the level of 149 and 298 milligrams per one-hundred grams of diet. They found that either D- or L-methionine was equally effective in supporting rate of growth in weanling rats.

Bennett (1939) fed young rats a diet deficient in methionine in which the principal protein constituent was arachin. Twenty-five male rats from five litters were divided into five groups, using one rat from each litter per group. After eight days on the methionine deficient diet the various groups of rats were supplemented daily with 6 or 12 milligrams of either L- or DL-methionine. Weight gain and food utilization were used as criteria to measure the utilization of DL- and L-methionine for a fourteen-day period. The two groups of rats receiving L-methionine at the level of 6 and 12 milligrams daily gained 11.2 and 13.1 grams, as compared to 8.1 and 12.4 grams for the rats receiving DL-methionine supplementation at the same levels. The food consumed for the two levels of L-methionine was 88.6 and 85.8 grams as compared to 81.0 and 95.4 grams for DL-methionine. Bennett concluded from this data that the L-form was more efficiently utilized than the DL-form.

Bauer and Berg (1943) fed a diet containing amino acids as a source of nitrogen to determine the amino acid requirements of mice and the utilization of their optical isomers. They found that both forms of methionine and phenylalanine were utilized, but that only the natural form of valine, leucine, isoleucine, and threonine could be utilized by the mouse for growth.

Grau and Almquist (1943) fed chicks a ration composed of soybean protein, 23; glucose, 52.8; cellulose, 5; calcium gluconate, 8; mineral mixture, 4.24; cottonseed oil, 5 percent. This ration was supplemented with either 0.25 percent L- or 0.25 percent DL-methionine. During a six-day experimental period the data obtained showed that the two isomers were equally effective in promoting growths in chicks.

Bell <u>et al</u>. (1950) reported the effect of methionine supplementation of a soybean meal-purified ration for growing pigs. Two groups of 4 litter-mate Yorkshire barrows were allotted to the four rations and studied in a 4 x 4 Latin square design. The rations fed contained 1.68 percent nitrogen. The nitrogen for each ration was supplied by either whole egg containing 0.27 percent methionine; soybean meal containing 0.07 percent methionine; soybean meal plus egg plus methionine, to make a total of 0.27 percent methionine; soybean meal plus methionine to make a total of 0.27 percent methionine. Nitrogen balance studies were used as the primary measure of the relative value of the proteins fed. Bell et al. found that the pigs receiving soybean meal without methionine supplementation retained a significantly lower percentage of the apparent absorbed nitrogen than the pigs receiving any one of the other three rations. It was concluded from this data that the methionine requirement for growing swine was between 0.07 and 0.27 percent of the diet, when the diet contained 10 percent protein.

Shelton, Beeson, and Mertz (1951) fed weanling pigs a ration consisting of oxidized casein, 12; gelatin, 10; dextrose, 39.84; dextrin, 25; mineral mix, 5.2; lard, 5; celluflour, 2.0; liver extract, 0.5; APF supplement, 0.16; DL-tryptophan, 0.3 percent. The ration was supplemented with fat and water soluble vitamins. This basal ration contained 0.1 percent methionine, 0.01 percent cystine, and 21 percent protein. Nine pigs were divided into five lots. The pigs in Lot 1 received the basal ration; Lot 2, basal plus 0.6 percent cystine; Lot 3, basal plus 0.5 methionine; Lot 4, basal plus 0.2 methionine plus 0.3 cystine; Lot 5, basal plus 0.5 methionine plus 0.6 cystine. Weight gains and feed efficiency were used to measure the methionine requirement for a 28-day period. The pigs receiving the basal ration supplemented with 0.5 percent methionine, or 0.2 percent methionine plus 0.3 percent cystine, or 0.5 percent methionine plus 0.6 cystine made the most rapid gains and utilized their feed most efficiently. It was concluded on the basis of this data that the methionine requirement was 0.3 percent in the presence of 0.31 percent cystine or 0.6 percent methionine of the total ration for growing swine.

More recently, Curtin *et al.* (1952) fed a ration in which the protein consisted of isolated soybean protein and found that the methionine requirement of weanling pigs was not more than 0.45 percent of the ration when the ration contains 0.27 percent cystine.

EXPERIMENTAL

Studies on D-Tryptophan Utilization

Ten litter-mate purebred Duroc-Jersey pigs (8 females and 2 males) were allowed to nurse the sow for two days, then transferred to individual pens equipped with raised floor of one-half-inch screen mesh which permitted essentially quantitative collection of urine and feces. The pens were located in the small animal room of the Animal Husbandry building where a constant temperature of 78° F. was maintained. The pigs were fed artificial "milks" of known composition containing 20 percent solids. These milks were prepared by dissolving either lactose or cerelose and gelatin in warm water and homogenizing the mixture with melted lard by means of a medium-size mechanical homogenizer. The other protein component, salts, amino acids (other than tryptophan), and vitamins were then added and the mixture was suspended with a Waring blender. The milk was refrigerated until used at which time small amounts were resuspended by warming and blending. The baby pigs were fed Ration 1 (Table 1) until they had become accustomed to the new environment and to eating from crocks.

Ration 2 was fed during the experimental periods. It was prepared as above and a solution containing either L- or DL-tryptophan was dispended into a measured quantity of the milk at the time of reblending prior to feeding. Ration 2 was designed to be extremely deficient in tryptophan. By calculation it contained less than 0.02 percent tryptophan and this was confirmed by microbiological assay of the ration components. A lysine deficiency (Brinegar _et al_., 1950) and a possible methionine deficiency (Shelton _et al_., 1951) were corrected by the addition of 1.0 percent DL-lysine·HCl and 0.2 percent DL-methionine.

During collection periods quantitative collections of urine and feces were made for successive two-day periods. Any rejected food, together with the food wasted, was combined with the feces and analyzed. The urine was collected in a bottle containing an amount of HCl to render it distinctly acid, then quantitatively transferred to a volumetric flask of convenient size and made to volume. From this an aliquot was taken for nitrogen analysis. Feed constituents were likewise analyzed for total nitrogen to determine the amount of nitrogen offered. Nitrogen retention was calculated by the following formula: Nitrogen retention = (Nitrogen offered) - (Nitrogen of refused feed and feces) - (Urinary nitrogen). The pigs were weighed at two-day intervals.

Table 1

Rations Used in DL-Tryptophan Utilization Study*

Ingredients	Percentage Composition Ration 1	 Ration 2	 Ration 3
Crude casein	35		
Zein		17.5	17.5
Gelatin		17.5	17.5
Lard	41.5	41.5	41.5
Lactose	20.5	19.0	
Cerelose			19.0
Salts**	5.0	5.0	5.0
DL-Lysine·HCl		1.0	1.0
DL-Methionine		.2	.2

* The following vitamins were added to a liter of milk: thiamine 1.1 mg.; riboflavin 1.8 mg.; niacin 10.1 mg.; inositol 26.8 mg.; choline 260 mg.; para-amino benzoic acid 5.0 mg.; folic acid 0.13 mg.; biotin 0.025 mg.; pyridoxine 2.0 mg.; calcium pantothenate 7.1 mg.; ascorbic acid 130 mg.; vitamin B-12 10 mcg.; vitamin A 900 I.U.; Vitamin D 120 I. U.; menadione 0.29 mg.; alpha tocopherol acetate 1.5 mg.

** Johnson, B. C. <u>et al</u>., <u>Jour</u>. <u>Ani</u>. <u>Sci</u>. (1948), 7:486.

The experiment consisted of an adjustment period followed by a depletion period and finally by a series of four eight-day collections during which each pig received each of the treatments. During the first four days of the adjustment period the pigs were fed Ration 1. They were gradually shifted from Ration 1 to Ration 2 during the next six days. The following six days constituted a depletion period during which the pigs were fed Ration 2 without any tryptophan supplementation. Quantitative collections of urine and feces were begun at this time. The response of the pigs to this tryptophan-deficient ration is shown in Table 2.

Following this depletion period the pigs were kept on this same ration, but four pigs in each of two groups were supplemented with either 0.05 percent L- or 0.1 percent DL-tryptophan. Two pigs served as a positive control and received 0.3 percent DL-tryptophan; two were used as negative controls without any tryptophan supplementation. Equal amounts of food were offered, and the quantity was kept sufficiently small to assure that nitrogen intake was relatively constant for all pigs. Four successive two-day collection periods (18 to 25 days of age) constituted Trial 1. During the next eight days (Trial 2) those pigs which had received a supplement of 0.05 percent L-tryptophan were fed the same ration with 0.1 percent DL-tryptophan and vice versa. The results of these two trials are summarized in Table 3.

A third trial was then conducted (34-41 days) in which Ration 3 replaced Ration 2. The essential difference between these two rations was in the carbohydrate constituent. The data obtained in this trial are also presented in Table 3. The individual data for all pigs are shown in Table 9, appendix.

Table 2

Response of Young Pigs to Tryptophan-Deficient Ration
12-17 Days

Pig Number	1	2	3	4	5	6	7	8	9	10
Weight Change (gm.)	-50	-130	-105	+25	-50	-6	-95	-185	-30	-20
N offered (gms.)	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
N retained (gms.)	3.2	0.6	6.4	5.3	6.1	4.3	3.7	3.6	3.9	2.3
N retained per day (gms.)	0.54	0.10	1.07	0.89	1.01	0.72	0.61	0.60	0.65	0.38

Table 3

Response of Young Swine to Supplmentation of Tryptophan-Deficient Ration with L- and DL-Tryptophan

	Trial 1		
Level of supplementation	0.05% L-	0.1% DL-	0.3% DL-
Number of pigs	4	4	2
Age (days)	18-25	18-25	18-25
Weight change (gm.)	280	322	320
Nitrogen offered (gm.)	36.8	36.8	37.0
Nitrogen retained (gm.)	8.6	11.6	14.4
Nitrogen retained per day (gm.)	1.08	1.44	1.80
	Trial 2		
Level of supplementation	0.05% L-	0.1% DL-	0.3% DL-
Number of pigs	4	4	2
Age (days)	26-33	26-33	26-33
Weight change (gm.)	234	309	480
Nitrogen offered (gm.)	39.5	39.6	39.8
Nitrogen retained (gm.)	7.4	8.9	12.2
Nitrogen retained per day (gm.)	.92	1.11	1.52
	Trial 3		
Level of supplementation	0.05% L-	0.1% DL-	0.3% DL-
Number of pigs	4	4	2
Age (days)	34-41	34-41	34-41
Weight change (gm.)	116	202	332
Nitrogen offered (gm.)	38.5	38.5	38.7
Nitrogen retained (gm.)	8.9	10.8	15.9
Nitrogen retained per day (gm.)	1.10	1.35	1.99

Results and Discussion

No particular difficulties of a technical nature were encountered in preparing the milk rations or in training the baby pigs to eat them. The pigs readily consumed Ration 1 containing casein, but on being transferred to the tryptophan-deficient Ration 2 they sometimes refused feed and vomited. When tryptophan was added, a distinctive improvement in appetite and other subjective signs were noted. No particular difference was noted in the response of the pigs when cerelose in Ration 3 was substituted for lactose in Ration 2.

Maintenance of nitrogen equilibrium has long been accepted as a major criterion of the degree of essentiality of an amino acid. In view of the demonstrated essentiality of tryptophan for maintenance of nitrogen equilibrium or growth in a number of higher animals, the failure to observe prompt negative nitrogen balances when baby pigs were transferred from a ration containing casein, which promoted significant nitrogen retention, to one deficient in tryptophan was unexpected. Examination of the data obtained, however, showed that while the pigs did not gain weight, they were at most in only slight negative balance. However, certain qualifications must be kept in mind in interpreting such data. In common with all such studies, any loss of urine, or feces, or wasted feed resulted in an over-estimation of nitrogen retention. Although every precaution was taken to minimize losses, it is recognized that some loss cannot be avoided. This is particularly true when the pigs are young, when they do not have a good appetite, and when feed wastage is high. All of these conditions occurred during the depletion period on the low-tryptophan ration. Even when such factors are taken into account, these data strongly suggest that the young pig has a lower preformed dietary requirement for tryptophan for maintenance of nitrogen equilibrium than do most other animals for which quantitative requirements have been estimated. Examination of the data on pigs 11 and 12 Table 9, appendix, which were maintained on this low-tryptophan ration for a three-week period, support this view. Further evidence of a low maintenance requirement for tryptophan is found in the observations of Shelton, Beeson, and Mertz, (1951) who fed a diet somewhat similar in composition to Ration 2 to post-weanling pigs. They reported that during a 28-day period on this ration pigs weighing about 35 pounds initially lost an average of 2.5 to 3.0 pounds. Maintenance of body weight within such narrow limits would be unlikely, were a severe nitrogen deficit existing.

Since the purpose of this experiment was to determine whether or not D-tryptophan was utilized for nitrogen retention, both L- and DL-isomers were fed at levels below that reported by Shelton, Beeson, and Mertz (1951) as necessary for maximum growth of older pigs consuming a similar ration. Limiting the supply of tryptophan in this manner would tend to permit maximum differences between two groups fed equal amounts of L-tryptophan as the natural isomer and the racemic mixture. Addition of either 0.05 percent L- or 0.1 percent DL-tryptophan resulted in marked improvement in appetite in the pigs which had been receiving the unsupplemented Ration 2. The pigs receiving the higher level of total tryptophan showed the more marked subjective improvement; they consumed their food more promptly and with an occasional exception ate all that was offered them. The pigs receiving 0.05 percent L-tryptophan, however, ate with greater reluctance and more frequently rejected a portion of the feeding. Objective differences were less obvious. The weighted averages of gains and nitrogen retention for the three trials are: 26.2, 1.04 grams for 0.05 percent L-tryptophan; 34.8 and 1.30 for 0.1 percent DL-tryptophan. It will be noted that the weighted averages favor the higher level of tryptophan intake in the form of the DL-mixture. The combined subjective observations and objective data strongly indicate utilization of the D-isomer. Whether this utilization is relatively high (as in the rat) or low (as in the chick) awaits the availability of the D-form in sufficient quantity to compare it with the natural isomer.

Summary

The degree of utilization of D-tryptophan by swine was studied using "baby pigs" fed rations deficient in tryptophan and supplemented with either L- or DL-form of this amino acid. Growth and nitrogen retention were the principal criteria employed to estimate the efficiency of use of the unnatural isomer. Pigs maintained on a ration extremely deficient in tryptophan lost weight, but, at most, showed only a slight negative nitrogen balance. When this ration was supplemented with 0.05 percent L-, 0.1 percent DL-, or 0.3 percent DL-tryptophan, the pigs consumed the ration more readily, growth improved, and definitive positive nitrogen retention was found. Averages for every trial favored the pigs receiving DL-tryptophan, but differences were not sufficiently great to show statistical significance. These combined data support the view that partial utilization of D-tryptophan was effected.

Studies on D-Methionine Utilization

Two separate nitrogen balance experiments were conducted. Nine litter-mate purebred Duroc-Jerseys were used in the first experiment, and eight purebred Poland Chinas in the second. In both experiments the pigs were allowed to nurse the sow for at least two days. They were then transferred to individual pens in the small animal room in the Animal Husbandry building. The same experimental procedure was employed in these experiments as in the previous nitrogen balance study.

Experiment 1

This experiment consisted of an adjustment period on Ration 1 (Table 4) for a six-day period, followed by an eight-day depletion period on Ration 2. Quantitative collections of urine and feces were made the last six days of the depletion period. The response of the pigs to this low-methionine ration is shown in Table 5.

Following this depletion period, the pigs were kept on this same ration, supplemented with either 0.05 percent L- or 0.05 percent D-methionine. Equal amounts of food were offered, and the quantity was kept sufficiently small to assure that the nitrogen intake was relatively constant for all pigs. Three successive two-day collection periods constituted Trial 1.

During the next six days (Trial 2) those pigs which had received a supplement of 0.05 percent L-methionine were fed the same ration with 0.05 percent D-methionine and vice versa. Following these trials, a four-day trial was conducted, using supplementation levels of none, 0.1 percent L- and 0.1 percent D-methionine. The results of all three trials are summarized in Table 6. The data for each pig are shown in Table 10, appendix.

Table 4

Rations Used in D- and L-Methionine Utilization Study*

Ingredients	Percentage Composition Ration Number 1	2	3	4
Crude casein			30.0	
Soybean sodium proteinate	20.0	20.0		20.0
Lard	45.0	45.0	42.5	35.0
Lactose	30.0	30.0	23.0	40.0
Salts**	5.0	5.0	5.0	5.0
L-cystine	0.14	0.14		0.14
DL-methionine	0.14			
Aureomycin Mg/Kg			100	100

* The following vitamins were added to a liter of milk: thiamine 1.1 mg.; riboflavin 1.8 mg.; niacin 10.1 mg.; inositol 26.8 mg.; choline 260 mg.; para-amino benzoic acid 5.0 mg.; folic acid 0.13 mg.; biotin 0.025 mg.; pyridoxine 2.0 mg.; calcium pantothenate 7.1 mg.; ascorbic acid 130 mg.; vitamin B-12 10 mcg.; vitamin A 900 I.U.; vitamin D 120 I.U.; menadione 0.29 mg.; alpha tocopherol acetate 1.5 mg.

** Johnson, B. C. et al. Jour. Ani. Sci. (1948), 7:486.

Table 5

Response of Young Pigs to a Low Methionine Ration
Experiment 1 Duration 6 Days

Pig Number	1	2	3	4	5	6	7	8	9
Weight gain (gm.)	130	100	155	200	150	140	120	85	65
N offered (gm.)	7.50	7.50	7.50	5.39	7.50	7.50	7.50	7.50	7.50
N retained (gm.)	5.0	4.9	4.8	3.6	4.1	4.8	4.3	4.3	3.8
N retained per day (gm.)	0.83	0.82	0.80	0.90	0.68	0.80	0.72	0.72	0.63

Table 6

Response of Young Pits to Supplementation of a Low Methionine Ration Supplemented with L- and D-Methionine

Experiment 1

Trial 1			
Level of supplementation		0.05% L-	0.05% D-
Number of pigs		5	4
Length of trial (days)		6	6
Weight change (gm.)		178	151
Nitrogen offered (gm.)		9.4	9.4
Nitrogen retained (gm.)		5.0	5.45
Nitrogen retained per day (gm.)		0.83	0.91
Trial 2			
Level of supplementation		0.05% L-	0.05% D-
Number of pigs		4	5
Length of trial (days)		6	6
Weight change (gm.)		306	247
Nitrogen offered (gm.)		11.0	11.0
Nitrogen retained (gm.)		6.7	6.3
Nitrogen retained per day (gm.)		1.12	1.05
Trial 3			
Level of supplementation	None	0.1% L-	0.1% D-
Number of pigs	3	3	3
Length of trial (days)	4	4	4
Weight change (gm.)	332	293	273
Nitrogen offered (gm.)	10.4	10.4	10.4
Nitrogen retained (gm.)	6.4	6.6	6.5
Nitrogen retained per day (gm.)	1.61	1.64	1.63

Table 7

Response of Young Pigs to a Low-Methionine Ration
Experiment 2   Duration 4 Days

Pig Number	1	2	3	4	5*	6	7	8
Weight Gain (gm.)	310	270	370	225	340	335	275	125
N offered (gm.)	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
N retained (gm.)	5.3	3.1	6.3	4.5		5.0	4.2	2.6
N retained per day (gm.)	1.32	0.78	1.58	1.12		1.25	1.05	1.65

* Lost collection.

Experiment 2

This experiment was essentially a repetition of Experiment 1. The experiment began with an adjustment period of twelve days during which the pigs were accustomed to the methods of feeding and gradually changed from Ration 3 to Ration 4. They were fed Ration 4 without any methionine supplementation for a five-day period. The response of the pigs to this ration is shown in Table 7.

This depletion period was followed by an eight-day collection period. The feeding design of this period and results obtained were as shown in Table 8.

Table 8

The Experimental Design and Results of Pigs Fed a Low-Methionine Ration Supplemented with L- or D-Methionine

Experiment 2

Supplement	None	0.05% L-	0.05% D-
Quantity fed (gm.)			
Pair 1		1680	1680
Triad 2	2160	2160	2160
Triad 3	1875	1875	1875
Average	2018	1905	1905
Weight gain (gm.)			
Pair 1		1440	1480
Triad 2	1695	1750	1925
Triad 3	1175	1410	1590
Average	1435	1533	1654
Feed efficiency (gm.)			
Pair 1		1.17	1.14
Triad 2	1.27	1.23	1.12
Triad 3	1.60	1.33	1.18
Average	1.44	1.24	1.15

Results and Discussion

An examination of the data in Experiment 1, Trial 3, reveals no difference between the pigs receiving no methionine supplementation when compared to either 0.1 percent D- or L-methionine supplementation in weight gain or nitrogen retention. By calculation the basal ration contained 0.16 percent methionine and was assumed to contain an equal amount of cystine, since the methionine and cystine content of soybean meal are practically the same. Supplementing the basal ration with 0.14 percent cystine, the total cystine content was 0.30 percent, which is the optimum requirement reported by Shelton, Beeson, and Mertz (1951) for maximum growth of weanling pigs. Therefore, the basal ration contained about one-half the methionine requirement in the presence of adequate cystine. In Experiment 2, the pigs receiving supplementation of D- or L-methionine gained slightly faster than the pigs receiving the basal ration. All during this latter experiment a persistent gastrointestinal disturbance existed, and after fourteen days the experiment was terminated. Fecal collections were rendered so difficult that the nitrogen balance data obtained was irregular and it has been omitted.

Summary

The degree of utilization of D-methionine by swine was studied using "baby pigs" fed rations low in methionine and supplemented with either L- or D-form of methionine. Growth and nitrogen retention were employed to estimate the efficiency of utilization. Pigs fed a ration containing 0.16 percent methionine gained almost as rapidly and had nitrogen retention values as high as pigs receiving this ration supplemented with either 0.05 percent D- or L- or 0.1 percent D- or L-methionine, respectively.

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APPENDIX

Table 9

Response of Pigs to Supplementation of Tryptophan-Deficient Ration with L- and DL-Tryptophan

	Level of Supple-mentation	Weight Change (gm.)	Nitrogen Offered (gm.)	Nitrogen Retained (gm.)	Nitrogen Retained Per Day (gm.)
		Trial 1:	18-25 Days		
Pig No.					
1	0.05% L-	250	36.8	11.1	1.39
2	0.05% L-	275	36.8	8.5	1.06
6	0.05% L-	275	36.8	7.8	0.98
9	0.05% L-	320	36.8	7.1	0.89
4	0.1% DL-	310	36.8	12.0	1.50
5	0.1% DL-	315	36.8	13.2	1.65
7	0.1% DL-	335	36.8	9.0	1.12
10	0.1% DL-	330	36.8	11.8	1.47
3	0.3% DL-	320	37.0	14.7	1.84
8	0.3% DL-	320	37.0	14.1	1.76
		Trial 2:	26-33 Days		
4	0.05% L-	310	39.5	7.8	0.98
5	0.05% L-	290	39.5	10.7	1.34
7	0.05% L-	160	39.5	5.4	0.68
10	0.05% L-	175	39.5	5.5	0.69
1	0.1% DL-	230	39.6	11.1	1.39
2	0.1% DL-	315	39.6	7.9	0.99
6	0.1% DL-	375	39.6	8.1	1.01
9	0.1% DL-	315	39.6	8.4	1.05
3	0.3% DL-	525	39.8	10.1	1.26
8	0.3% DL-	435	39.8	14.3	1.79
		Trial 3:	34-41 Days		
1	0.05% L-	210	38.5	11.1	1.39
5	0.05% L-	20	38.5	8.1	1.01
7	0.05% L-	130	38.5	8.2	1.02
9	0.05% L-	105	38.5	8.0	1.00
2	0.1% DL-	145	38.5	11.4	1.42
4	0.1% DL-	180	38.5	12.3	1.54
6	0.1% DL-	220	38.5	11.2	1.40
10	0.1% DL-	265	38.5	8.4	1.05

Table 9 (continued)

	Level of Supple-mentation	Weight Change (gm.)	Nitrogen Offered (gm.)	Nitrogen Retained (gm.)	Nitrogen Retained Per Day (gm.)
3	0.3% DL-	400	38.7	17.6	2.20
8	0.3% DL-	265	38.7	14.2	1.78
			16-23 Days		
11	None	-65	34.4	9.1	1.13
12	None	-65	34.4	8.3	1.04
			Trial 4		
3[1]	0.3% DL-	325	39.8	21.5	3.59
8[2]	0.3% DL-	390	89.0	45.7	3.26
11[3]	None	-125	71.4	20.2	1.44
12[3]	None	-85	71.4	18.7	1.34

[1] No. 3 on trial 42-47 days of age.

[2] No. 8 on trial 42-55 days of age.

[3] No. 11 and 12 on trial 24-37 days of age.

Table 10

Response of Pigs to Supplementation of Low-Methionine Ration with L- and D-Methionine

	Level of Supple-mentation	Weight Change (gm.)	Nitrogen Offered (gm.)	Nitrogen Retained (gm.)	Nitrogen Retained Per Day (gm.)
		Trial 1:	Duration 6 Days		
Pig No.					
1	0.05% D-	185	9.5	6.0	1.0
2	0.05% D-	190	9.5	5.9	0.98
4	0.05% D-	80	9.0	4.4	0.73
7	0.05% D-	150	9.5	5.5	0.92
3	0.05% L-	210	9.5	5.6	0.93
5	0.05% L-	175	9.5	5.4	0.90
6	0.05% L-	145	9.5	5.2	0.87
8	0.05% L-	160	9.0	4.1	0.68
9	0.05% L-	200	9.5	4.7	0.78
		Trial 2:	Duration 6 Days		
3	0.05% D-	245	11.0	6.9	1.15
5	0.05% D-	275	11.0	6.4	1.06
6	0.05% D-	300	11.0	6.4	1.06
8	0.05% D-	270	11.0	5.7	0.95
9	0.05% D-	145	11.0	6.3	1.05
1	0.05% L-	295	11.0	7.2	1.20
2	0.05% L-	310	11.0	6.9	1.15
4	0.05% L-	310	11.0	6.2	1.03
7	0.05% L-	310	11.0	6.6	1.10
		Trial 3:	Duration 4 Days		
1	None	335	10.4	6.8	1.70
5	None	370	10.4	6.2	1.55
6	None	290	10.4	6.3	1.58
3	0.1% D-	330	10.4	7.7	1.92
8	0.1% D-	250	10.4	6.2	1.55
9	0.1% D-	240	10.4	5.7	1.42
2	0.1% L-	335	10.4	7.0	1.75
4	0.1% L-	275	10.4	6.7	1.68
7	0.1% L-	270	10.4	6.0	1.50

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PART II. UTILIZATION OF D-AMINO ACIDS BY SWINE

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