

THE EFFECTS OF LIMIT FEEDING FINISHING SWINE ON  
PERFORMANCE AND CARCASS MEASUREMENTS

by

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## INTRODUCTION

Many areas of the world experience a limited or expensive supply of feedstuffs. In these areas it has been a long established practice to feed finishing pigs less feed than they would normally consume if fed on an ad libitum basis.

If limit feeding of finishing pigs is to be an accepted practice in the United States it must provide some advantage over the common practice of ad libitum feeding. In order to evaluate limit feeding it is necessary to consider several areas of response.

The first area of response to consider is growth. It is well established that as feed intake is restricted, daily gain decreases. Therefore, it is necessary to keep feed intake at a level which allows an acceptable increase in days to market.

Feed conversion efficiency (FCE) is the second criteria of response to limit feeding for consideration. A study of the literature indicates a lack of agreement as to whether FCE is improved, poorer, or not affected by limit feeding. It is reasonable to assume such a lack of agreement may be due to the various methods of limit feeding. For limit feeding to become an accepted practice in the United States, FCE must at least equal that of ad libitum feeding.

A third area of response to be considered is carcass composition. When finishing pigs are fed ad libitum, more feed is consumed than that needed for maximum lean tissue formation. The excess beyond that needed for maintenance and protein formation is deposited as fat. With few exceptions, there is general agreement that limit feeding will improve lean content of the carcass. This means reduced backfat thickness and a larger percent muscle, and therefore a more desirable carcass.

It is generally accepted that barrows consume more feed, grow faster, have a poorer FCE, and produce a fatter carcass than gilts when fed ad libitum.

Limit feeding is generally restricted to equal feeding of the sexes. It is reasonable to assume that due to biological differences separate feeding of barrows and gilts may need to be considered when restricting feed intake. Therefore, it is important to consider the effect of limit feeding on barrows vs. gilts. This may allow for maximum performance and carcass composition of the sexes.

In addition to the above criteria for limit feeding, a consideration of lysine (the first limiting amino acid) as a percent of the diet should be made. Current recommendations of NRC (1979) for ad libitum fed finishing swine and ARC (1967) for limit feeding are similar as a percent of the diet. It would be reasonable to assume that when

limiting intake, lysine would become limiting.

The efforts of this research were to evaluate limit feeding of finishing pigs.

## LITERATURE REVIEW

### Lysine Requirement for Ad libitum and Limit Fed Finishing Swine

Ad libitum feeding. (N.R.C. 1979) list the minimum requirement for ad libitum fed finishing swine, 60-100 kg liveweight, as .57% of the diet.

Vipperman et al. (1963) fed 36 barrows and gilts different levels of supplemental L-lysine HCL with a 12% corn-peanut oil meal diet from 57 kg liveweight to slaughter. With six different lysine levels, the best daily gain and feed conversion efficiency (FCE) were observed at .68% lysine in the diet.

Four feeding trials conducted by Brown et al. (1973) were performed to determine the lysine requirements for daily gain and FCE in ad libitum fed finishing swine. Six levels of L-lysine HCL were added to a 13.3% protein corn-sesame meal diet. Estimated lysine requirement for the maximum daily gain was determined to be .48% of the diet. The lysine requirement for the best FCE was estimated to be .62% of the diet. Nitrogen retention increased with each increase of lysine (.45, .55, and .65%) but at a decreasing rate. Rate of increase was not sufficient for an accurate estimate of requirement for maximum nitrogen retention.

Bell (1965) fed pigs at two different levels of lysine from 45 kg to 90 kg liveweight. Growth rate and FCE were superior at .67% lysine when compared to .55% lysine in the diet. This agrees with the previous work of Bellis (1961).

Limit feeding. The Agricultural Research Council (1967) suggested requirement for lysine in pigs from 50 kg liveweight to slaughter of .6 to .65% of the diet. This suggestion is made for diets currently used in Britain which have less DE than a corn-soybean meal diet.

Costain and Morgan (1961) scale fed 32 Large White barrows and gilts individually from 45 to 90 kg liveweight. From their work, they suggested that a level of .5 to .6% lysine is needed for maximum growth.

Two hundred and fifty six Large White barrows and gilts were scale fed from 68 to 90 kg liveweight in an experiment conducted by Blair et al. (1969). Best overall gain was produced with a .62 to .87% lysine and FCE was best optimized at .70% lysine. These results are in good agreement with previous findings and with the levels recommended by ARC (1967).

Work done by Cole et al. (1980) found a linear response in FCE and growth at lysine levels above those suggested by ARC (1967). Their review of literature found some support for higher levels of lysine in the diet.

### Effect of Feed Restriction on Weight Gain

In a review of literature to 1956, Lucas and Calder (1956) concluded that feeding finishing pigs less than ad libitum will reduce daily gain. They also stated the more severe the restriction, the greater the reduction in gain.

A review of eleven research publications on limit feeding by Vanschoubroek et al. (1967) revealed that feed restriction reduced daily gain in all experiments.

Numerous other experiments, regardless of design, reached the same conclusion (Hines, 1966; Veum et al., 1970; Barber et al., 1972; Davies and Lucas, 1972ab; Fuller and Livingstone, 1978; Aherne et al., 1981; Yen et al., 1981; Giles et al., 1981).

### Effect of Feed Restriction on Feed Efficiency

There is a general lack of agreement as to the affect of feed restriction on feed efficiency. Lucas and Calder (1956) reviewed a number of experiments and calculated total daily nutrients supplied by the various planes of feeding in each experiment. These calculations of energy content led to a possible explanation for the different results found when looking at FCE. The plane of feeding considered high in one experiment could be considered low in another. Lucas and Calder (1956) found from their comparisons that different planes of nutrition was not the

total answer. A more likely explanation for some of the discrepancies is the interaction between housing and plane of nutrition.

Vanschoubroek et al. (1967) reviewed eleven different research experiments and found FCE was generally improved when feed was restricted. However, four of the papers reviewed found FCE was not improved by limit feeding. Vanshoubroek et al. (1967) believed these exceptions may have been caused by small numbers of animals in three of the experiments and disease problems in the fourth.

From these eleven experiments, Vanschoubroek et al. (1967) reported optimum FCE would be at 25% less feed than that consumed by pigs fed ad libitum.

An experiment conducted by Hines (1966) compared ad libitum feeding with various levels of restriction of ad libitum (90, 80, 70, and 60%) and access to feed every second 24-hour period and every third 24-hour period. No significant difference in FCE was noted. Ad libitum fed pigs did show an advantage in FCE when compared to limited access to feed. Pigs restricted to 90% of ad libitum showed a slight advantage in FCE.

Research conducted by Allee et al. (1972) compared ad libitum feeding with meal-feeding two hours per 24 hours and two hours per 48 hours. Pigs fed two hours

per 24 hours had a significantly better FCE than those fed ad libitum. No FCE difference was found between ad libitum feeding and pigs fed two hours per 48 hours.

Veum et al. (1970) compared ad libitum feeding (control treatment) with three feeding-fasting intervals. Pigs that were fasted in treatment two were allowed access to feeders on alternate days for 24 hours; treatment three pigs were fasted two days and allowed feed access to self-feeders for 24-hours the third day. Treatment four pigs were fasted three days and allowed access to feed on the fourth day for 24 hours. A slight improvement in feed efficiency was observed in treatment two (alternate days full feed) over the ad libitum fed control pigs. Feed conversion was significantly poorer for pigs fasted two days and fed 24 hours and pigs fasted three days then fed 24 hours.

Two similar experiments to those of Veum et al. (1970) were conducted by Grandhi and Strain (1980) and Castell (1980). Grandhi and Strain (1980) conducted two experiments; the first in the winter, and the other in summer.

In experiment one (winter) FCE was significantly effected in only one of the four limit feeding treatments. This treatment allowed pigs no access to feed for three twenty-four hour periods on alternating days per week. Experiment two (summer) used the same treatments as



experiment one. Results showed an improved FCE for treatment three allowing pigs no access to feed for three 24 hour periods on alternating days per week. Castell (1980) used similar methods of restriction and reported no significant difference in FCE for restricted treatments. However, a trend toward improvement of FCE was reported for a one day restriction per week and two non-consecutive days restricted access to feed per week.

Research conducted by Davies and Lucas (1972b) found optimum FCE for pigs 50 to 90 kg liveweight is three times the feed needed for maintenance. Pigs were fed at different levels above maintenance to determine best FCE. Their results closely approximated the digestible energy suggested by ARC (1967) for maximum FCE.

Barber et al. (1972) conducted an experiment comparing pigs fed according to a scale feeding system based on liveweight and a system allowing the pigs to eat to appetite on a daily basis which was defined as semi-ad libitum feeding. They reported FCE to be similar in both systems of feeding. In a comparison with an earlier similar experiment conducted by Barber et al. (1957), the results found were similar in both experiments even though pigs with entirely different genetic backgrounds were used. The general conclusion reached was that some form of controlled scale-feeding was necessary.

Recent research of Giles et al. (1981) compared ad libitum feeding with ARC (1967) recommended daily

digestable energy intake and two further restricted intake levels. Results showed improved FCE for the three limit feeding treatments when compared to the ad libitum treatment. No improvement in FCE was noted when ARC (1967) feed level was compared with further reductions of feed intake of 12.5% and 25%.

A significantly poorer FCE was reported by Passback et al. (1968) for Duroc and Hampshire pigs fed a constant restricted feed intake from 35 to 90 kg liveweight when compared to the ad libitum control. FCE was slightly improved when pigs were restricted to 1.02 kg feed, given twice daily to 72 kg liveweight, then ad libitum fed to 90 kg liveweight.

Stahly and Wahlstrom (1973) conducted an experiment using pigs from 59 kg liveweight to slaughter. Treatments were a 14% protein fed ad libitum, a 10% protein fed ad libitum, and a 14% protein fed restricted. The limit fed treatment was calculated to mimic the growth rate of the 10% ad libitum treatment. No significant difference existed between the pigs fed 14% protein and the restricted treatment, although FCE was slightly better in the ad libitum fed pigs. FCE was significantly better in both 14% C.P. treatments when compared to the 10% ad libitum treatment.

A similar experiment to Stahly and Wahlstrom (1973) was conducted by Yen et al. (1981). In this

experiment no significant difference in FCE was noted. However, FCE was improved by restricting intake to 82% of ad libitum.

Aherne et al. (1981) conducted two experiments on limit feeding. Experiment 1 compared an ad libitum treatment with two restricted feeding treatments of four hours access to feed and 85% of the feed consumed by the ad libitum fed pigs. A slight improvement was observed in both restricted treatments, but this was not significant.

Experiment 2 was designed to determine the effect of restricted feeding of individually penned pigs. Pigs were fed either ad libitum or 80% of ad libitum. Pigs in the 80% treatment had a significantly better FCE than those fed ad libitum. This data suggests pigs fed individually respond to a limit feeding system, whereas those fed in groups do not respond when the criteria of evaluation was FCE.

#### Effect of Feed Restriction on Carcass Measurements

Lucas and Calders (1956) review of literature stated that a severe feed restriction improves carcass measurements. They further stated, that a severe restriction has too great of an adverse effect on daily gain. Also, a less severe restriction brings the total growth period into a more acceptable range, but has only a small effect on improving carcass quality.

In Vanschoubroeks et al. (1967) review of literature, they concluded from the work of eleven different researchers that a feed restriction of 15.8% diminished backfat thickness by 7.63% or .53% for each 1% restriction. In only one experiment was backfat thickness increased and this was probably due to the small number of experimental animals.

Studies conducted by Hines (1966) found restricting feed intake improves carcass quality. Loin eye area was significantly larger with restriction and backfat was reduced approximately .25 cm with each 10% restriction. Percent muscle was improved by .5% to 1% with each 10% restriction of feed intake.

Davies and Lucas (1972a) concluded from their work that each 10% reduction in daily feed below ARC (1967) allowance plus 5% additional feed led to an increase of 1.2% of carcass lean and a decrease of 1.3% of carcass fat.

With few exceptions a number of other experiments have concluded that feed restriction will decrease the percent fat in the pig and increase the amount of lean. The most notable observation is the reduction in backfat thickness which decreases in a linear fashion as feed intake is reduced (Babatunde et al., 1966; Passback et al., 1968; Veum et al., 1980; Stahly and Wahlstrom, 1973; Grandhi and Strain, 1980; Skipitaris, 1981, Ven et al., 1981, Giles

et al., 1981).

A recent experiment by Aherne et al. (1981) reported no improvement in percent muscle and little improvement in backfat thickness for restricted feeding when pigs were group fed. No information on carcass measurements was available for their experiment on individual feeding.

Effect of Feed Restriction on Growth, FCE, and Carcass Measurements in Barrows vs Gilts

Growth and FCE of barrows vs. gilts. Early work on the effect of sex on growth and FCE is contradictory when pigs are limit fed. Lucas and Calder (1956) in two experiments derived a different conclusion from each experiment. In experiment 1, females grew faster than males and males had a lower FCE than females. Males in experiment 2 grew 4% faster than females but were less efficient on a high plane of nutrition and more efficient on a low plane of nutrition. Although Woodman et al. (1936) reported a significantly faster growth rate in gilts than in barrows, the majority of investigators as reviewed by Lucas and Calder (1956) found that barrows grow faster than gilts.

Some interaction between sex and level of feeding was noted by Hines (1966) in his study. However, growth and FCE differences between the sexes were inconsistent. He further stated that sex and limit feeding do not appear to interact to impair or improve performance.

Blair and English (1965) fed boars, barrows, and gilts from 54 kg to slaughter weight. Pigs were fed all they could consume in two twenty minute feedings per day. Daily feed intake was 5.9% lower and FCE 6.1% better in the gilts vs. the barrows. There were no significant differences between barrows and gilts in daily gain. Other reports as reviewed by Blair and English (1965) on growth comparisons in barrows and gilts found a lack of agreement as had Lucas and Calder (1956). Feed conversion falls into the same category of inconsistency, but is generally better in gilts in the literature reviewed by Blair and English (1965).

Davies and Lucas (1972) fed gilts and barrows on three different diets using a fixed scale according to body weight. Diets were medium energy with 18% CP (ME18); high energy 16% CP (HE16); and a high energy 19% CP (HE19). Gilts were more efficient than barrows and grew faster. Gilts also responded with increased growth and better FCE to the HE19 when compared to the HE16 and barrows did not. Davies and Lucas (1972) also felt growth rate difference between experiments was far more variable when variation in feed intake occurs and pigs are not fed on a fixed scale.

Barrows and gilts were fed by Lodge et al. (1972) four different diets with various levels of crude protein and DE. Diet A contained 13.8% CP and 3190 kcal DE/kg;

diet B, 17.3% CP, 3168 kcal DE/kg; diet C, 20.6% CP, 3150 kcal DE/kg; and diet D, 23.7% CP, with 3155 kcal DE/kg. Pigs were fed on a fixed scale adjusted by body weight. No significant difference was found between the sexes in gain or FCE. This may partly be explained by the fact all animals were slaughtered at 59 kg liveweight. Response, or lack of response, to limit feeding of barrows and gilts for FCE and weight gain may be restricted to weights at slaughter beyond 59 kg.

Fuller and Livingstone (1978) stated that the superiority of gilts when compared with barrows in weight gain, feed conversion, and carcass quality is well known. Although carcass data fits well in this broad statement, which will be discussed later, the literature does not support Fuller and Livingstone (1978) on daily gain and FCE.

Two recent experiments by Castell (1980), and Giles et al. (1981), found no significant difference between barrows and gilts in FCE but growth was significantly better in barrows.

Carcass measurements in barrows vs. gilts. Numerous experiments as reviewed by Lucas and Calder (1956) agree with Lucas and Calders (1956) experiment which found females had longer carcasses, less fat, and larger loin eye areas than castrated males when limit fed. Since that early review, other researchers support Lucas and Calders (1956) work (Davies and Lucas, 1972; Fuller and Livingstone, 1978; Castell, 1980; Giles et al., 1981).

Research on carcass characteristics of the sexes when pigs are fed ad libitum has also found gilts to be leaner with more muscle than barrows (Allen et al., 1964; Baker et al., 1967; Doornenbal, 1967; Bruner and Swiger, 1968).



## MATERIALS AND METHODS

Three experiments were conducted in the fall of 1981 and in the winter and spring of 1982. All pigs were selected from the Kansas State University swine herd on the basis of thriftiness, sex, and weight.

Trial 1. Sixteen crossbred barrows with an average weight of 74.4 kg were placed in metabolism cages in an environmentally controlled building at the University swine unit. Cages were designed to allow separate collection of feces and urine. Sides were constructed of wire panels to allow airflow and pig contact.

A feeding trial and a metabolism trial was conducted to determine the lysine requirement of limit fed pigs.

The trial consisted of four treatments (2 x 2 factorial) with two feeding methods and two lysine levels with four pigs randomly allotted to each treatment. Treatments were as follows:

- A. Ad libitum .6% lysine diet
- B. Ad libitum .8% lysine diet
- C. 85% of ad libitum .6% lysine diet
- D. 85% of ad libitum .8% lysine diet

Ad libitum consumption was monitored for one week and 85% of that consumption calculated to a daily basis and fed to the restricted intake pigs once daily. Water was offered ad libitum by nipple waterers.

During the metabolism trial, feces and urine were collected during one five day period for the determination of nitrogen retention and digestability.

Collection of feces was done daily by the marker to marker technique. Ferric oxide was added to the feed at the rate of approximately 2% and was fed on the first and fifth day of the collection period. Feces collection began with the appearance of the first marker and ended with the appearance of the second. After each daily collection, the feces was refrigerated to reduce mold growth. The entire fecal collection was then dried in a forced air oven at 50 C until no moisture could be physically detected. After drying, each collection was weighed, then ground in a Wiley mill using a 40-mesh screen. Random samples were taken from each collection and analyzed for dry matter and nitrogen content at the University laboratory by the methods of A.O.A.C. (1975). In addition, samples of each feed were ground and presented for the same analyses.

Urine was collected daily in a container placed under the metabolism cages. Before each collection was started, 500 ml. of water and 8 ml. of concentrated hydrochloric acid was added to each container to reduce microbial growth. Each daily collection was recorded by volume and a 1% sample taken. Daily samples from each pig were mixed and stored at 1 C. Samples from the five day

collection of each pig were then analyzed for nitrogen content by the methods of A.O.A.C. (1975).

Apparent protein digestability and nitrogen retention were calculated by the methods of Maynard et al. (1979). The formulas for calculation are as follows:

Apparent protein digestability (%) =

$$\frac{\text{N intake} - \text{N in feces}}{\text{N intake}}$$

Nitrogen retention (g/day) = N intake - N in feces - N in urine

All pigs were removed from test as they reached an approximate liveweight of 100 kg and slaughtered at the University's slaughtering facilities. Hot carcass weight was recorded for each pig. Backfat thickness was measured at the tenth rib. Loin eye area (LEA) was determined by cutting one-half of the carcass between the tenth and eleventh rib and tracing the exposed longissimus muscle. After tracing, actual area was determined by use of a compensating polar planimeter to calculate sq. cm. of LEA. From these measurements, % muscle was calculated by the method described in USDA Program Aid 1157 (1981). The formula is as follows:

$$\begin{aligned} \text{Pounds Muscle} = & 0.45 \times \text{hot carcass weight (lb)} + 2.0 \\ & + 5.0 \times \text{loin eye area (in.}^2\text{)} - 11.0 \times \text{fat depth} \\ & \text{over LE (in.)} \end{aligned}$$

$$\% \text{ Muscle} = \frac{\text{lbs muscle}}{\text{hot carcass weight}}$$

Trial 2. Ninety-six crossbred barrows averaging 56.1 kg were selected for a feeding trial. Pigs were fed on one of four treatments with four replicates per treatment. Treatments were as follows:

- A. Ad libitum feeding
- B. 85% of ad libitum feeding
- C. Two hours access to feed
- D. Eight hours access to feed

Pigs were randomly allotted by weight and housed six to a pen at the University's swine finishing facility. Care was taken to insure no litter mates were in the same pen. Pigs were housed in a modified open front building with sixteen pens measuring 1.83 meters by 4.88 meters. The pens had totally slatted concrete floors with a stagnant pit and solid pen partitions. Supplemental heat was available as needed by means of a hover and catalytic heaters in each pen.

The diet containing .8% lysine was used for all treatments (Table 1). Feed was either weighed or added from 22.68 kg bags to feeders. All feed was fed in two-hole self-feeders. Treatment A (ad libitum) pens contained one self-feeder which was weighed to monitor feed consumption.

Pens in treatment B (85% of ad libitum) contained three self-feeders which allowed each pig access to a feeder hole. Feed consumption of the ad libitum fed pigs

in each replication was calculated and 85% of that consumption was calculated to a daily basis and divided equally into each feeder once daily. Pigs in the 85% treatment were one week behind on test due to the necessity of monitoring feed consumption of the ad libitum fed pigs for the prior week.

Treatment C (two hour access to feed) pens had three self-feeders which were placed in the pens at 0800 and removed at 1000 hours each day.

Pens in treatment D (eight hours access to feed) had three self feeders which were placed in the pen at 0800 and removed at 1600 hours each day.

Pigs were removed from test by pens as they reached approximately 100 kilograms. Fifty-four pigs were then slaughtered either at a commercial slaughter plant or the University's slaughtering facilities. Carcass measurements were recorded, and % muscle calculated as described in Trial 1.

Trial 3. Forty-eight crossbred pigs were selected with an average initial weight of 62.9 kilograms. For this experiment there were 24 barrows and 24 gilts.

Housing was an open front building with solid partitions between each pen and a concrete floor. There were a total of 24 pens used each measuring 1.22 meters by 4.57 meters.

Pigs were randomly allotted by weight and sex to one of four treatments. Treatments were:

- A. Ad libitum feeding
- B. 85% of ad libitum feeding
- C. 80% of ad libitum feeding
- D. Four hour access to feed.

There were two pigs per pen with six replicates. Three replicates were barrows and three were gilts.

The diet was the same as that used in Trial 2. All feed was either weighed for percent of ad libitum treatments or placed in self-feeders from 22.68 kg bags.

As in Trial 1 and 2, feed for the 80% and 85% treatments was calculated from the ad libitum treatment in each replication. Both percentages of ad libitum treatments were fed once daily on the floor of the pen. Treatment D (four hours access to feed) feeders were placed in the pens at 0900 and removed at 1300 hours each day. Water was offered ad libitum.

Pigs were removed from test at an average weight of 102 kilograms. Growth, feed consumption, and FCE were recorded. All pigs from this trial were slaughtered as in Trial 2 and carcass data recorded and evaluated by the techniques described in Trial 1.

## RESULTS

Trial 1--Metabolism. Results of the metabolism study are summarized in Table 2. Nitrogen retention expressed as a percent of nitrogen intake, was not affected by lysine level or feeding method ( $P < .05$ ). Nitrogen digestibility was significantly ( $P < .05$ ) higher for pigs fed 85% of ad lib with .6% lysine in the diet when compared to ad lib with .8% lysine in the diet, ad lib .6% lysine and 85% of ad lib .8% lysine.

Trial 1--Performance. Pig performance in Trial 1 can be seen in Table 3. Feeding method had a significant effect on initial weight, feed intake, and ADG ( $P < .05$ ). The initial weight difference was due to ad lib fed pigs being started on trial one week prior to the limit fed pigs. Feed intake was a calculated difference between ad lib feeding and limit feeding and is therefore different. Pigs fed ad lib gained faster than those limit fed with the ad lib pigs fed the .6% lysine diet having the best ADG. Feed conversion efficiency was not significantly affected by feeding method. However, pigs fed ad lib with the .6% lysine diet had an improved FCE of 19% when compared to pigs fed .8% lysine ad lib or 85% of ad lib.

Lysine level had no significant effect on any of the parameters of measurement used. There was no feeding method by lysine interaction.

TABLE 1. COMPOSITION OF BASAL DIETS

Ingredients	Diets, %	
	.6% lysine	.8% lysine
Milo	81.85	81.60
Soybean meal	14.60	14.60
Dicalcium phosphate	1.50	1.50
Limestone	1.20	1.20
Vitiman premix <sup>a</sup>	.50	.50
Salt	.30	.30
Trace-mineral premix <sup>b</sup>	.05	.05
L-lysine HCL <sup>c</sup>	---	.25
Calculated analysis		
Lysine	.60	.80
Crude protein	13.71	13.71
Calcium	.79	.79
Phosphorus	.64	.64

<sup>a</sup>Each kg of premix contained: Vit. A, 880,000 USP units; Vit. D<sub>3</sub>, 66,000 USP units; Riboflavin 990 mg; Choline, 88 g; d-panothenic acid 2640 mg; Niacin, 5500 mg; Vit. E, 4400 IU; Vit. B<sub>12</sub>, 4.84 mg; Menadione Dimethyl-pyrimimidinal Bisulfite, 550 mg; Ethoxyquin, 6270 mg.

<sup>b</sup>Containing 5.5% Manganese, 10.0% Iron, 1.1% Copper, 20.0% Zinc, .15% Iodine, .1% Cobalt.

<sup>c</sup>L-lysine HCL 78% lysine activity.



TABLE 2. EFFECT OF LYSINE LEVEL AND FEEDING METHOD ON NITROGEN RETENTION AND NITROGEN DIGESTIBILITY

Lysine level, %	Feeding method	Nitrogen <sup>d</sup> retention, %	Nitrogen <sup>bc</sup> digestibility, %
.8	Ad lib <sup>a</sup>	49.16	78.06
	85% of Ad lib <sup>a</sup>	52.18	79.38
.6	Ad lib <sup>a</sup>	55.26	79.84
	85% of Ad lib <sup>a</sup>	50.29	81.15

<sup>a</sup>Values are the least square means of four observations.

<sup>b</sup>Feeding method effect ( $P < .05$ ).

<sup>c</sup>Lysine effect ( $P < .05$ ).

<sup>d</sup>Nitrogen retention as a percent of nitrogen intake.

TABLE 3. EFFECT OF LYSINE LEVEL AND FEEDING METHOD  
ON PERFORMANCE OF PIGS IN TRIAL 1

Lysine Level, %	Feeding Method	Initial weight (kg) <sup>b</sup>	Daily feed intake (kg)	ADG (kg)	FCE
.8	Ad lib <sup>a</sup>	72.6	2.72	.75	4.21
	85% of Ad lib <sup>a</sup>	76.0	2.38	.60	4.26
.6	Ad lib <sup>a</sup>	70.4	2.49	.79	3.35
	85% Ad lib <sup>a</sup>	79.1	2.29	.60	4.05

<sup>a</sup>Values are the least square means of four observations.

<sup>b</sup>Feeding method effect ( $P < .05$ ).

Pigs fed ad lib and those with eight hours access to feed had similar feed intakes and had approximately 18% more feed intake than those fed 85% of ad lib and two hours access to feed.

Average daily gain was closely correlated with feed intake. As with feed intake, there was a significant difference ( $P < .05$ ) between ad lib feeding and eight hours access to feed vs. 85% of ad lib and two hours access to feed. Pigs fed ad lib and eight hours access to feed gained 13% faster than those pigs fed 85% of ad lib or two hours access to feed.

There was no difference in FCE between treatments.

Pigs fed ad lib consumed significantly more feed ( $P < .05$ ) than did those on the three limit fed treatments (Table 5). Pigs restricted to 4 hours access to feed ate 9% less feed than pigs fed ad lib and 6% more feed than pigs restricted to the 85% treatment.

Pigs fed ad lib grew at a significantly faster rate when compared to the three limit fed groups ( $P < .05$ ). There were no differences among pigs in ADG on the limit fed groups.

There was no difference in FCE between any of the treatment groups. Pigs restricted to 80% of ad lib had a slightly improved FCE when compared to pigs fed ad lib, 85% of ad lib, and 4 hours access to feed.

TABLE 4. EFFECT OF METHOD OF FEEDING ON  
PIG PERFORMANCE IN TRIAL 2

Treatment	Feed intake (kg)	ADG (kg)	FCE
Ad lib <sup>a</sup>	3.18 <sup>c</sup>	.79 <sup>c</sup>	4.02
85% of ad lib <sup>a</sup>	2.67 <sup>d</sup>	.67 <sup>d</sup>	4.00
2 hrs. access <sup>a</sup> to feed	2.54 <sup>d</sup>	.68 <sup>d</sup>	3.93
8 hrs. access <sup>a</sup> to feed	3.16 <sup>c</sup>	.76 <sup>c</sup>	4.18

<sup>a</sup>Values are the least square means of four observations.

<sup>b</sup>Total number of pigs 90. Avg. initial weight 56.20 kilograms. Avg. final weight 98.60 kilograms.

<sup>c</sup><sup>d</sup>Values in the same column with different letters are significantly different ( $P < .05$ ).

TABLE 5. EFFECT OF FEEDING METHOD ON  
PIG PERFORMANCE IN TRIAL 3

Treatment	Feed intake (kg)	ADG (kg)	FCE
Ad lib <sup>a</sup>	3.22 <sup>b</sup>	.86 <sup>b</sup>	3.76
85% of ad lib <sup>a</sup>	2.75 <sup>cd</sup>	.75 <sup>c</sup>	3.71
80% of ad lib <sup>a</sup>	2.60 <sup>d</sup>	.74 <sup>c</sup>	3.53
4 hrs. access <sup>a</sup> to feed	2.93 <sup>c</sup>	.75 <sup>c</sup>	3.88

<sup>a</sup>Values are the least square means of six observations.

<sup>bcd</sup>Values in the same column with different letters are significantly different ( $P < .05$ ).

<sup>e</sup>Total number of pigs; 48. Avg. initial weight; 63.20 kilograms. Avg. final weight 106.82 kilograms.

Trial 3--Performance by sex. Trial 3 data on performance by sex is shown in Table 6. Barrows consumed significantly more feed than the gilts ( $P < .05$ ), but average daily gain was the same. Gilts had an 8% better FCE than did barrows ( $P < .05$ ). There was no feeding method by sex interaction.

Trial 1--Carcass measurements. The results of Trial 1 on carcass measurements can be found in Table 7. Lysine level or feeding method did not effect any of the carcass measurements evaluated ( $P < .05$ ). Backfat thickness was decreased by an average of 7% in favor of the limit fed pigs. Loin eye area and percent muscle was increased 9% and 3% respectively with limit feeding when compared to the ad lib fed pigs.

Trial 2--Carcass measurements. Carcass measurements for Trial 2 is shown in Table 8. Slaughter weights were not different but pigs with 2 hours access to feed had a significantly lower hot carcass weight than did the ad lib, 85% of ad lib, and 8 hours access to feed fed pigs ( $P < .05$ ).

Backfat, loin eye area, and percent muscle were not different ( $P < .05$ ). There was, however, a trend towards a leaner carcass by pigs restricted to feed for two hours. Pigs with two hour access to feed had less backfat and 3% more muscle than the average of the pigs on the other three treatments.

TABLE 6. EFFECT OF FEEDING METHOD ON  
PERFORMANCE OF BARROWS VS.  
GILTS IN TRIAL 3

Sex	Feed intake (kg)	ADG (kg)	FCE
Barrows <sup>a</sup>	2.95 <sup>b</sup>	.79	3.87 <sup>b</sup>
Gilts <sup>a</sup>	2.80 <sup>c</sup>	.77	3.57 <sup>c</sup>

<sup>a</sup>Values are the least square means of 12 observations.

<sup>bc</sup>Values in the same column with different letters are significantly different ( $P < .05$ ).

<sup>e</sup>Total number of barrows 24. Total number of gilts 24.

<sup>f</sup>Barrows avg. initial weight 64 kilograms. Barrows final weight 107.4 kilograms.

<sup>g</sup>Gilts avg. initial weight 62 kilograms. Gilts final weight 106.3 kilograms.

TABLE 7. EFFECT OF LYSINE LEVEL AND FEEDING METHOD  
ON CARCASS MEASUREMENTS IN TRIAL 1

Lysine level, %	Feeding method	Slaughter weight (kg)	Hot carcass weight (kg)	Backfat (cm)	Loin eye area (cm <sup>2</sup> )	% Muscle
.8	Ad lib <sup>a</sup>	105.57	78.52	2.29	31.15	54.39
	85% of ad lib <sup>a</sup>	101.70	75.00	2.06	34.10	56.83
.6	Ad lib <sup>a</sup>	104.55	75.68	2.43	32.56	55.16
	85% of ad lib <sup>a</sup>	112.05	76.93	2.35	35.27	56.15

<sup>a</sup>Values are the least square means of four observations.

<sup>b</sup>Avg. initial weight 74.52 kilograms.



TABLE 8. EFFECT OF FEEDING METHOD ON CARCASS MEASUREMENT IN TRIAL 2

Treatment	Slaughter weight (kg)	Hot carcass (kg)	Backfat (cm)	Loin eye Area (cm <sup>2</sup> )	% Muscle
Ad lib <sup>a</sup>	103.74	75.58 <sup>b</sup>	2.92	31.67	53.48
85% of ad lib <sup>a</sup>	104.25	78.15 <sup>b</sup>	2.54	31.67	53.91
2 hrs. access <sup>a</sup> to feed	103.13	74.36 <sup>c</sup>	2.45	33.28	55.51
8 hrs. access <sup>a</sup> to feed	107.69	80.11 <sup>b</sup>	2.95	33.86	54.12

<sup>a</sup>Values are the least square means of three observations.

<sup>bc</sup>Values in the same column with different letters are significantly different (P<.05).

<sup>d</sup>Total number of pigs 48. Avg. initial weight 56.20 kilograms.

Trial 3--Carcass measurements by sex. A summary of carcass measurements of barrows vs. gilts is shown in Table 10.

Barrows and gilts slaughter weight and hot carcass weight were not different ( $P < .05$ ). Gilts had 25% less back fat, 9% larger loin eye areas, and 6% more muscle than did barrows. All three of these measurements were significant difference ( $P < .05$ ).

TABLE 9. EFFECT OF FEEDING METHOD ON CARCASS MEASUREMENTS IN TRIAL 3.

Treatment	Slaughter weight (kg)	Hot carcass (kg)	Backfat (cm)	Loin eye area (cm <sup>2</sup> )	% Muscle
Ad lib <sup>a</sup>	109.92	81.32	2.50	36.67	55.98
85% of ad lib	105.30	78.75	2.38	35.86	56.27
80% of ad lib	105.15	78.52	2.20	34.38	56.16
4 hrs. access to feed	106.90	80.53	2.34	36.13	56.08

<sup>a</sup>Values are the least square means of six observations.

<sup>b</sup>Total number of pigs 48. Avg. initial weight 63.20 kilograms.

TABLE 10. EFFECT OF FEEDING METHOD ON CARCASS MEASUREMENTS  
OF BARROWS VS. GILTS IN TRIAL 3.

Sex	Slaughter weight (kg)	Hot carcass (kg)	Back fat (cm)	Loin eye area (cm <sup>2</sup> )	% muscle
Barrows	107.39	80.30	2.67 <sup>b</sup>	34.06 <sup>b</sup>	54.52 <sup>b</sup>
Gilts	106.79	79.26	2.01 <sup>c</sup>	37.47 <sup>c</sup>	57.72 <sup>c</sup>

<sup>a</sup>Values are the least square means of 12 observations.

<sup>bc</sup>Values in the same column with different letters are significantly different (P .05).

<sup>d</sup>Total number of barrows 24. Total number of gilts 24.

<sup>e</sup>Barrows avg. initial weight 64 kilograms. Gilts avg. initial weight 62 kilograms.

## DISCUSSION

Metabolism study. The addition of approximately .2% L-lysine HCL above N.R.C. (1979) and A.R.C. (1967) suggested levels for finishing age swine was of no benefit to either the ad lib or pigs restricted to 85% of ad lib. These findings are in good agreement with the previous work of Vipperman et al. (1963), Brown et al. (1973), Bellis (1961), and Bell (1965) for ad lib fed pigs when considering growth and FCE. Work done by Cole et al. (1980) suggests a higher lysine level is needed for limit fed finishing pigs.

Percent nitrogen retention was not affected by the addition of L-lysine HCL or by restricting the pigs intake 15% below ad libitum. The lack of response in nitrogen retention above .6% lysine in the diet supports the N.R.C. (1979) and A.R.C. (1967) suggested levels. These results are also similar to those of Brown et al. (1973).

The percent of nitrogen digested was affected by both lysine level and feeding method (P .05). Limiting intake would slow the rate of passage through the digestive system of the pig thus possibly allowing for greater nitrogen digestability.

Performance. Feed intake of ad lib fed pigs was similar for Trials 2 and 3 and 14% lower in Trial 1.

The lower intake in Trial 1 was probably due to the pigs being confined in metabolism cages. In Trial 2, ad lib intake was the same as 8 hours access to feed and higher than 85% of ad lib and 2 hours access to feed. The ad lib fed pigs consumed significantly more feed than did the pigs limit fed 80 and 85% of ad lib, 2 hours access to feed, and 4 hours access to feed ( $P < .05$ ). Similar intakes were apparent between 80% of ad lib and 2 hours access to feed as were those pigs fed 85% of ad lib and 4 hours access to feed.

Results of the three trials clearly show ADG is decreased as feed intake is restricted below ad lib. All limit feeding methods, except 8 hours access to full feed, reduced ADG significantly ( $P < .05$ ). Similar results have been shown by numerous researchers (Lucas and Calder, 1956; Hines, 1966; Veum et al., 1970; Barber et al., 1972; Davis and Lucas<sup>a,b</sup>, 1972; Fuller and Livingston, 1978; Aherne et al., 1980; Yen et al., 1981; Giles et al., 1981).

Performance by sex. In Trial 3, barrows consumed more feed and had a poorer FCE than did the gilts ( $P < .05$ ). Both sexes gained at the same rate. These results are comparable to those found by Davies and Lucas (1972). Other reports have indicated barrows grow faster than gilts with a lack of agreement on FCE superiority by one or the other sexes (Lucas and Calder, 1956; Blair and English, 1965; Hines, 1966).

There were no sex by feeding method interaction which indicates both sexes responded similarly to restricted feeding.

Carcass measurements. No significant difference was found for slaughter weight, backfat thickness, loin eye area, or percent muscle in any of the three trials ( $P < .05$ ).

While overall carcass measurements were not significantly different, there was, however, a trend in all trials towards improvement in carcass measurements with limit feeding. An average of 85% of ad lib, 80% of ad lib, 2 hours access to feed, and 4 hours access to feed compared to ad lib feeding reduced backfat thickness by 8%. Percent muscle was improved by 2% for the limit feeding methods and loin eye area was not different. Pigs allowed 8 hours access to feed had similar carcass measurement to the ad lib fed pigs in Trial 2. This result agrees with Aherne et al. (1981). The reduced backfat thickness and increased percent muscle is supported by numerous studies (Lucas and Calder, 1956; Vanschoubrock et al., 1967; Hines, 1966; Stahly and Wahlstrom, 1973; and Giles et al., 1981). Contrary to this study, Hines (1966) reported a significantly larger loin eye area in pigs limit fed.

Carcass measurements by sex. In Trial 3, gilts had significantly less backfat, larger loin eye areas, and a greater percent muscle than did barrows ( $P < .05$ ).

The same results have been reported by other researchers (Lucas and Calder, 1956; Baker et al., 1967; Davis and Lucas, 1972a; and Giles et al., 1981).



## SUMMARY

A total of 154 finishing age pigs were fed to determine the effect of limit feeding on performance and carcass measurements.

In Trial 1, ADG was reduced by limit feeding to 85% of ad lib intake. Results of Trial 2 and 3 showed a significant decrease in ADG for pigs fed 85% of ad lib, 2 hours access to self-feeders and 4 hours access to self-feeders ( $P < .05$ ). FCE was generally improved by limit feeding but not at a level of significance as is often reported in the literature. FCE was significantly better for gilts when compared to barrows ( $P < .05$ ). ADG was the same for both sexes.

Carcass measurements were improved by the various methods and levels of limited intake but not significantly ( $P < .05$ ). Barrows had significantly more backfat, smaller loin eye areas, and less muscle than did gilts ( $P < .05$ ).

A metabolism study conducted in Trial 1 indicated a lysine level of .6% in the diet is adequate for maximum performance of ad lib and pigs restricted to 85% of ad lib. Percent of nitrogen retained was not effected by lysine level or feeding method. Nitrogen digestability was significantly effected by feeding method and lysine level ( $P < .05$ ). More nitrogen was digested at .6% lysine in the

diet fed at 85% of ad lib than in the other three treatments.

Results of this research do not indicate limit feeding is a viable alternative to ad lib feeding finishing age swine.

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THE EFFECTS OF LIMIT FEEDING FINISHING SWINE ON  
PERFORMANCE AND CARCASS MEASUREMENTS

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## ABSTRACT

A total of 154 pigs were used in three feeding trials to determine the effects of limit feeding of finishing swine on performance and carcass measurements. During Trial 1, a metabolism study was completed to determine optimum lysine level for limit-fed finishing swine.

In Trial 1, ADG was reduced by limit feeding to 85% of ad lib intake. Results of Trial 2 and 3 showed a significant decrease in ADG for pigs fed 85% of ad lib, and those restricted to 2 or 4 hours access to self-feeders ( $P < .05$ ). FCE was generally improved when pigs were limit fed, however; with the limited observations, differences were not statistically different.

In Trial 3, both barrows and gilts were fed. Barrows consumed more feed, gained at the same rate, and had a poorer FCE than gilts when limit-fed ( $P < .05$ ).

Carcass measurements were generally improved by limit feeding but not to a level of significance for any of the three trials ( $P < .05$ ).

Barrows had significantly more backfat, a smaller loin eye area, and less percent muscle than gilts ( $P < .05$ ).

Percent nitrogen retention was not affected by lysine level or feeding method. Nitrogen digestibility was significantly improved at .6% lysine in the diet when fed at 85% of ad lib intake.