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PERFORMANCE OF GROWING-FINISHING PIGS FED FROM CONVENTIONAL SELF FEEDERS VERSUS A PROGRAMMED HOG FEEDING SYSTEM

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

James C. Ligon

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ABSTRACT

Data from 1412 pigs in seven different trials formed the basis of this study. Each trial used a complete farrowing group of pigs from the swine confinement unit (System III) at Ames Plantation.

Each trial began with approximately 200 pigs weighing an average of 50 lb and were randomly divided into two groups by weight. The approximate 40 lightest pigs were divided equally into pens 1 and 2, the next heaviest 40 pigs were divided equally into pens 3 and 4 and so on until all pigs were assigned to 12 pens.

One group was fed by a conventional four-hole Smidley self feeder and watered by one nipple waterer located over the pit area. The other group was fed by a Stage III Meal-Time feeder which also had five nipple waterers attached to the feeder.

All pigs were crossbred and the ration fed was the same during each trial.

Average daily gain was calculated by subtracting total beginning pen weight from total end weight divided by pig days within each pen. Feed efficiency was calculated for each group (Smidley vs. Meal-Time) within each trial by dividing total pounds of feed by total pig gain. Water usage for each trial was measured by installing water meters for each feeding system.

It was found by least squares analysis that feeding system had no significant effect ($P > .05$) on average daily gain. Even though pigs fed

by Smidley feeders outgained pigs fed on the Meal-Time system, the difference was not significant ($P > .05$).

Least squares analysis revealed there was no difference ($P > .05$) in feed efficiency between the two feeding systems. Feed efficiency ratios were the same. Trial effect displayed more difference, but not significantly ($P > .05$).

System effect on water usage was highly significant. Pigs on Meal-Time feeders used significantly ($P < .0001$) less water than those on Smidley feeders as measured by water usage/pig/day and water usage/lb of feed consumed. Trial effect was not significantly different ($P > .05$).

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CHAPTER I

INTRODUCTION

Efficient feed utilization by the pig is essential to profitability in feeding swine during the growing-finishing period. According to a recent survey of the swine industry in the United States, feed conversion (pounds of feed per lb of gain) averaged 3.68 to 3.84 among all hog producers surveyed. Yet, swine feeding research and a limited number of swine farm records have produced feed efficiencies at or below 3.00 lb of feed/lb/gain. Then too, intense selection pressure applied to feed efficiency, growth rate and backfat thickness within the swine population in recent years have combined to yield feed conversions at or slightly below 2.00 lb of feed per lb of gain in swine testing stations.

On the average, a 235 lb market hog requires from 900 to 1000 lb of feed to reach market weight including a proportionate share of breeding herd and pig feed as well as growing-finishing feed. The post-weaning phase, however, accounts for about 75% of the total feed required to finish a hog for market. Small savings in feed resulting in an improved feed conversion from 50 lb to market weight are therefore economically important to the swine producer.

Efficient utilization of feed by swine during the growing-finishing phase depends upon nine basic factors: (1) genetic ability of the pig to convert feed to pounds of gain, (2) meatiness of the pig, (3) balanced feed rations, (4) form of the ration (meal, pellet, etc.), (5) feeding method, (6) environmental factors, (7) general health of the pigs, (8) swine management, and (9) prevention of feed wastage.

Feed wastage has not been extensively studied; however, limited research and general observations indicate a feed loss of 3 to 20% to be a realistic figure for many hog finishing units utilizing self feeders. Feed wastage may be attributed to poor feeder design, improper adjustment, pigs 'rooting feed' from the feeder, pigs spilling feed from their mouths as they walk from the feeder to water and stale or moldy feed which has been left in the feeder.

Most hogs in the United States are fed "ad-libitum' from conventional self feeders. Some researchers suggest self-fed hogs often eat out of boredom thus forcing the passage of nutrients through the digestive system more readily than they can be completely digested. In Europe, many hogs are 'limit fed' several times a day. Limit feeding improves feed efficiency, but rate of gain is sacrificed significantly in most cases.

A new concept for feeding hogs has been proposed which allows the pigs all the feed they care to eat during predetermined feeding periods. The design of the feeder also provides a water supply at the feeder allowing water and feed to be consumed without the pig leaving the feeder area. This concept and design has been named the 'Meal-Time' feeding system.*

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*Meal-Time is a trademark of Chore-Time Equipment, Inc. The University of Tennessee makes no endorsements, expressed or implied, of any commercial product. Trade names are used in this publication only to assure clarity of communication.

The objectives of this study were:

1. to compare the feed efficiency of swine fed from conventional self feeders to those fed by a programmed hog feeding system,

2. to compare rate of gain of swine fed on the two feeding systems, and

3. to compare the amount of water used by pigs on each of the two feeding systems.

CHAPTER II

REVIEW OF LITERATURE

Feed costs represent 60 to 75% of total swine production costs on the average in breeding and commercial herds (Drewry, 1980; Hogberg, et al., 1984) and the post weaning period accounts for about 75% of the total feed requirement. Therefore, if feed efficiency during the growing-finishing phase is improved, greater profits should be realized from swine feeding operations.

I. The Effects of Breed, Genetics, Sex, and Type of Hog on Gain and Feed Efficiency

Considerable research has been conducted comparing the various swine breeds with regard to gain and feed efficiency. Over the years breeds have changed and(or) improved; therefore, differences found 20 years ago may not be applicable to today's swine industry. The National Hog Farmer's (1985) central test station survey has shown Durocs to be consistently the fastest gaining breed and one of the top two breeds in feed efficiency. In a two-year comparison of 9,000 boars of all breeds, Durocs and Hampshires were the most feed efficient breeds (National Hog Farmer, 1985).

Genetists differ on whether feed efficiency is a medium or low heritability trait. Some researchers have reported low heritability estimates which range from .007 to .11 (Bernard and Fahmy, 1970; Jungst et al., 1981; Webb and King, 1983; Bereskin, 1986). In contrast, the National Swine Improvement Federation considers feed efficiency to be higher in heritability with a coefficient of about .35 (NSIF; Hubbard, 1981).

Neely et al. (1979), in a comparison of fat and lean hogs, found no differences in feed efficiency even though fat hogs gained faster and consumed more feed. This agrees with Drewry's (1980) research with test station boars in which fatter boars had higher average daily gains and feed consumptions, but feed efficiency was the same. Bereskin et al. (1975) differed, finding low fat lines of hogs to be more efficient in feed utilization.

Even though boars and barrows grow more rapidly than gilts, no differences were found in feed efficiency ratios (Bereskin et al., 1975; Vandergrift et al., 1985). Vandergrift (1985) also reported that barrows grew faster than gilts when fed ad-libitum but, when total nutrient intake was restricted, there was no difference in gain or feed efficiency.

II. The Interrelationships of Average Daily Gain, Feed Consumption and Feed Efficiency on Pig Performance

Daily feed consumption is positively associated with daily gain (Headley, 1946; Magee, 1962; Drewry, 1980). Researchers differ on whether increased daily gain is positively associated with improved feed efficiency (Magee, 1962; Drewry, 1980). Biswas et al. (1966) found feed efficiency to be positively correlated to average daily gain (.24), but not as highly correlated as feed consumption to average daily gain (.76).

Most researchers agree that feed consumption is negatively correlated to feed efficiency. In other words, pigs which eat more feed tend to be less efficient (Headley, 1946; Headley et al., 1961; Magee, 1962; Drewry, 1980). However, when daily feed consumption is limited, feed efficiency is improved (Winters et al., 1949; Merket et al, 1958; Prince et al, 1983).

III. The Effects of Ration and Ration Form on Gain and Feed Efficiency

Rations have been formulated mainly to increase pig performance. The inclusion of fat into the pig's diet has been shown to significantly improve feed efficiency (Hale et al., 1968; Brooks, 1972; McDonald and Hamilton, 1976; Seerley et al., 1978; Keaschall et al., 1983). These researchers reason that as energy in the diet is increased, feed consumption will decrease; thus, improving feed efficiency provided average daily gain does not decline. Fat additions ranging from 2 to 5% of diet produced the same effect. Chiba et al. (1985) found pigs fed a diet containing 5% tallow gained 8.3% faster, consumed 5.3% less feed, and were 12.6% more efficient. Seerly et al. (1978) reported 9% fat supplementation to the ration resulted in a 3% average improvement in feed efficiency during combined winter and summer months and a 13% improved feed efficiency during the summer.

Pigs fed a lower nutritional diet (11% digestible protein, 55% total digestible nutrients) grew significantly slower, were less efficient and consumed more feed than pigs fed a higher nutritional diet (16% DP, 75% TDN) (Kuhlers et al., 1977). Some researchers have reported feed efficiency was not improved by feeding crude protein levels in excess of 14% (Becker et al., 1954; Wahlstrom, 1954; Aunan et al., 1961), while others have reported pigs fed diets containing 15 to 18% crude protein grew faster and had more efficient gains than pigs fed diets containing approximately 14% protein.

Feed form (pellet or mash) does have a significant effect on efficiency of feed utilization while daily gain effects are variable. Pelleting improved feed efficiency (Jensen and Becker, 1965; Chamberlain et al., 1967; Hanke et al., 1972; Baird, 1973; Skoch et al., 1983). Baird (1973) found pelleting improved daily gain while Skoch (1983) and others (NCR-42 Committee on Swine Nutrition, 1969) reported pelleting to have no significant effect on daily gain.

There has been considerable interest concerning the advantages and(or) disadvantages of wet vs. dry feeding of pigs. Research results differ, but this may be due to the various definitions of "wet" feeding. Forbes et al. (1968) reported no significant differences between wet and dry feeding upon average daily gain and feed conversion. Feed conversion ratios obtained on wet feeding were lower than those obtained on dry feeding; however, the differences were not significant at the .05 level.

Braude and Rowell (1967) found that pigs fed dry feed and _ad lib_ water had substantially lower growth rates and feed conversions than pigs consuming wet diets. The ratio of 2½:1 water to meal seemed to be adequate. It was established that the ratio of 4 parts of water to 1 part of feed as required for satisfactory pumping of the mixture through mechanized liquid feeding systems did not result in substantially lower performance than a ratio of 2½:1 (Braude and Rowell, 1967).

IV. The Effects of Housing and Environment on Pigs Performance

Higher ambient temperatures decrease feed consumption, decrease daily gain, but have little or no effect on feed efficiency (Heitman and Hughes, 1949; Mangold et al., 1960; Seymour et al., 1964). Lower temperatures increase feed consumption and decrease feed efficiency (less desirable) due to the need for heat production for maintenance of body temperature (Heitman and Hughes, 1949; Mangold et al., 1960).

This is somewhat contradicted by Jones et al. (1968), who reported faster gains but no difference in feed efficiency of pigs fed in open-front buildings compared to pigs fed in enclosed buildings. Wahlstrom et al. (1971) found no consistent effect on daily gain and feed efficiency when comparing open-front to enclosed buildings during winter months.

V. The Effects of Water Consumption/Usage on Daily Gain and Feed Efficiency

Water consumption and(or) usage and its effects upon pig performance is difficult to measure. In trials studying _ad lib_ water consumption, the amount of water actually consumed by pigs is difficult to accurately measure due to wastage when using nipple or bowl waterers. The effects of predetermined daily water consumption by pigs have been studied. Researchers generally agree there are no differences in the rate of growth or feed efficiency of growing pigs allotted 3 lb, 2½ lb, 2 lb, or 1½ lb of water mixed with 1 lb of feed (Barber et al., 1958; Barber et al., 1963; Holme et al., 1965). Nienaber et al. (1984) found in nursery-age pigs that water use increased as flow rate increased, but there was no measurable effect of flow rate on weight gain, feed consumption, or feed efficiency.

Hines (1986) compared an *ad lib* water and feeding system to Chore-Time's Meal-Time feeding system. Pigs on the Meal-Time system consumed 1.76 lb of water per 1 lb of feed consumed while the *ad lib* pigs consumed 3.15 lb of water per 1 lb of feed with no significant differences in average daily gain and feed efficiency.

VI. The Effects of Feeding System on Daily Gain and Feed Efficiency

Most growing-finishing swine are fed ad-libitum in the United States from self feeders. Recently, studies have been conducted comparing 'meal-time feeding' in which pigs are fed at two or three predetermined periods during the day. Meal-time feeding was introduced by Chore-Time Equipment, Inc., a few years ago to offer an alternative to *ad lib* feeding. Hines and Vargas (1983) conducted three feeding trials using 480 finishing pigs to evaluate meal-time feeding versus ad-libitum feeding. There were no significant differences in feed efficiency (3.50 vs. 3.49 lb feed/lb/ gain) or daily gain (1.63 vs. 1.64 lb).

Hines and Vargas (1984) conducted two additional feeding trials using 240 growing-finishing pigs to evaluate meal-time feeding vs. ad libitum feeding, dry and wet. Again, there were no significant differences in feed efficiency (3.84, 3.83, 3.83 lb feed/lb/gain, respectively) or average daily gain (1.51, 1.52, 1.59 lb, respectively).

CHAPTER III

EXPERIMENTAL PROCEDURE

Data from this study were collected from May 1982 through November 1984 from experiments conducted at the swine confinement unit (System III), Ames Plantation, Grand Junction, Tennessee.

I. Experimental Animals

During a 30-month period, approximately 1400 pigs were used in seven feeding trials.

At the beginning of each trial, approximately 200 pigs weighing an average of about 50 lb from the nursery in System III (all pigs from one farrowing group were utilized in a trial) were allotted to 12 experimental groups and fed for about 100 days in total confinement. Pigs that had not reached market weight at the end of each trial were removed from the pens so the barn could be emptied and a new trial begun.

All pigs were weighed in the nursery and allotted to the finishing pens by weight. The (approximately) 40 lightest pigs were divided equally into pens one and two, the next heaviest 40 pigs were divided equally into pens three and four and so on until all pigs were allotted to 12 pens. Average beginning pig weight between the two pens within each weight range was no more than .1 lb except between pens one and two in trial 1 where there was a difference of 1.8 lb. Each pen within each trial and weight range began the experiment with an equal number of pigs or plus/minus one pig when there was an odd number of pigs.

All pigs were crossbred, the result of a rotational crossbreeding program including the Duroc, Hampshire, and Landrace breeds.

II. Facilities

All trials were conducted in a modified-open front partial slatted finishing barn consisting of 12 uniform pens. Curtains were mounted on the sides which could be raised or lowered to provide wind protection or ventilation depending upon the outside environment. No supplemental heat was used. Sprinklers were mounted in each pen above the slat area and were operated when needed to help cool the pigs during periods of hot temperature.

All pens were 8 x 20 feet with a 12-foot area of solid concrete floor and an 8-foot slat area over a 6-foot deep manure pit. Pens 1, 2, 9, and 10 were equipped with coated wire over the pit. Pens 3, 4, 7, and 8 contained pre-fabricated concrete slats that were poured in place over the pit area. Pit ventilation reduced odors in the barn.

Odd numbered pens were equipped with new standard 4-hole Smidley self-feeders; even numbered pens were equipped with Stage III Meal-Time feeders (Figure 1). All feeders were examined three times weekly and adjusted as needed. Odd numbered pens were equipped with one nipple waterer over the slat area of the pen. Even numbered pens were equipped with five nipple waterers mounted on the Stage III feeder (Figure 1). Water pressure at all nipple waterers was maintained at 40 psi.

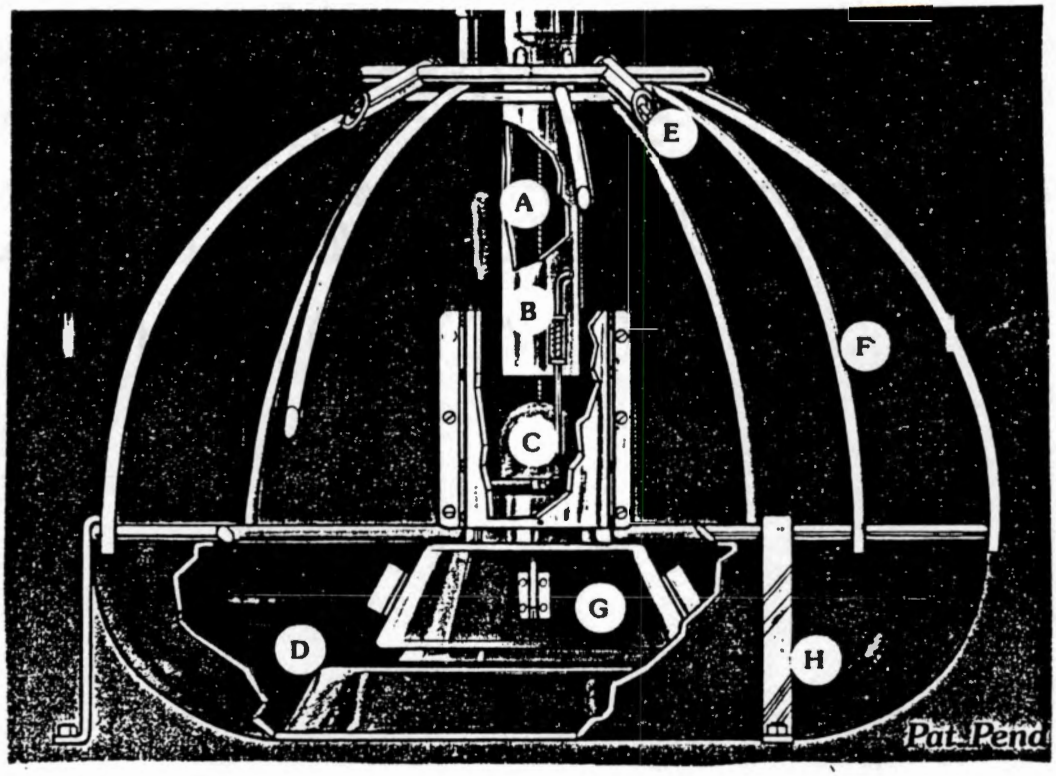


Figure 1. Stage III Feeder used in the Meal-Time Feeding System.

III. Feeding and Management

During each trial, pigs on both Meal-Time and Smidley feeders were fed the same ration. The basic ration fed was:

Ground yellow corn	1540 lb
Soybean meal (44%)	410 lb
Swine Premix (Table 1)	50 lb
	2000 lb
Calculated Crude Protein %	15.6

However, wheat was used in the ration during the summer months (approximately June 15 - October 1). The wheat was grown on Ames Plantation and utilized in the ration when economically feasible. The ration then consisted of a 50:50 mix of corn and wheat plus soybean meal and swine premix as follows:

Ground yellow corn	770 lb
Ground wheat	770 lb
Soybean Meal (44%)	410 lb
Swine Premix (Table 1)	50 lb
	2000 lb
Calculated Crude Protein %	16.9

All pigs were wormed with Atgard® one week after entering the finishing floor. No wormer was used while the pigs were in the nursery.

In trials 1, 2, and 3, pigs in pens 1, 3, 5, 7, 9, and 11 (Smidley feeders) were fed and watered *ad lib*. Pigs in pens 2, 4, 6, 8, 10, and 12 (Meal-Time feeders) were fed and watered during three feeding/watering periods each day, two hours each. Also, pigs were watered during a two-hour period between each feeding (Figure 2a). However, when the pigs on Meal-Time feeders reached approximately 100

Table 1. Feed Analysis of Swine Premix.

GUARANTEED ANALYSIS PER POUND

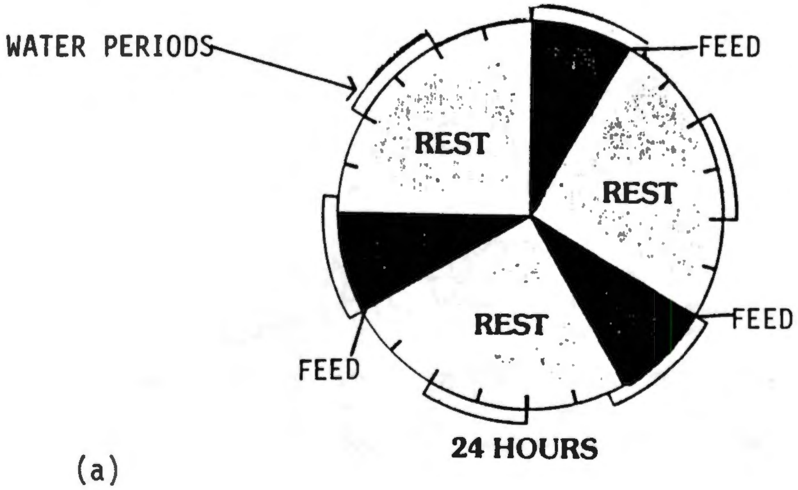
Vitamin A	80,000	USP	Units
Vitamin D-3	20,000	IC	Units
Vitamin E	100	Inc.	Units
Riboflavin	80		Mgs.
d-Pantothenic Acid	200		Mgs.
Niacin	400		Mgs.
Choline Choloride	4,000		Mgs.
Vitamin K	20		Mgs.
Vitamin B-12	300		Mcg.
Lysine (Added)	0.25%		
Methionine (Added)	0.25%		

Calcium (Ca), Maximum	30.0%
Calcium (Ca), Minimum	25.0%
Phosphorus (P), Minimum	9.0%
Salt (Nacl), Maximum	18.0%
Salt (Nacl), Minimum	15.0%
Zinc (Zn)	0.24%
Iron (Fe)	0.24%
Manganese (Mn)	0.16%
Copper (Cu)	0.024%
Cobalt (Co)	0.004%
Iodine (I)	0.0014%
Selenium (Se)	0.00027%

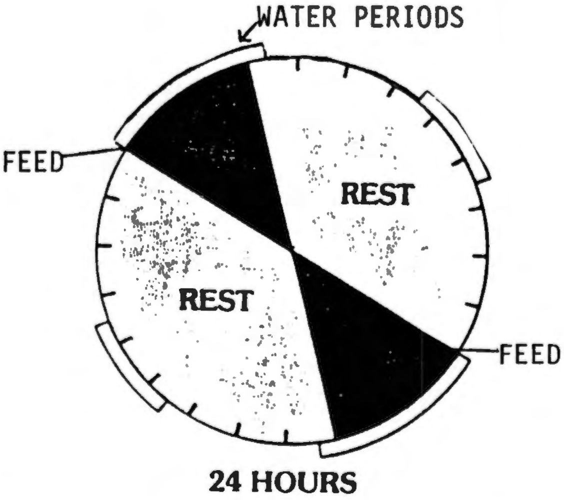
INGREDIENTS

Vitamin A Supplement, D-Activated Animal Sterol (Source of Vitamin D-3), Vitamin E Supplement, Riboflavin Supplement, Calcium Pantothenate, Niacin, Vitamin B-12 Supplement,. BHT (A Preservative), Zinc Oxide, Ferrous Sulfate, Managenous Oxide, Copper Oxide, Cobalt Carbonate, Ethylenediamine dihydriodide, Menadionine Sodium Bisulfite Complex, (Source of Vitamin K), Sodium Senenite, Sodium Bentonite, L-Lysine, DL Methionine, Calcium Carbonate, Diacalcium Phosphate, Defluorinated Phosphate, Salt, Yeast Culture, Potassium Magnesium Sulfate.

CAUTION: This premix contains Selenium. Add to finished feeds at a rate of not more than 75 pounds per ton. This will add 90.8 Mg. or 0.10 PPM Selenium which is the permitted level in swine. Feed to swine only. Use as the sole source of Selenium when added at 75 pounds per ton of finished feed. Use mixing suggestions on back of this label. For mixing purposes only. Follow label directions.



(a)



(b)

Figure 2. Feeding/Watering Period used in the Meal-Time Feeding System.

lb, they were switched to two feeding/watering periods daily for three hours each. Again, pigs were watered during a two-hour period between each feeding (Figure 2b).

In trials 4, 6, 8, and 9, pigs on Smidley feeders were fed and watered ad lib. Pigs on Meal-Time feeders were fed from the beginning to the end of the feeding trial during two feeding/watering periods each day, three hours each with a two-hour water period between each feeding (Figure 2b).

IV. Objective Measures

Average daily gain was calculated by subtracting total beginning pen weight from total end weight divided by pig days within each pen.

Feed efficiency was calculated for each feeding system (Smidley vs. Meal-Time) within each trial by dividing total pounds of feed by total pig gain. Feed was weighed when augered into the feed bins. Feed efficiency for Meal-Time pigs was not calculated on a pen basis because of the closed feed handling design of the Meal-Time feeding equipment (Figure 3).

Water usage for each trial was measured by installing water meters for each feeding system. Meter readings were recorded at the beginning and end of each trial for both feeding systems. Comparisons of water usage for each feeding system were made by comparing water usage/pig/day. The term 'water usage' was used because the water meter for each feeding system measured total water including water wastage as well as water consumption. These comparisons were calculated in two ways; water usage/pig/day and water usage/lb of feed consumed/pig/day.

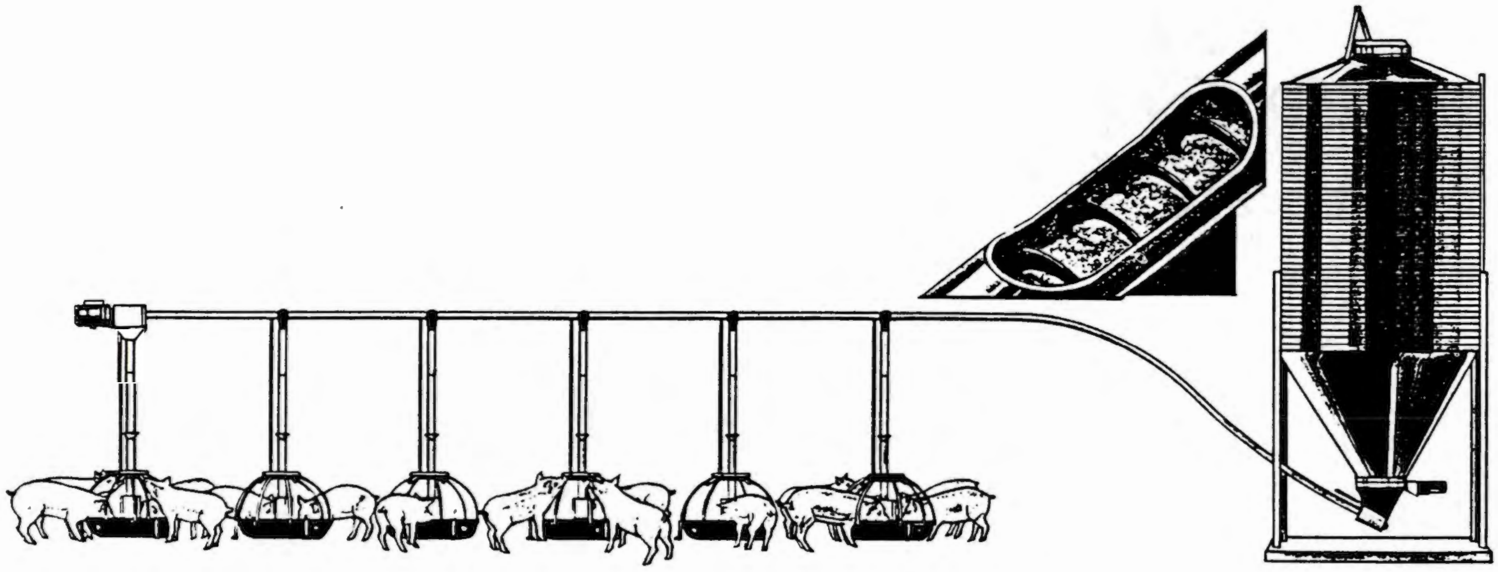


Figure 3. Closed-Feed Handling Design of the Meal-Time Feeders.

Water usage/pig/day was derived by dividing pounds of water used by total pig days for each feeding system. Water usage/lb of feed consumed/pig/day was calculated by first dividing total pounds of water used by total pounds of feed consumed and then dividing by total pig days. This was accomplished for each feeding system.

V. Statistical Analysis

An analysis of variance was used to determine the effects of the independent variables (trial, feeding system, trial x feeding system interaction) on the dependent variables (average daily gain, feed efficiency, water use/lb of feed consumed/pig/day and water use/pig/day).

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to study the effects of two different feeding systems for growing-finishing swine on average daily gain, feed efficiency and water usage in a swine confinement finishing unit.

Average Daily Gain

When the mean average daily gain of seven trials of the Smidley feeding system was compared to the mean average daily gain of the seven trials of the Meal-Time feeding system, there was no significant difference ($P > .05$). Table 2 shows the mean average daily gain and standard deviation for each feeding system. Even though pigs fed by Smidley feeders outgained the pigs fed by the Meal-Time system (1.589 vs. 1.550 lb/day, respectively), the difference was not significant ($P > .05$).

An analysis of variance (Table 3) explains that while the trial effect was significant ($P < .05$), the effects of the feeding system and the trial x feeding system interaction were not significant ($P > .05$).

Smidley feeders produced the fastest gains in five of seven trials (Table 4). Statistical analysis using a t-test revealed that only in two trials was there a significant difference in gain. In Trials 1 and 8, the pigs fed from Smidley feeders significantly outgained the pigs on Meal-Time feeders ($P < .05$, $P < .01$, respectively).

The differences in gains in Trials 1 and 8 may possibly be explained by the number of death losses in each of these trials. Since average daily gain was calculated by subtracting total pen weight from

TABLE 2. Means and Standard Deviations of Average Daily Gain and Feed Efficiency Measured for Smidley and Meal-Time Feeding Systems

	Smidley		Meal-Time	
	Mean	Std. Dev.	Mean	Std. Dev.
Average Daily Gain (lb/day)	1.589^{a}	.161	1.550^{a}	.169
Feed Efficiency (lb)	3.273^{b}	.212	3.271^{b}	.217

[a,b]Means in the same row that do not have a common subscript differ ($P < .05$).

TABLE 3. Analysis of Variance for Average Daily Gain

Source	df	MS[1]	F Value	PR> F
Trial	6	0.4367	2.91	0.0139
System	1	0.0317	1.26	0.2647
Trial x System	6	0.0354	0.24	0.9633
Residual	68	1.7023		
R-square	.23			

[1]Mean squares for treatment effects are Type III sums of squares.

TABLE 4. Mean Average Daily Gain for Each Trial by Feeding System

Trial	Smidley (ADG lb/day)	Meal-Time (ADG lb/day)
1	1.57[a]	1.51[b]
2	1.69[a]	1.62[a]
3	1.65[a]	1.67[a]
4	1.64[a]	1.61[a]
6	1.51[a]	1.46[a]
8	1.53[g]	1.43[h]
9	1.54[a]	1.56[a]
Combined trials	1.589[a]	1.550[a]

[a,b] Means in the same row that do not have a common subscript differ ($P < .05$).

[g,h] Means in the same row that do not have a common subscript differ ($P < .01$).

total ending pen weight divided by pig days, a higher death loss would tend to decrease calculated average daily gain. However, the difference in total death loss in each feeding system for all seven trials was only one pig (Table 5). Therefore, total pig death loss throughout the experiment did not adversely affect the outcome of this study.

When the pens which contained the lightweight, middleweight and heavyweight pigs allotted to each feeding system over all trials (Table 6) were compared using a t-test, no significant differences were found in average daily gain ($P > .05$). Small and non-significant differences in average daily gain between the two feeding systems agrees with the work of Hines and Vargas (1983, 1984).

Feed Efficiency

There was no significant difference in feed efficiency between the two feeding systems. In fact, the mean feed efficiency ratio combining all seven trials was the same (3.27) for each feeding system. This agrees with similar studies involving conventional feeders and Meal-Time feeding systems conducted by Hines and Vargas (1983, 1984).

Table 2 shows the mean and standard deviation for each system. There were slightly greater differences in feed efficiency among the trials than there were between feeding systems, but both F-values were far from being significant (Table 7).

Pigs being fed from Smidley feeders were more efficient in feed utilization during the first two trials, but pigs on Meal-Time feeders were more efficient in Trials 3, 6, 8, and 9. There was no difference in Trial 4 (Table 8).

TABLE 5. Death Losses for Each Trial by Feeding System

Trial	Smidley			Meal-Time		
	No. pigs started	No. pigs end	Death loss	No. pigs started	No. pigs end	Death loss
1	105	105	0	105	103	2
2	106	104	2	106	105	1
3	111	108	3	111	111	0
4	89	87	2	89	89	0
6	84	83	1	85	85	0
8	109	107	2	109	104	5
9	113	113	0	111	108	3
Total	717	707	10	716	706	11

TABLE 6. Mean Average Daily Gain for Lightweight, Middleweight, and Heavyweight Pens of Pigs for all Trials

Pen	Smidley	Meal-Time
Lightweight	1.40[a]	1.34[a]
Middleweight	1.67[a]	1.61[a]
Heavyweight	1.71[a]	1.68[a]

[a]Means in the same row that do not have a common subscript differ ($P < .05$).

TABLE 7. Analysis of Variance for Feed Efficiency

Source	df	MS[1]	F Value	PR > F
Trial	6	0.2874	1.09	0.4607
System	1	0.0000	0.00	0.9903
Residual	6	0.2642		
R-square	.52			

[1]Mean squares for treatment effects are Type III sums of squares.

TABLE 8. Mean Feed Efficiency for Each Trial by Feeding System

Trial	Smidley (lb)	Meal-Time (lb)
1	2.97	3.58
2	3.14	3.22
3	3.22	3.01
4	3.50	3.51
6	3.58	3.30
8	3.18	3.03
9	3.32	3.25

The variation from trial to trial in feed efficiency between the two feeding systems can not be readily explained. One difference which might explain the feed efficiency advantage of the Smidley feeders in the first two trials is the Meal-Time feeding schedule. In the first two trials, Meal-Time pigs were scheduled for three feeding/watering periods per day, two hours each and then switched when the pig weighed an average of approximately 100 pounds to two feeding/watering periods per day, three hours each. In the remaining five trials, the Meal-Time pigs were allotted two feeding/watering periods per day, three hours each from the beginning pig weight of about 50 lb.

More research needs to be conducted studying feed efficiency at different feeding periods and varying pig weights when using Meal-Time feeding systems. It was impractical in these trials to determine feed efficiency at varying pig weights due to the closed feeding system of the Meal-Time feeders and the fact that feed was weighed as it was augered into the feed bins.

Water Usage

Research priorities in these trials were primarily concerned with average daily gain and feed efficiency. However, water usage was measured and proved to be the most significant difference between the two feeding systems.

The F-values (Table 9) explain the effect that feeding system exerted on water usage. Small differences were found among the various trials of each feeding system ($P > .05$) on water usage; however, feeding system effect was highly significant ($P < .0001$). Pigs on the Meal-Time system used significantly less water compared to pigs fed from self

TABLE 9. Analysis of Variance for Water Usage

Source	df	MS[1]	F Value	PR F
		Water Use/Pig/Day		
Trial	6	12.3486	2.40	0.1559
System	1	265.7857	309.40	0.0001
Residual	6	5.1543		
R-square	.98			

[1] Mean squares for treatment effects are Type III sums of squares.

TABLE 9. (Continued)

Source	df	MS[1]	F Value	PR F
		Water Use/lb feed/ Pig/Day		
Trial	6	0.5965	1.15	0.4331
System	1	9.8113	113.91	0.0001
Residual	6	0.5168		
R-square	.95			

[1]Mean squares for treatment effects are Type III sums of squares.

feeders (Table 10), yet there were no significant differences in average daily gain or feed efficiency. This substantiates earlier research work which reported no statistically apparent differences in the rate of growth or feed efficiency of growing pigs offered various amounts of water (Barber et al., 1958; Barber et al., 1963; Holme et al., 1965).

Furthermore, the results of these trials agree with Hines (1986) which showed pigs fed on the Meal-Time feeding system to utilize significantly less water with no significant differences in average daily gain and feed efficiency when compared to pigs fed on conventional swine feeding systems.

One possible explanation for the conservative water usage by pigs on the Meal-Time system may be that during warm weather pigs in the Smidley pens wasted more water by playing with the nipple waterer. However, during the winter months when water wastage would normally be expected to be lower, there was significantly less usage by the Meal-Time fed pigs when compared to the Smidley fed pigs (Table 11).

Another possible explanation for less water usage by the Meal-Time pigs may be attributed to the Meal-Time feeder design (Figure 1). If and when pigs play with the nipple waterers, water wasted falls into the feeder bowl and may possibly be consumed as moist feed or consumed as water from the bowl. In the Smidley pens, the nipple waterer was located over the pit area and water wastage from the nipple fell directly into the pit.

Nienaber et al (1984) found as water flow rate increased, water usage increased. However, all nipple waterers on both feeding systems in this study operated at the same pressure (40 psi).

TABLE 10. Mean Water Usage for Each Trial by Feeding System (Water Usage/lb feed/pig/day, lb)

Trial	Smidley	Meal-Time
1	3.36	.87
2	3.08	1.21
3	2.28	.97
4	2.53	1.16
6	2.31	.94
8	2.96	1.23
9	2.71	1.13
Total	2.75[a]	1.07[b]

[a,b]Means in the same row that do not have a common subscript differ ($P < .0001$).

TABLE 11. Mean Water Usage/Pig/Day for Each Trial by Feeding System

Trial	Trial period	Smidley (lb/day)	Meal-Time (lb/day)
1	May - Aug.	15.6	4.7
2	Aug.- Nov.	16.3	6.3
3	Dec. - Mar.	12.1	4.9
4	Mar. - June	14.4	6.5
6	Oct. - Jan.	12.5	4.5
8	May - Aug.	14.2	5.3
9	Aug. - Nov.	13.8	5.7
Overall mean		14.1[a]	5.4[b]

[a,b]Means in the same row that do not have a common subscript differ ($P < .0001$).

Water usage by pigs on the Meal-Time feeding system agrees with the findings of Hines (1986); however, no explanation was given for these differences. More research is needed in this area to adequately assess the exact water needs of growing-finishing swine.

Conclusions

Results of this study led to the following conclusions:

1. Type of feeding system did not affect average daily gain or feed efficiency. These traits are affected more by such things as feeder maintenance, genetics, ration, and feed wastage.

2. Water usage was significantly reduced by using Meal-Time feeders. Small savings from reduced water costs may accrue to swine producers using the Meal-Time feeding system.

CHAPTER V

SUMMARY

Data from 1412 pigs in seven different trials formed the basis of this study. Each trial used a complete farrowing group of pigs from the swine confinement unit (System III) at Ames Plantation.

Each trial began with approximately 200 pigs weighing an average of 50 lb and were randomly divided into two groups by weight. The approximate 40 lightest pigs were divided equally into pens 1 and 2, the next heaviest 40 pigs were divided equally into pens 3 and 4 and so on until all pigs were assigned to 12 pens.

One group was fed by a conventional four-hole Smidley self feeder and watered by one nipple waterer located over the pit area. The other group was fed by a Stage III Meal-Time feeder which also had five nipple waterers attached to the feeder.

All pigs were crossbred and the ration fed was the same during each trial.

Average daily gain was calculated by subtracting total beginning pen weight from total end weight divided by pig days within each pen. Feed efficiency was calculated for each group (Smidley vs. Meal-Time) within each trial by dividing total pounds of feed by total pig gain. Water usage for each trial was measured by installing water meters for each feeding system.

It was found by least squares analysis that feeding system had no significant effect ($P > .05$) on average daily gain. Even though pigs fed by Smidley feeders outgained pigs fed on the Meal-Time system, the difference was not significant ($P > .05$).

Least squares analysis revealed there was no difference ($P > .05$) in feed efficiency between the two feeding systems. Feed efficiency ratios were the same. Trial effect displayed more difference, but not significantly ($P > .05$).

System effect on water usage was highly significant. Pigs on Meal-Time feeders used significantly ($P < .0001$) less water than those on Smidley feeders as measured by water usage/pig/day and water usage/lb of feed consumed. Trial effect was not significantly different ($P > .05$).

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APPENDIX

TABLE A-1. Trial 1 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	105	105
Pigs ending trial	105	103
Total wt, 5-12-82, lb	5,637	5,604
Avg. pig wt, lb	53.7	53.4
Ending wt, 8-13-82, lb	20,866	19,971
Avg. pig wt, lb	198.7	193.9
Total gain, lb	15,229	14,367
Avg. gain/pig	145	139.5
Pig Days	9,702	9,502
ADG	1.57	1.51
Feed Consumed, lb	45,201	51,500
Feed/lb/gain	2.97	3.58
Water usage, lb	151,652	44,903
Water usage/pig/day, lb	15.63	4.73
Water usage/lb feed consumed/pig/day, lb	3.36	.87

TABLE A-2. Trial 2 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	106	106
Pigs ending trial	104	105
Total wt, 8-24-82, lb	5,212	5,214
Avg. pig wt, lb	49.2	49.2
Ending wt, 11-29-82, lb	22,254	21,693
Avg. pig wt, lb	214.0	206.6
Total gain, lb	17,042	16,479
Avg. gain/pig	163.9	156.9
Pig Days	10,088	10,185
ADG	1.69	1.62
Feed Consumed, lb	53,470	53,100
Feed/lb/gain	3.14	3.22
Water usage, lb	164,137	64,042
Water usage/pig/day, lb	16.3	6.3
Water usage/lb feed consumed/pig/day, lb	3.08	1.21

TABLE A-3. Trial 3 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	111	111
Pigs ending trial	108	111
Total wt, 12-7-82, lb	5,588	5,589
Avg. pig wt, lb	50.3	50.4
Ending wt, 3-14-83, lb	22,908	23,578
Avg. pig wt, lb	212.1	212.4
Total gain, lb	17,320	17,989
Avg. gain/pig	160.4	162.1
Pig Days	10,476	10,767
ADG	1.65	1.67
Feed Consumed, lb	55,856	54,105
Feed/lb/gain	3.22	3.01
Water usage, lb	127,242	52,771
Water usage/pig/day, lb	12.1	4.9
Water usage/lb feed consumed/pig/day, lb	2.28	.97

TABLE A-4. Trial 4 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	89	89
Pigs ending trial	87	89
Total wt, 3-21-83, lb	5,484	5,485
Avg. pig wt, lb	61.6	61.6
Ending wt, 6-27-83, lb	19,457	19,511
Avg. pig wt, lb	223.6	219.2
Total gain, lb	13,973	14,026
Avg. gain/pig	160.6	157.6
Pig Days	8,526	8,722
ADG	1.64	1.61
Feed Consumed, lb	48,912	49,196
Feed/lb/gain	3.50	3.51
Water usage, lb	122,650	56,334
Water usage/pig/day, lb	14.4	6.5
Water usage/lb feed consumed/pig/day, lb	2.53	1.16

TABLE A-5. Trial 6 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	84	85
Pigs ending trial	83	85
Total wt, 10-18-83, lb	4,595	4,628
Avg. pig wt, lb	54.7	54.4
Ending wt, 1-12-84, lb	15,349	15,145
Avg. pig wt, lb	184.9	178.2
Total gain, lb	10,754	10,517
Avg. gain/pig	129.6	123.7
Pig Days	7,138	7,224
ADG	1.51	1.46
Feed Consumed, lb	38,500.4	34,746.2
Feed/lb/gain	3.58	3.30
Water usage, lb	89,079	32,247
Water usage/pig/day, lb	12.5	4.5
Water usage/lb feed consumed/pig/day, lb	2.31	.94

TABLE A-6. Trial 8 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	109	109
Pigs ending trial	107	104
Total wt, 5-8-84, lb	5,270	5,272
Avg. pig wt, lb	48.3	48.4
Ending wt, 8-13-84, lb	21,103	19,666
Avg. pig wt, lb	197.2	189.1
Total gain, lb	15,833	14,394
Avg. gain/pig	148.0	138.4
Pig Days	10,379	10,088
ADG	1.53	1.43
Feed Consumed, lb	50,324.7	43,573.9
Feed/lb/gain	3.18	3.03
Water usage, lb	147,782	53,159
Water usage/pig/day, lb	14.2	5.3
Water usage/lb feed consumed/pig/day, lb	2.96	1.23

TABLE A-7. Trial 9 Summary - Smidley vs. Meal-Time

	Smidley	Meal-Time
Pigs starting trial	113	111
Pigs ending trial	113	108
Total wt, 8-20-84, lb	5,098	5,015
Avg. pig wt, lb	45.1	45.2
Ending wt, 11-26-84, lb	22,172	21,494
Avg. pig wt, lb	196.2	199.0
Total gain, lb	17,074	16,479
Avg. gain/pig	151.1	152.6
Pig Days	11,074	10,584
ADG	1.54	1.56
Feed Consumed, lb	56,648.3	53,566.4
Feed/lb/gain	3.32	3.25
Water usage, lb	152,714	59,888
Water usage/pig/day, lb	13.8	5.7
Water usage/lb feed consumed/pig/day, lb	2.71	1.13

TABLE A-8. Trial 1 Pen Summary

				SMIDLEY		
Pen	1	3	5	7	9	11
No. pigs/pen	18	18	18	17	17	17
Avg. pig starting wt., lb	34.7	43.7	50.9	57.1	64.0	73.6
Avg. pig end wt., lb	178.2	178.4	204.3	212.1	205.3	216.0
Total gain	2583	2425	2761	2635	2402	2423
ADG (93 days), lb	1.54	1.45	1.65	1.67	1.52	1.60
				MEAL-TIME		
Pen	2	4	6	8	10	12
No. pigs/pen	18 (16)*	18	18	17	17	17
Avg. pig starting wt., lb	32.9	43.7	50.9	57.1	64.0	73.5
Avg. pig end wt., lb	165.1	180.3	196.3	203.8	203.4	213.5
Total gain	2049	2458	2617	2494	2369	2380
ADG (93 days), lb	1.38	1.47	1.56	1.58	1.50	1.58

*Two pigs died. ADG calculated by subtracting total beginning weight from total end weight divided by pig day.

TABLE A-9. Trial 2 Pen Summary

			SMIDLEY			
Pen	1	3	5	7	9	11
No. pigs/pen	18	18 (17)*	18	18 (17)*	17	17
Avg. pig starting wt., lb	28.7	40.3	47.6	53.3	59.4	67.4
Avg. pig end wt., lb	177.7	192.4	213.6	228.8	229.4	244.2
Total gain	2683	2545	2988	2931	2889	3006
ADG (97 days), lb	1.54	1.54	1.71	1.78	1.75	1.82
			MEAL-TIME			
Pen	2	4	6	8	10	12
No. pigs/pen	18 (17)*	18	18	18	17	17
Avg. pig starting wt., lb	28.7	40.3	47.6	53.3	59.4	67.4
Avg. pig end wt., lb	167.4	197.1	202.6	214.2	218.5	240.2
Total gain	2329	2822	2791	2895	2705	2937
ADG (97 days), lb	1.42	1.62	1.60	1.66	1.64	1.78

*One pig died in each pen. ADG calculated by subtracting total beginning weight from total weight divided by pig days.

TABLE A-10. Trial 3 Pen Summary

			SMIDLEY			
Pen	1	3	5	7	9	11
No. pigs/pen	19 (18)*	19	19	18 (17)*	18 (17)*	18
Avg. pig starting wt., lb	27.2	39.5	48.2	55.1	62.2	72.0
Avg. pig end wt., lb	162.7	199.1	209.5	230.9	234.4	239.2
Total gain	2411	3033	3065	2935	2866	3010
ADG (97 days), lb	1.38	1.65	1.66	1.78	1.74	1.72
			MEAL-TIME			
Pen	2	4	6	8	10	12
No. pigs/pen	19	19	19	18	18	18
Avg. pig starting wt., lb	27.3	39.5	48.2	55.0	62.2	72.0
Avg. pig end wt., lb	158.9	203.3	207.1	229.8	231.7	247.4
Total gain	2501	3112	3019	3147	3052	3158
ADG (97 days), lb	1.36	1.69	1.64	1.80	1.75	1.81

*One pig died in each pen. ADG calculated by subtracting total beginning weight from total end weight divided by pig days.

TABLE A-11. Trial 4 Pen Summary

			SMIDLEY		
Pen	3	5	7	9	11
No. pigs/pen	17 (16)*	18 (17)*	18	18	18
Avg. pig starting wt., lb	42.6	56.4	62.6	68.4	76.9
Avg. pig end wt., lb	207.7	217.8	225.2	223.1	242.4
Total gain	2598	2687	2926	2784	2978
ADG (98 days), lb	1.66	1.61	1.66	1.58	1.69
			MEAL-TIME		
Pen	4	6	8	10	12
No. pigs/pen	17	18	18	18	18
Avg. pig starting wt., lb	42.7	56.5	62.6	68.4	76.9
Avg. pig end wt., lb	195.8	206.3	218.7	230.2	243.9
Total gain	2602	2697	2810	2912	3005
ADG (98 days), lb	1.56	1.53	1.59	1.65	1.70

*One pig died in each pen. ADG calculated by subtracting total beginning weight from total end weight divided by pig days.

TABLE A-12. Trial 6 Pen Summary

			SMIDLEY			
Pen	1	3	5	7	9	11
No. pigs/pen	14	14(13)*	14	14	14	14
Avg. pig starting wt., lb	31.3	43.1	52.0	59.9	65.5	76.4
Avg. pig end wt., lb	123.3	154.5	184.4	203.1	210.4	231.6
Total gain	1288	1405	1854	2006	2029	2172
ADG (86 days), lb	1.07	1.26	1.54	1.67	1.69	1.80
			MEAL-TIME			
Pen	2	4	6	8	10	12
No. pigs/pen	15	14	14	14	14	14
Avg. pig starting wt., lb	31.3	43.2	52.0	59.9	65.5	76.5
Avg. pig end wt., lb	128.8	139.6	188.0	196.0	212.3	217.1
Total gain	1334	1349	1904	1906	2055	1969
ADG (86 days), lb	1.11	1.12	1.58	1.58	1.71	1.64

*One pig died in each pen. ADG calculated by subtracting total beginning weight from total end weight divided by pig days.

TABLE A-13. Trial 8 Pen Summary

			SMIDLEY			
Pen	1	3	5	7	9	11
No. pigs/pen	19	18	18 (17)*	18	18	18 (17)*
Avg. pig starting wt., lb	32.2	41.0	46.2	50.7	56.3	64.6
Avg. pig end wt., lb	169.2	184.7	200.9	198.2	208.9	224.8
Total gain	2602	2586	2584	2655	2747	2659
ADG (97 days), lb	1.41	1.48	1.57	1.52	1.57	1.61
			MEAL-TIME			
Pen	2	4	6	8	10	12
No. pigs/pen	19 (17)*	18	18 (16)*	18	18 (17)*	18
Avg. pig starting wt., lb	32.3	41.0	46.2	50.7	56.4	64.6
Avg. pig end wt., lb	157.8	176.6	192.9	202.0	199.5	204.9
Total gain	2071	2441	2255	2724	2376	2527
ADG (97 days), lb	1.26	1.40	1.45	1.56	1.44	1.45

*One pig died in each pen. ADG calculated by subtracting total beginning weight from total end weight divided by pig days.

TABLE A-14. Trial 9 Pen Summary

Pen	1	3	5	7	9	11
No. pigs/pen	19	19	19	19	19	18
Avg. pig starting wt., lb	26.1	35.1	41.9	48.6	54.6	65.4
Avg. pig end wt., lb	143.6	174.3	195.1	209.5	219.8	237.1
Total gain	2232	2645	2910	3057	3139	3091
ADG (98 days), lb	1.20	1.42	1.56	1.64	1.69	1.75
			MEAL-TIME			
Pen	2	4	6	8	10	12
No. pigs/pen	18	19 (18)*	19 (18)*	19	18 (17)*	18
Avg. pig starting wt., lb	26.1	35.1	41.9	48.6	54.7	65.3
Avg. pig end wt., lb	152.5	174.1	205.1	198.2	224.2	241.5
Total gain	2276	2468	2894	2843	2827	3171
ADG (98 days), lb	1.29	1.40	1.64	1.53	1.70	1.80

*One pig died in each pen. ADG calculated by subtracting toal beginning weight from total end weight divided by pig days.

VITA

James Cloyd Ligon, son of Herschel Cloyd Ligon and Lillie Eller Ligon, was born in Nashville, Tennessee on November 24, 1954. He attended the Wilson County school system, where he graduated from Mt. Juliet High School in 1972. He enrolled in the University of Tennessee at Knoxville in the Fall of 1972. He graduated in June 1976 with a Bachelor of Science Degree in Animal Husbandry. He was then employed with Jaritas Ranch of Springer, New Mexico.

In October 1977, after working for Anchor Animal Health as a Field Representative in Georgia, he was employed as Farm Manager/Instructor with Tennessee Technological University, Cookeville, Tennessee. In January 1986 he took a one-year leave of absence from Tennessee Tech University and entered the University of Tennessee, Knoxville, and received his Master of Science Degree in Animal Science in June 1987.