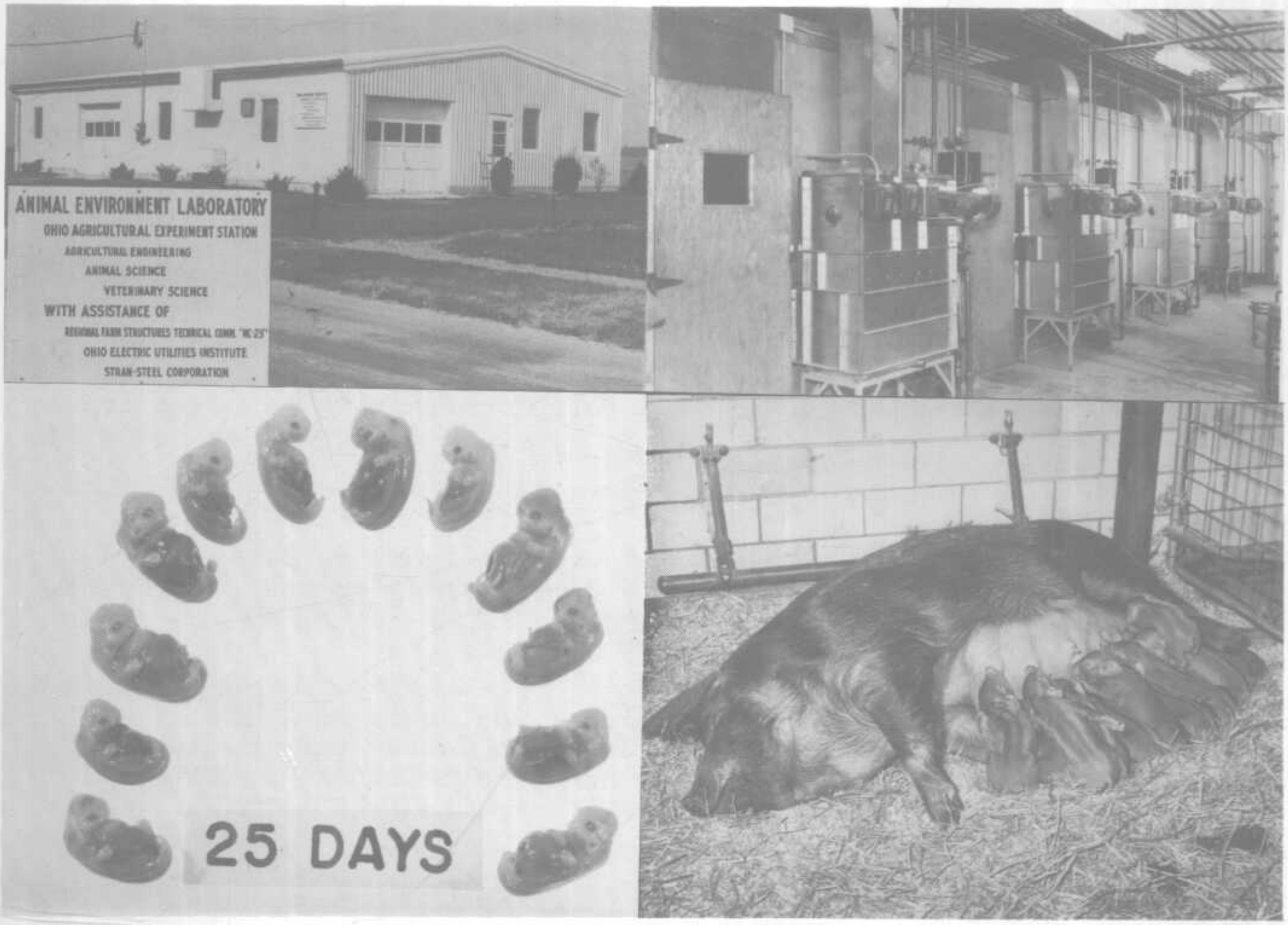
RESEARCH SUMMARY 13 JULY 1966

SWINE RESEARCH



Ohio Agricultural Research and Development Center

WOOSTER, OHIO

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Appreciation is expressed to Glenn Todd, herdsman, and other workers at the W. L. Robison Swine Research Center and to James Foster, manager, and co-workers at the Western Branch, South Charleston, for the feeding and care of experimental animals.

7/66-4.5M

VITAMIN B_{12} IN SOW RATIONS

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Vitamin B_{12} is considered an essential nutrient for growing-finishing pigs and for sows. The recommended feeding level for breeding stock is the same as for growing-finishing pigs--10 mg. per ton of feed (National Research Council, 1964).

While considered essential, the role of vitamin B_{12} in the reproductive process has not been established. In earlier work, it was suggested that the supplementation of 10 times the level presently recommended in a complete feed (100 mg. per ton) increased both littersize and birthweight in sows but not in gilts (AS 133-5, 1964). In these earlier trials, a mixed-protein basal ration was fed which, without supplementation, furnished approximately 10 mg. of B_{12} activity per ton of feed.

An all-plant (corn-soy) basal ration has been used to further measure the effects of high levels of vitamin B_{12} on reproductive performance. The study reported extended over four consecutive farrowing periods, permitting measurement of the long-term effects of depletion and supplementation.

EXPERIMENTAL PROCEDURE

Thirty-six Duroc gilts from the Center's herd were allotted by age, weight, and relationship to 1 of 3 ration treatments:

Lot 1 - Basal ration
Lot 2 - Basal + 100 mg. of vitamin B_{12} per ton
Lot 3 - Basal + 1,000 mg. of vitamin B_{12} per ton

Average initial age was 205 days and average initial weight was 249 lb. A preliminary feeding period of 30 days preceded initiation of first breeding.

Composition of the basal ration is shown in Table 1. Vitamin B_{12} was added in crystalline form[1]. The animals were confined to concrete-floored pens and each lot was hand fed equal quantities of feed daily. All females remained on the same ration treatment for four consecutive farrowing and 8-week lactation periods (778 days).

Analytical values were obtained for total body B_{12} activity in pigs at birth and for liver tissue from a sampling of similar gilts at the start and all sows at the end of the study.

Performance measurements are summarized in Tables 2 and 3.

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[1] Furnished through the courtesy of Merck and Co., Inc., Rahway, N. J.

TABLE 1.--Composition of Basal Rations[a]

Ingredient	Breeding-gestation	Lactation
Ground shelled corn	52.60	56.60
Dehydrated alfalfa meal (17%)	15.00	10.00
Oats, finely ground	15.00	-
Soybean oil meal (44%)	14.50	15.50
Wheat middlings	-	15.00
Steamed bonemeal	1.16	1.16
Ground limestone	1.16	1.16
Trace mineralized salt	.58	.58
B-vitamin supplement[b]	+	+
Calculated crude protein, %	15.0	15.5

[a] Vitamin B_{12}, was added to Lot 2 and 3 rations as a 0.1% trituration of cyanocobalamin with mannitol.

[b] Merck No. 92 Vitamin Mixture to furnish 300 mg. riboflavin, 550 mg. pantothenic acid, 1,350 mg. niacin and 1,500 mg. choline chloride per 100 lb. of ration.

SUMMARY OF RESULTS

The two levels of vitamin B_{12} supplementation had no apparent effect on performance in the first and second farrowing periods. However, B_{12} addition appeared to increase sow productivity in the third and fourth farrowings.

An average increase of 2.3 and 2.0 live pigs farrowed was associated with the 1,000 mg./ton level of addition in farrowings 3 and 4 respectively. No increase in number of pigs farrowed resulted from the lower B_{12} level.

Pig and litterweight at birth were increased by both levels of B_{12} supplementation in the latter two farrowings. Because of increased littersize and weight of pigs at birth, the higher level of supplementation resulted in the greatest weight of live pigs farrowed. Vigor at birth and livability to 14 days were not lowered by the increased number of pigs farrowed by Lot 3 sows.

Determinations of total body B_{12} activity in pigs at birth showed a linear relationship to the B_{12} intake of the sow. In pigs farrowed by sows fed the basal ration, vitamin content did not decrease over the four farrowing periods. The terminal B_{12} activity in liver from sows was also directly related to B_{12} intake. Values for sows fed the basal ration, when compared to those obtained at the start of the trial, did not decrease during the 2-year period.

These results indicate that the vitamin B_{12} requirement of the sow is not known but that for an extended reproductive period it is probably higher than the present recommended feeding level.

TABLE 2.--Summary of First and Second Farrowing Performance

	First Farrowing 1964 Spring			Second Farrowing 1964 Fall			Av. of 1st & 2nd Farrowing		
	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
B_{12} level/ton, mg.	0	100	1,000	0	100	1,000	0	100	1,000
No. bred	12	12	11	12	12	11	24	24	22
No. farrowed	12	12	11	11	11	10	23	23	21
Av. no. pigs farrowed:									
Alive	10.1	9.3	10.5	11.2	7.7	9.9	10.7	8.6	10.2
Stillborn	.3	.4	.5	.3	.4	.8	.3	.4	.7
Total	10.4	9.7	11.0	11.5	8.1	10.7	11.0	9.0	10.9
% Alive	96.8	95.7	95.0	97.6	95.5	92.5	97.2	95.6	93.9
Av. birthweight live pigs, lb.:									
Litter	26.0	26.2	27.5	31.9	23.7	27.7	28.8	24.9	27.6
Pigs	2.57	2.57	2.63	2.83	3.07	2.79	2.70	2.79	2.71
Vigor at birth, %:									
Strong	74.4	61.6	73.9	79.0	78.8	72.7	76.7	69.0	73.4
Medium	17.4	24.2	26.1	14.5	12.9	19.2	16.0	19.3	22.9
Weak	8.2	14.2	-	6.5	8.3	8.1	7.3	11.7	3.7
Strong + med.	91.8	85.8	100.0	93.5	91.7	91.9	92.7	88.3	96.3
Av. 14-day performance:									
Littersize	9.6	9.1	10.2	9.3	7.0	7.2	9.5	8.0	8.8
Litterweight	76.0	71.3	77.5	79.5	66.4	61.3	77.7	69.0	69.8
Pig weight, lb.	7.93	7.84	7.61	8.41	8.63	8.51	8.20	8.20	7.96

TABLE 3.--Summary of Third and Fourth Farrowing Performance

	Third Farrowing 1965 Spring			Fourth Farrowing 1965 Fall			Av. of 3rd & 4th Farrowing		
	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
B_{12} level/ton,mg.	0	100	1,000	0	100	1,000	0	100	1,000
No. bred	11	12	10	11	12	10	22	24	20
No. farrowed	11	12	10	10	12	9	21	24	19
Av. no. pigs farrowed:									
Alive	10.2	10.8	12.5	10.7	9.8	12.7	10.4	10.3	12.6
Stillborn	1.3	1.3	.7	.9	1.5	.9	1.1	1.4	.8
Total	11.5	12.1	13.2	11.6	11.3	13.6	11.5	11.7	13.4
% Alive	88.9	89.7	94.7	92.2	86.7	93.4	90.4	88.3	94.1
Av. birthweight, live pigs, lb.:									
Litter	27.0	33.1	38.1	28.4	29.4	36.8	27.7	31.3	37.5
Pigs	2.66	3.06	3.05	2.66	2.99	2.90	2.65	3.03	2.98
Vigor at birth, %:									
Strong	67.9	84.6	87.2	77.6	84.7	80.7	72.6	84.6	84.1
Medium	21.4	13.1	9.6	16.8	9.3	13.1	19.2	11.3	11.3
Weak	10.7	2.3	3.2	5.6	6.0	6.2	8.2	4.1	4.6
Strong + med.	89.3	97.7	96.8	94.4	94.0	93.8	91.8	95.9	95.4
Av. 14-day performance:									
Littersize	8.8	9.8	10.8	7.2	8.0	9.7	8.0	8.9	10.3
Litterweight	72.1	89.5	98.1	56.0	65.5	74.6	64.4	77.5	87.0
Pig weight,lb.	8.18	9.17	9.08	7.78	8.19	7.72	8.01	8.73	8.47

THE EFFECT OF HIGH TEMPERATURE AND VARIABLE HUMIDITY ON THE REPRODUCTIVE PERFORMANCE OF GILTS

(Progress Report)

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Field experience indicates that high summer temperatures can cause a decline in the reproductive performance of swine. The manner in which gilts and sows react to high temperatures, and how this in turn influences performance, has not been determined. Research with the growing-finishing pig has shown that body temperature increases at some elevation in environmental temperature (above 80° F.) and that humidity (the amount of water vapor in the air) is an important factor influencing animal response.

Controlled study of the effect of high temperature and variable humidity on the reproducing gilt was undertaken following the construction in 1962 of a large-animal Environmental Control Laboratory. The research has been conducted as a cooperative project between the Departments of Agricultural Engineering and Animal Science. The results reported are a summary of the first phase of the study, now nearing completion. This phase of the research has extended over a 3-year period. A complete formal publication of results will follow termination of the current trial.

EXPERIMENTAL PROCEDURE

In 3 experiments, dry bulb temperatures of 80°, 86° and 92° F. were imposed on sexually mature Duroc gilts. Length of exposure was for one estrual cycle prior to breeding and the first 25 days of gestation. Within each experiment, one of three dry-bulb temperatures and four different levels of dew-point temperature (relative humidity) were maintained. Thus, at 80° F. a total of 20 gilts per treatment were subjected to dew-point temperatures of either 52°, 60°, 68°, or 76° F. At 86° and 92° F., the same number of gilts were subjected to dew-point temperatures of 60°, 68°, 76°, or 84° F. In the 3-year period, measurements have been obtained on a total of 240 gilts. At this writing, slaughter information is not yet available for the last 20 gilts in Experiment III.

Gilts were placed at random in the four rooms on the first day of estrus and were bred on the first return to estrus, approximately 21 days later. The gilts were slaughtered 25 days after breeding and the numbers of corpora lutea and live embryos determined. Boars used for breeding were confined to the air-conditioned outer shell of the laboratory, which was held at a temperature of 65° to 75° F.

Gilts were bred on the first day of observed estrus. In Experiment I, each of the first group of gilts confined to the rooms was bred to a single boar. One of the four boars used proved to be infertile. Subsequently, all gilts have been bred on the first day of estrus to two different boars. Average age at breeding was 250 days.

TABLE 1.--A Summary of Measurements Obtained in the Controlled Temperature Rooms and Observations at Slaughter 25 days after Breeding
(Adjusted for differences in age and initial weight)

Experiment	I	II	III
Dry bulb temperature	80°F	86°F	92°F[a]
Average daily feed intake, lb.[b]	4.72	4.54	(4.20)
Average daily gain, lb.	1.06	1.02	(0.50)
Average rectal temperature, (°F.)	101.1	102.8	(103.8)
Breeding and reproductive performance			
No. which returned to estrus after breeding	2[c]	8	(8)
No. which failed to come into estrus in rooms	0	2	(3)
No. not pregnant at slaughter (did not return to heat after breeding)	5	2	(3)
No. pregnant (25 days)[d]	67	67	(46)
Average no. corpora lutea (25 days)	14.2	13.6	(13.2)
Average no. live embryos (25 days)	10.3	9.7	(9.6)

[a] Data for the remaining 20 gilts, presently under 92°F. exposure are not yet available.

[b] Offered 5 lb./day.

[c] Does not include 6 gilts which returned to heat in Trial 1 as a result of boar infertility (see procedure).

[d] One gilt died at 86°F. Cause of death diagnosed as a ruptured ureter.

Rectal temperatures were obtained periodically and an attempt was made to visually determine respiration rate.

Individual feeding stalls permitted an accurate record of feed intake. Five pounds of a complete (15% crude protein) ration were offered to each gilt daily and each room was provided with an automatic waterer.

A summary of the effects of dry-bulb temperature on performance is shown in Table 1. Data relative to the effects of dew-point temperature will be analyzed after completion of the current experiment.

SUMMARY OF RESULTS

The control over dry-bulb and dew-point temperature was very satisfactory in all experiments. When gilts were placed in the controlled temperature rooms they appeared to adjust without undue stress. Except when eating or drinking, as temperature was increased there was a greater tendency for animals to remain in a lying position. Extreme variation in respiration, including occasional panting, prohibited any accurate measurement of respiration rate.

Rectal temperature was elevated with each increase in dry-bulb temperature. Values as high as 107° F. were recorded for individual gilts exposed to 92° F.

Feed intake showed a significant decline as dry-bulb temperature increased. In Experiment III, the decreased intake was accompanied by a depression in average daily gain. Rate of gain decreased from 1.02 lb./day to 0.50 lb./day from 86° to 92° F., while feed intake decreased only 0.34 lb. or 7.5%.

Breeding performance may have been adversely affected by the elevated environmental temperatures. Among the 60 gilts exposed to 92° F., 8 returned to estrus after breeding, the same number as among the 80 gilts exposed to 86° F. in Experiment II. At the two higher temperatures, five gilts which were cycling when put into the controlled temperature rooms failed to return to estrus during a 49-day period. Those affected in this manner in Experiment III were then removed to the outer shell of the building (maintained at approximately 70° F.) and returned to estrus in from 4 to 17 days.

The number of corpora lutea on the ovaries, which is believed to represent the number of eggs ovulated at breeding time, decreased with increasing temperature. The average number of live embryos also was lower at 86° and 92° F. In all experiments, however, littersize represented a similar percentage of the corpora lutea present.

THE CONTINUOUS OR INTERMITTENT SUPPLEMENTATION OF COPPER IN FEED AND WATER

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Feeding levels of copper, higher than the amount known to be required by the growing-finishing pig, are capable of improving both rate and efficiency of gain. Such high level copper feeding has been adopted to only a limited extent in this country but is common practice in many foreign countries.

The mechanism of response to copper supplementation is not known. Preliminary work, reported in AS 133-1, 1964, suggested that with the addition or withdrawal of a level of 125 ppm, a correlated increase or decrease occurred in feed and water consumption. By addition of copper to either feed or the drinking water, it appeared that consumption of both was influenced, irrespective of the mode of intake.

In the trials being reported, a further effort was made to determine the immediate effect on the animal from continuous versus intermittent consumption of a level of 125 ppm of copper added to feed or a similar quantity added to the drinking water.

EXPERIMENTAL PROCEDURE

In four trials (1964 spring, 1964 fall, 1965 spring, and 1965 fall), Duroc pigs from the Center's herd were allotted to one of six treatments. Each treatment group consisted of three lots of nine pigs each and the experimental design was as follows:

Group	Lots	Feed Treatment	Water Treatment
1	1-3	Basal	None
2	4-6	Basal + 125 ppm copper continuously	None
3	7-9	Basal	Copper continuously
4	10-12	Intermittent feeding of the basal + 125 ppm copper for 2 weeks followed by 2 weeks without copper--throughout the trial	None
5	13-15	Same as Lots 10, 11, and 12	Copper added when not in feed
6	16-18	Basal	Intermittent addition of copper for 2 weeks followed by 2 weeks without copper--throughout the trial

All trials were conducted in the same indoor concrete-floored pens. Composition of the basal rations is shown in Table 1. The rations were self-fed in meal form. Copper was added to both feed and water as copper sulfate ($CuSO_4 \cdot 5H_2O$). Liveweight and feed and

TABLE 1.--Percentage Composition of Basal Rations

Ingredients	To 120 lb.	From 120 lb.
Ground shelled corn	78.10	82.20
Meat and bone scraps (50%)	7.20	4.70
Soybean meal (44%)	8.10	5.50
Dehydrated alfalfa meal (17%)	5.00	5.00
Steamed bonemeal	-	1.00
Trace mineralized salt	0.50	0.50
B-vitamin supplement[a]	0.05	0.05
Vitamin B_{12} supplement[b]	0.05	0.05
Irradiated yeast corn premix[c]	1.00	1.00
Calculated crude protein %	14.5	12.5

[a] Merck No. 92 Vitamin Mixture containing 2 gm. riboflavin, 4 gm. calcium pantothenate, 9 gm. niacin, and 10 gm. choline chloride per lb.

[b] Hoffman Vitamin B_{12} Supplement containing 10 mg. of vitamin B_{12} per lb.

[c] A mixture of 1 lb. irradiated yeast 9f in 200 lb. of ground shelled corn.

water consumption were determined at weekly intervals. The amount of copper added to the water was calculated to provide the same level of intake as consumed by pigs receiving 125 ppm in feed. Thus an attempt was made to supplement pigs in Group 2 with a similar amount of copper in feed as those in Group 3 via water and as those in Group 5 by alternating the two means of administration. The influence of treatment on liver copper level at the end of the trials was determined.

A summary of average performance in the four trials is shown in Table 2.

SUMMARY OF RESULTS

To 120 lb. liveweight:

All methods of copper supplementation brought about an average increase in feed intake, average daily gain, and efficiency of feed conversion.

Continuous feed supplementation resulted in the greatest response in daily gain (0.18 lb./day), followed by the alternate inclusion of copper in feed and water (Treatment 5). During this growing period, continuous addition to water appeared to be less effective than continuous feed supplementation.

Water consumption by the pigs in all copper supplemented groups was higher than that of the controls. The largest (and similar) increases resulted from continuous addition to water (Treatment 3)

TABLE 2.--Summary of Performance (Four trials)

Treatment	1	2	3	4	5	6
Copper supplementation of ration	Basal	Continuous	Basal	Alternate 2-week	Alternate 2-week	Alternate 2-week
Copper supplementation of water	None	None	Continuous	None	When not in ration	Alternate 2-week
Number of lots[a]	12	12	12	12	12	12
Total number pigs, (end of trials)	107	106	106	106	107	108
Av. daily gain, lb.						
To 120 lb.	1.25	1.43	1.36	1.34	1.38	1.34
From 120 lb.	1.59	1.53	1.63	1.58	1.62	1.59
Entire trial	1.42	1.48	1.50	1.46	1.51	1.47
Av. daily feed, lb.						
To 120 lb.	3.77	4.15	3.98	3.95	4.00	3.93
From 120 lb.	5.97	5.77	5.95	5.93	6.00	6.00
Entire trial	4.93	5.00	5.00	5.00	5.05	5.03
Feed/100 lb. gain, lb.						
To 120 lb.	302	288	292	294	292	294
From 120 lb.	377	381	367	375	367	376
Entire trial	344	340	335	340	335	340
Av. daily water cons./pig, gal.						
To 120 lb.	.87	.94	1.09	.90	.93	1.09
From 120 lb.	1.37	1.30	1.57	1.36	1.43	1.59
Entire trial	1.13	1.13	1.34	1.13	1.19	1.34
Av. cons. of added copper/pig (entire trial), gm.						
In ration	-	125.5	-	63.2	62.8	-
In water	-	-	150.0	-	68.3	76.7

[a] Nine pigs per lot.

Av. initial and final weight in each of the four trials, 44.3-210.6, 51.0-210.7, 46.1-210.7 and 48.1-209.7 lb.

and intermittent addition to water (Treatment 6). The alternate 2-week addition of copper to water when not in feed (Treatment 5) did not increase water consumption to the same degree as when copper was intermittently added to water only in Treatment 6.

From 120 lb. liveweight to finish:

In contrast to the growing period, the addition of copper to water was apparently more beneficial during the finishing period than where it was added to feed. Compared to control performance, the continuous supplementation of feed (Treatment 1) appeared to cause some depression in performance. By way of comparison, the same intake of copper via water (Treatment 3) or alternately in feed or water (Treatment 5) resulted in an average improvement in both rate and efficiency of gain.

Water consumption was again markedly increased by continuous or intermittent addition of copper to water (Treatments 3 and 6) and to a lesser extent by Treatment 5.

General Comments:

The increase or decrease in feed consumption, corresponding to copper addition or withdrawal from feed or water, was less evident than preliminary results suggested. However, water intake was highly correlated with the presence or absence of copper in the water. Such an effect was most evident in Treatment 6 where intake was on an intermittent basis and where this was the only method of copper supplementation.

Because of the increased amount of water drank by pigs in Treatments 3 and 6, the average intake of copper was somewhat higher than intended. Copper intake by pigs in Treatments 4 and 5 approximated the intended levels.

The range in copper content per unit of liver tissue at the end of the trials was similar following any of the three methods of continuous supplementation. Values ranged from 14.7 to 97.8 mcg./gm. of fresh tissue from animals in Treatments 2, 3, or 5 compared to a range of 6.2 to 17.7 mcg./gm. in liver from control pigs.

These results show that a level of 125 ppm of copper is an effective feed additive, particularly during the growing period. Addition of a similar amount of copper to drinking water was, by some measures of performance, superior to feed addition. The continuous addition to feed, but not to water, caused an apparent depression in performance during the finishing period (from 120 lb. liveweight).

PASTE FEED FOR GROWING-FINISHING PIGS

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Systems for movement of a complete swine feed include: (1) dry-batch, such as by truck, wagon, or cart; (2) dry-flow, such as by augers or elevators; (3) dry-pneumatic, using ducts or blowers; or (4) liquid, with the use of mixing tanks, pumps, and hoses. Advantages and disadvantages of each system are apparent in use. Movement of feed as a paste offers the possibility of combining several advantages of the different systems.

The blending of water with a complete feed should not have a detrimental effect on performance as long as the amount of water in the daily wet ration does not exceed the daily water requirement of the animal. While the addition of sufficient water to make a thin slurry results in problems of separation and settling out of feed components, less water provides a material which can be pumped through pipes or hoses hydraulically and which does not create problems of separation or settling out. A blending ratio of 1.3 to 1.5 parts of water by weight to 1.0 part of air-dry mixed feed results in a paste with desirable characteristics for mechanized handling.

The objectives of this study were: (1) to determine the effect of paste feed on the performance of growing-finishing pigs, (2) to design and evaluate pilot paste feeding systems, and (3) to develop a fully mechanized and controlled system for feeding paste feed.

EXPERIMENTAL PROCEDURE

Animals

Three similar trials were conducted at the Swine Research Center in Wooster using Duroc pigs from the Center's herd. At an average liveweight of 120 lb., two lots of eight pigs each were assigned to the following treatments:

1. Dry ration (self-fed)
2. 5 lb./pig/day (hand-fed dry twice daily)
3. 5 lb./pig/day (paste-feed mechanically fed four times daily).

Allotment was based upon liveweight, sex, and relationship.

Feed composition is shown in Table 1. Automatic waterers were provided and water consumption was measured in all lots. The pigs were weighed and the feed consumption of the self-fed groups determined at 2-week intervals.

Pigs were housed in 11 x 12-foot indoor concrete-floored pens. Temperatures of 60° F. or above were maintained.

TABLE 1.--Composition of Basal Ration

Ingredient	Percent
Ground shelled corn	82.20
Meat and bone scraps (50%)	4.70
Soybean meal (44%)	5.50
Dehydrated alfalfa meal (17%)	5.00
Steamed bonemeal	1.00
Trace mineralized salt	0.50
Vitamin B_{12} supplement[a]	0.05
Irradiated yeast corn premix[b]	1.00
Copper sulfate[c]	.05
B-vitamin supplement[d]	+
Calculated crude protein, %	12.5

[a] Vitamin B_{12} supplement containing 10 mg. of vitamin B_{12} per lb.

[b] A mixture of 1 lb. irradiated yeast 9f in 200 lb. of ground shelled corn.

[c] $CuSO_4 \cdot 5\ H_2O$ (powdered).

[d] Merck B-vitamin mixture to supply 100 mg. riboflavin, 184 mg. calcium pantothenate, 450 mg. niacin, and 500 mg. choline chloride per 100 lb. of feed.

At the finish of each trial, differences in fill between full and limited-fed pigs were minimized by removing pigs from the lot as they reached 205 lb. and allowing them access to water only for 16 hours. Liveweight after this 16-hour shrink was used as a terminal weight. Pigs were then shipped to the Meats Laboratory at The Ohio State University, Columbus, and carcass measurements were obtained.

Performance data are summarized in Table 2. Carcass data are shown in Table 3.

Equipment

Due to the flow characteristics of paste feed and some basic criteria of a controlled feeding system, all developmental work with equipment has been based upon the following requirements:

1. Provide each animal with a feeding station.

2. Deposit paste feed in the proper quantity at each feeding station.

3. Meter the paste feed by running-time control of a repeat-cycle distributor or by the position of a single-cycle distributor.

TABLE 2.--Summary of Average Performance-Based upon Liveweight after 16-hr. Off-feed Shrink[a]

	Lots 1 & 2 Full-fed (Dry)	Lots 3 & 4 5 lb./day (Dry)	Lots 5 & 6 5 lb./day (Paste)
Initial weight, lb.			
Trial 1	122.1	122.1	122.2
Trial 2	124.9	124.8	124.8
Trial 3	122.0	121.7	122.0
Final weight (after shrink, lb.			
Trial 1	201.3	202.6	201.1
Trial 2	199.3	200.9	201.3
Trial 3	201.4	201.8	200.9
Daily feed intake, lb.			
Trial 1	6.30	5.00	5.00
Trial 2	6.41	5.00	5.00
Trial 3	6.49	5.00	5.00
Daily water intake, gal.[b]			
Trial 1	1.13	0.99	1.14
Trial 2	1.77	1.50	1.32
Trial 3	1.37	1.16	1.16
Daily gain, lb.			
Trial 1	1.59	1.23	1.31
Trial 2	1.58	1.26	1.28
Trial 3	1.63	1.24	1.31
Feed/100 lb. gain, lb.			
Trial 1	397.4	407.5	381.5
Trial 2	405.1	395.7	388.9
Trial 3	398.9	401.8	382.9

[a] Eight pigs per lot.

[b] For paste-fed pigs, includes water mixed with feed.

TABLE 3.--Summary of Average Carcass Measurements

	Lots 1 & 2 Full-fed (Dry)	Lots 3 & 4 5 lb./day (Dry)	Lots 5 & 6 5 lb./day (Paste)
Slaughter weight, lb.			
Trial 1	198.4	198.5	197.5
Trial 2	196.5	197.2	197.9
Trial 3	197.3	199.6	198.2
Dressing percent			
Trial 1	73.5	73.8	73.4
Trial 2	74.5	73.6	73.9
Trial 3	73.9	73.4	73.8
Backfat, in.			
Trial 1	1.44	1.38	1.31
Trial 2	1.47	1.36	1.43
Trial 3	1.45	1.42	1.41
Lean cuts, %			
Trial 1	54.4	55.2	55.5
Trial 2	51.7	53.6	53.1
Trial 3	54.0	54.0	54.2
Firmness score - loin eye muscle[a]			
Trial 1	3.40	3.19	3.73
Trial 2	3.78	4.36	4.04
Trial 3	3.75	4.12	4.54
Marbling score - loin eye muscle[b]			
Trial 1	5.39	4.56	4.96
Trial 2	5.53	6.03	5.92
Trial 3	5.52	5.33	5.97

[a] Scoring system, 1 = very soft to 5 = firm.

[b] Scoring system, 1 = trace to 10 = extremely abundant.

4. Blend dry feed and water suitable for automatic operation and time cycle control.

5. Provide air-tight pump and piping to avoid problems of spoilage and plugging due to drying.

6. Adapt piping and distribution equipment to existing management systems and housing.

The development of components for paste feeding systems has been carried out in several stages. The functioning of some of these components, plus the flow characteristics of paste feeds of various moisture contents, have been reported in Paper No. 65-617, Design and Development of a Paste Feeding System, available from the senior author or from the American Society of Agricultural Engineers, P. O. Box 229, St. Joseph, Michigan.

SUMMARY OF RESULTS

Animal Performance

1. Paste feed was readily consumed.

2. Full-fed pigs made the most rapid gains but were less efficient than those limited-fed paste feed.

3. In all trials, pigs fed the paste feed drank additional water. The total amount of water consumed per pig ranged from 1.14 to 1.32 gallons per day, which was similar to the amount drank by pigs fed 5 lb. of dry feed per day.

4. A comparison of performance between pigs fed a restricted amount of feed in paste or dry form shows that the average daily gain of those receiving paste feed was greater in Trials 1 and 3 and similar to those fed dry feed in Trial 2.

5. In all trials, the efficiency of feed conversion by paste-fed pigs was greater than pigs fed the same quantity of dry feed.

6. Restriction of feed intake had no apparent influence on dressing percent but resulted in decreased backfat thickness.

7. Neither feed intake nor form of feed had a consistent effect upon lean cut yield or marbling score.

8. Average firmness scores, when compared to those of carcasses from full-fed pigs, were higher for carcasses from paste-fed pigs in all trials and in Trials 2 and 3 were higher for pigs fed a restricted quantity of dry feed.

Equipment Components

1. The blending of dry, mixed feed into a measured quantity of water was readily accomplished and mechanized under the control of a sequence timer.

2. A helical rotor pump with a natural rubber stator and a case-hardened rotor was used successfully for pumping all blends from 1.2 to 1.0 up to a 2.0 to 1.0 water-to-feed ratio. The positive displacement pump was used as a meter.

3. Large rubber hose, plastic pipe, and copper pipe with streamline fittings have all proven satisfactory for distribution of paste feed.

4. Mechanized distributors were developed which accurately distributed the paste feed to each feeding station. Distributors powered only by line pressure and spring tension are under development.

System

1. Feed wastage throughout the systems developed was essentially eliminated.

2. The compartmentalized feeding trough discouraged movement and fighting for space during feeding.

3. Spoilage was not a problem, even though feed was blended only once a day and remained in the pipes between feedings.

4. On the basis of pumping energy studies in the laboratory, the electrical energy to blend and deliver paste feed to 100 pigs for 1 month would not exceed 30 to 35 kilowatt hours or an approximate cost of $0.75.

THE INFLUENCE OF GRADED LEVELS OF VITAMIN A INTAKE ON GROWING-FINISHING PIG PERFORMANCE

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Vitamin A is considered one of the more important vitamins in the nutrition of all domestic animals. The recommended level of vitamin A (or carotene equivalent) in the ration for pigs weighing from 50 to 225 lb. was 400 I.U. per lb. (National Research Council, 1959) and is now 600 I.U. per lb. of feed (National Research Council, 1964). In the U. S., the primary natural source of vitamin A activity in swine feeds is the carotene present in yellow corn. For the pig, 1 mg. of beta carotene is believed to be equal to 500 I.U. of biologically active vitamin A. Based on these recommendations, the yellow corn content of most growing-finishing feeds should meet the pigs' need for pro-vitamin A.

Smith and co-workers at Purdue reported that the addition of 400, 800, or 1,600 I.U. of vitamin A palmitate to a corn-soy basal ration tended to increase rate of gain and in one summer trial was associated with a 6% increase in feed consumption (Mimeo AS-104, Aug. 1961). Therefore, it is possible that, under certain conditions, the performance of pigs may be improved by levels of vitamin A higher than those shown to be necessary to prevent deficiency symptoms.

The objective in the trials being reported was to determine the effect on growing-finishing performance of adding graded levels of vitamin A palmitate to a mixed-protein basal ration. The quantities added ranged from 0 to 3,500 I.U. per lb. of feed.

EXPERIMENTAL PROCEDURE

In three trials, pigs 6 to 9 weeks of age were allotted by weight, sex, and relationship to the different ration treatments. The levels of vitamin A added and the number of pigs per treatment were as follows:

	Level of vitamin A palmitate/lb. (I.U.)							
	0	500	1,000	1,500	2,000	2,500	3,000	3,500
	Number of pigs/treatment							
Trial 1	20	20	20	20	20			
Trial 2	15	15	15	15	15	15	15	15
Trial 3	15	15	15	15	15	15	15	15

Trial 1 was initiated in April 1964, Trial 2 in July 1964, and Trial 3 in January 1965. All trials were conducted at the Western Branch, South Charleston. The pigs used were produced from a Yorkshire-Duroc-Hampshire rotational cross-breeding program.

TABLE 1.--Percentage Composition of Basal Ration

Ingredients	To 120 lb.	From 120 lb.
Ground shelled corn	79.11	83.68
Meat & bone scraps (50%)	6.40	4.30
Soybean meal (44%)	12.80	9.77
Steamed bone meal	1.00	1.00
Ground limestone	-	.56
Trace mineralized salt	0.40	0.40
Vitamin B_{12} supplement[a]	0.10	0.10
Antibiotic supplement[b]	0.14	0.14
Vitamin-yeast-zinc premix[c]	0.05	0.05
Calculated crude protein	15.6	13.6

[a] Hoffman Vitamin B_{12} supplement containing 10 mg. of Vitamin B_{12} per lb.

[b] Aurofac 2A containing 3.6 gm. chlortetracycline per lb.

[c] Merck B-Vitamin Supplement to supply 2.5 mg. riboflavin, 4.6 mg. pantothenic acid, 11.3 mg. niacin, and 12.6 mg. choline chloride per lb. of feed. Fleischmann's irradiated yeast, type 9f, to supply 200 I.U. of vitamin D_2, and zinc sulfate to provide 50 ppm of zinc per lb. of feed.

Average initial and final weights in each trial were as follows: Trial 1, 38.4 and 209.9 lb.; Trial 2, 36.4 and 209.1 lb.; and Trial 3, 40.5 and 209.4 lb.

Composition of the basal ration is shown in Table 1. All rations were self-fed in meal form and liveweight and feed consumption were measured at 2-week intervals.

Vitamin A was added as Pfizer's Vitamin A-30-P, containing 30,000 I.U. of vitamin A palmitate per gram. Forty pounds of soybean oil meal were used to premix the vitamin A needed for each ton of feed.

A summary of the effect of vitamin A on performance is shown in Table 2.

SUMMARY OF RESULTS

By statistical analysis, vitamin A intake had no significant effect on performance in either the growing or finishing period.

From the data in Table 1, there was a tendency for vitamin A to increase rate of gain from 120 lb. to market weight. The average gains of all but one of the seven supplemental groups were faster than controls during this period and the combined rate of gain of all groups

TABLE 2.--A Summary of the Effect of Vitamin A Levels on Pig Performance (3 trials)

Level of added vitamin A/lb. (I.U.)	0	500	1,000	1,500	2,000	2,500	3,000	3,500
Number of pigs[a]	50	49	50	50	50	29	30	29
Average daily gain, lb.								
To 120 lb.	1.51	1.50	1.53	1.53	1.50	1.51	1.53	1.56
From 120 lb.	1.83	1.90	1.94	1.91	1.88	1.82	1.96	1.87
Entire trial	1.66	1.68	1.72	1.71	1.68	1.66	1.72	1.70
Average daily feed, lb.								
To 120 lb.	4.38	4.37	4.40	4.44	4.34	4.40	4.47	4.59
From 120 lb.	6.92	6.97	6.95	7.09	6.90	7.01	7.23	7.10
Entire trial	5.59	5.57	5.57	5.66	5.55	5.64	5.71	5.78
Feed/100 lb. gain, lb.								
To 120 lb.	289	291	289	289	289	291	293	294
From 120 lb.	379	368	359	371	367	385	369	380
Entire trial	336	331	324	332	330	340	332	339

[a] At end of trials.

receiving additional vitamin A was 4 percent faster than controls. While not statistically significant, such a trend may justify a further study of the vitamin A needs of the pig.

Previous work showed a depression in performance would be expected at some high level of vitamin A intake. No such depression was evidenced at the 3,500 I.U./lb. addition in these trials.

PREDICTING LEAN CUT PERCENT FOR SELECTION OF SWINE

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The past few years have seen a rapid improvement in the ability of swine producers to produce a carcass yielding a high percent of the high priced cuts. This improvement has been accomplished largely through selection by subjective appraisal of live pigs and by slaughtering littermates.

A new tool, ultrasonics, has become available in recent years for measuring composition of live animals. By means of high frequency sound waves, fat and lean in the live animal can be measured. This offers the breeder the potential for identifying live pigs with a high lean cut percent. Since heritability of carcass traits is high, rapid improvement in carcass composition would be possible if reliable measures of body composition in the live animal are available. The accurate selection of individuals might largely replace the use of carcass data on relatives.

The ability to evaluate lean cut percent of market weight hogs with ultrasonics was investigated, using 186 hogs from the Ohio Swine Evaluation Station and the Ohio Pork Improvement field program. Data were collected at the Meat Laboratory of The Ohio State University.

Ultrasonic fat readings were taken at the following six locations:

1. First rib
2. Fifth rib
3. Last rib
4. Third lumbar vertebrae
5. Last lumbar vertebrae
6. Outside of ham

Formulas using fat measures and liveweight for estimating lean cut percent were developed and compared to the percent lean cuts determined by cutout procedures.

The results indicated that relationships between fat measures and percent lean cuts are similar for different breeds and for barrows and gilts, even though these groups have different averages for percent lean cuts. Thus an equation can be developed for general use in selecting breeding stock from among a breed-sex group of pigs.

The correlation of percent lean cuts predicted with the formula and the actual carcass percent lean cuts was about 0.80. This result is high enough to encourage further refinement of this method.

This research is continuing to establish the accuracy of the method and further refine it for practical use in the field. The prediction formula obtained from this group of pigs will be applied to another group as a further check on the correlation obtained in this study. A careful evaluation will be made of which and how many fat measures should be taken and how they should be used in a prediction formula to yield a simple, accurate estimate of lean cuts. Measures of fat thickness near the middle of the loin and on the ham appear to be most promising. Inclusion of loin eye area in the formula did not add materially to the ability to predict percent lean cuts.

A typical scheme of selection in use in Ohio is to slaughter two pigs from a litter and select replacement stock from the best litter. From the high cutting litters, breeders select what appear to be the best pigs by subjective appraisal.

This scheme may be compared to using the ultrasonic prediction formula to select pigs with highest estimated lean cuts. Slaughtering two pigs per litter decreases the genetic progress which could be made because occasionally a pig is slaughtered which should have been saved for breeding. Full sibs are related only one-half. So a carcass test on littermates is not the same as knowing the carcass performance of a pig which is a candidate for selection. On the other hand, the ultrasonic evaluation of percent lean cuts is not completely accurate. When these factors are considered together, selection of ultrasonic estimates of percent lean cuts should lead to more genetic progress for lean cuts than selection based on litter testing and subjective appraisal.

This study suggests that although considerable progress can and has been made by the litter testing scheme, breeders could expect to increase lean cut percent about one-third more rapidly by mass selection based on ultrasonic estimates of percent lean cuts.

Percent lean cuts is only one of several important swine traits. It cannot be assumed that pigs which have the least fat at 200 lb. are the most desirable economically. Such factors as growth rate, feed efficiency, and prolificacy are also important in selecting breeding stock. This experiment is part of a continuing swine breeding research project to investigate selection procedures for the economical production of quality pork.

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Eastern Ohio Resource Development Center, Caldwell, Noble County: 2039 acres

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Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Marietta, Washington County: 20 acres

Western Branch, South Charleston, Clark County: 428 acres