FACTORS AFFECTING PERFORMANCE OF PIGS WEANED AT THREE WEEKS OF AGE

by

JERRY R. CLARKSON

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Gary L. Allee
Major Professor

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INTRODUCTION

In an effort to maximize reproductive efficiency of the swine herd, many swine producers are utilizing early weaning. The most popular age for early weaning is two or three weeks of age. By weaning at this age, litters/sows/year can be maximized (approximately seventeen day weaning). At this time sow milk production is peaking and beginning to be deficient for maximum pig growth. Thus it appears from a management standpoint that three week weaning is optimal.

Problems exist with three week weaning due to pig physiology. At three weeks of age, the colostral antibody protection is waning and pig's immune system is just beginning to start producing protective levels of antibodies. Therefore, the pig is very susceptible to many disease agents. The pig is born with an underdeveloped digestive enzyme system that is just beginning to mature to the point it can digest and absorb the feedstuffs that are normally used in starter diets. Because the pig has had all of it's nutritional requirements met up to this point by an all milk diet, it has not learned to utilize a feeder or dry feed. Added to these problems are the problems common to weaning at no matter what age: mixing and establishing a completely new social order, moving to a new enviornment, ect.

It comes as no surprise that with three week weaning a growth check is seen. Many pigs in that first week after weaning actually lose weight, and all but a few have a depression in their growth rate. Many people have come to accept this growth check as a necessary part of early weaning.

The present trials were conducted to evaluate the effects of dried whey in the diet on the growth check normally observed after weaning at 3 weeks. We also wanted to determine if hand-feeding a liquid or dry diet would affect pig performance the first week after weaning.

LITERATURE REVIEW

Effect of Age or Weight at Weaning

It has been shown that age at weaning has an effect on the degree of growth check experienced by pigs at weaning time. Aherne (1981) observed that pigs weaned at five weeks of age had considerably less growth check than those weaned at three weeks of age.

Liebbrandt et al. (1975) reported the effects of two, three, or four week weaning. As weaning age increased from two to four weeks of age, feed intake and rate of gain increased more rapidly after weaning. Energy intake per unit of metabolic size was maximized by three weeks after weaning. It was concluded that the increased age at weaning enhanced the adaptability to the postweaning enviornment, resulting in a less severe weight gain depression. By the time all pigs were six weeks of age, pigs weaned at two or three weeks of age were equal in weight to pigs weaned at four weeks of age.

Average daily gain and feed intake were less (P .01) during the first week after weaning for pigs weaned at fifteen to seventeen days compared to those weaned at nineteen to twenty-two days of age. (Kornegay et al., 1979). Feed efficiency was not significantly different, but favored the older pigs. By seven weeks of age, compensatory gain had occurred and there was little difference in body weight between the two groups.

Leece et al. (1979) shifted pigs from hourly liquid feeding to a dry starter diet at thirty, fourteen, or nine days of age. The pigs shifted at thirty days of age showed no decline in rate of gain while the fourteen day old pigs showed a slight decline. The pigs shifted to the dry diet at nine days of age had poor performance. From this Leece concluded young pigs are not "physiologically" receptive to dry diets much before four weeks of age. One suggestion to eliminate the postweaning growth check following

two to four week weaning was to individually cage these pigs and liquid feed them hourly.

It has been suggested that weight may be a better criteria than age on which to base weaning time. Smith and Lucas (1957) weaned three pigs at each weight of 3.6, 6.4, and 9.1 kilograms from seven different litters. Pigs were fed a thirty percent crude protein (forty-two percent dried skim milk) diet up to 11.4 kilograms then switched to a less expensive twenty-two percent crude protein (twenty percent dried skim milk) diet to fifty-six days of age. The amount of thirty percent crude protein diet required to reach 11.4 kilograms was 11.4, 7.3, and 2.7 kilograms respectively for the 3.6, 6.4, and 9.1 kilogram weaning weight pigs. The amount of twenty-two percent crude protein diet required from 11.4 to 18.2 kilograms was 13.6, 12.7, and 12.3 kilograms respectively ($P<.05$). Fifty-six day weights were 21.1, 22.8, and 21.7 kilograms respectively for 3.6, 6.4 and 9.1 kilogram weaning weights, this tended to favor the 6.4 kilogram weaning weight ($P .10$). The weaning weight had no effect on age at 18.2 kilograms.

Average digestibility of dry matter, energy, crude protein, ether extract, and total carbohydrates was higher at seven than at three weeks of age (Lloyd et al., 1957). This trend seems significant in spite of the fact that only in the case of calories and crude protein was statistical significance reached between the mean values of all thirty-two pigs at the two ages.

Enzyme Systems in the Pig and Their Development

LACTASE

Baby pigs are generally considered to be born with an underdeveloped digestive enzyme system. Lactase activity is high at birth and then falls rapidly to stable adult levels by four weeks of age. (Ekstrom et al., 1975). Ekstrom also found breed differences in lactase activity at twenty-one weeks of age with Chester Whites having a significantly greater level than Hampshires. It was concluded that lactase is not an inducible enzyme, since a diet with up to forty percent lactose did not increase lactase levels.

Manners and Stevens (1972) looked at changes in lactase activity of homogenates of the small intestine mucosa of pigs from birth through maturity. Six sites: 5,20,40,60,80, and 95% of the length of the small intestine, measured from the pylorus, were examined. There was a fall in lactase activity from birth to eight weeks of age. Lactase activity was high in the newborn with a maximum level at the 20% site. Distribution of lactase activity along the small intestine, but not levels, changed from eight weeks of age to adult.

In both weaned and unweaned pigs, lactase decreased rapidly from birth to three weeks of age, then levels off (Hartman et al., 1961).

The total amount of lactase at birth is maintained at a constant level up to five weeks of age. An increased gastrointestinal system and body weight decreased values when expressed per kilogram of body weight or per gram of tissue weight (Walker 1959).

SUCRASE

Sucrase activity was found only once in thirty-six samples from six newborn pigs, but was present in all six pigs sampled at one week of age (Manners and Stevens, 1972). Levels of activity continued to rise until maturity. Maximum sucrase activity was at the 20-40% sites of the small

intestine of younger pigs (one to eight weeks of age), while in older pigs the range of sites maximum activity was wide but generally in the 40-60% sites.

Hartman et al., (1961) found that sucrase activity increased from birth through seven weeks of age.

Pancreatic sucrase levels, shown to be very low at birth, increased steadily up to five weeks of age (Walker, 1959).

AMYLASE

Small intestine amylase activity decreased from an initial peak at one week of age until the curve flattens out at four to five weeks. The total amount of small intestinal amylase at one week of age was maintained at a constant level up to five weeks of age, an increased GI tract and body weight decreases values when expressed per kilogram of body weight or per gram of tissue weight. Small intestine amylase activity represents an average of approximately 1/7 of the pancreatic amylase activity at birth, 1/100 at thirty-five days of age. Pancreatic amylase activity is initially very low at birth but increases steadily up to five weeks of age with a small dip in the curve between two and three weeks of age. (Walker, 1959)

Hartman et al., (1961) found that pancreatic amylase increased with increasing age in both weaned and unweaned pigs.

Shields et al., (1980) compared the effects of two or four week weaning, creep feed or no creep feed from two to four weeks of age, and paste or dry feed on amylase in pancreas, gut mucosa, and gut contents. Pancreatic contribution to total activity increased for amylase with increasing pig age. Mucosal amylase represented 60% of total amylase at birth, but had dropped to 8% by ten weeks of age. Total amylase activity increased with increasing feed consumption. At ten weeks of age, amylase levels in all locations were higher in pigs weaned at two weeks of age than pigs weaned at an older age. Access to creep diet prior to weaning at four weeks increased pancreatic amylase

activities, by six weeks of age all had similiar pancreas weights and amylase activities suggesting a rapid adaptation of pancreatic tissue growth and enzyme synthesis upon consumption of cereal grain diet. Paste diets at two weeks of age did not affect amylase levels. Amylase at all sites increased approximately two times during each fourteen day period to ten weeks of age. The most rapid increase was from six to ten weeks of age, this corresponds to the greatest feed consumption and most rapid growth rate. Pancreatic contribution increased from 33% at birth to 50% at four weeks and an average of 71% during the last six weeks of the trial.

MALTASE

Maltase digestion during the first few days of life may be borderline for optimal feed consumption and growth, but after one week of age there was no difference in performance of pigs fed glucose or maltose (Cunningham and Brisson, 1957).

Pancreatic maltese is present at birth in very low levels and increases steadily up to five weeks of age (Walker, 1959). Hartman et al., (1961) found that maltese increased gradually from one to seven weeks of age in both weaned and unweaned pigs.

PROTEOLYTIC ENZYMES

Proteinase activity increases up to seven weeks of age, with greater activity in the distal two-thirds of the intestine. Stomach tissue proteinase is low in the first two weeks of life, then increases rapidly. Ingesta proteinase decreased to three weeks of age then increased to seven weeks in unweaned pigs. In weaned pigs stomach ingesta proteinase decreased throughout the experimantal period. (Hartman et al., 1961).

Shields et al., (1980) observed that pancreatic contribution to total protease activity increased with age. Total protease activity increases with increasing feed consumption. Weaning age (two or four weeks of age) and

feeding method (paste or dry feed) had no effect on protease. Pancreatic protease increases curvilinearily with age, most rapid increase between six and ten weeks of age. Pancreatic protease is seventy to eighty percent of the total activity up to six weeks of age, after six weeks of age it is fifty percent.

PANCREAS

Pancreas weight in the pig increased approximately six times from birth to twenty-three days of age. Chymotrypsinogen activity per gram increased slightly, total activity per pancreas increased approximately three times. Trypsinogen activity per gram increased three times and total activityincreased twenty times. Amylase increases six times per gram and total activity thirty times. Lipase activity decreased slightly per gram, but total activity increased three times. Pancreatic enzyme activity was not significantly different among pigs fed casein, fish protein concentrate, or isolated soy protein from two to three days of age to twenty-three days of age. (Pond et al., 1971). It was concluded that inferior performance of baby pigs fed isolated soy protein was not due to enzyme deficiencies, but other factors.

GENERAL

Pekas et al., (1964) observed that dried skim milk protein was significantly more digestible than soybean meal protein. Digestibility of both was significantly depressed with pancreatic duet ligation with a significantly greater reduction of protein digestibility for soybean meal protein than dried skim milk protein. Seemingly the pancreas plays a more prominent role in the digestion of soybean meal protein than skim milk protein. Without pancreatic secretion, dried skim milk protein was approximately twice as digestible as soybean meal protein in pigs two weeks of age. The difference decreases with increasing pig age until at eight weeks there is no differences in digest-

ibility, suggesting intestinal and gastric secretion are producing more degradation.

The digestibility of dry matter, crude protein, and energy is significantly greater for a dried skim milk diet than soybean meal and fish meal diets during three to four and five to six weeks of age. For pigs of seven to eight weeks of age, digestibility was the same for all treatments. All treatments increased in digestibility with increasing age. Dried skim milk significantly increased average daily gain and average daily feed intake versus soybean meal and fish meal diets and significantly increased feed efficiency versus fish meal (Combs et al., 1963).

Kidder et al. (1968) worked with one, two, and three week old pigs to determine sugar absorption in the small intestine. They found that glucose disappeared most rapidly and was never present in more than traces in the second half of the small intestine. Fructose and xylase disappeared much more slowly especially in the younger pigs, with great similarity in their rates, and were usually absent from contents in the last quarter of the small intestine. Sucrose was removed far less completely and the amount was not decreased along the second half of the small intestine. Sucrose was removed much less efficiently at fifteen percent of the diet than at five percent, and much less efficiently by younger than older pigs.

Weaning age and feeding method (both preweaning and postweaning) had no influence on long-term enzyme development or pig performance (Shields et al., 1980).

Walker (1959) found no striking difference on enzyme development by intentionally producing an anemic litter.

Liquid vs. Dry Starter Diets

A finely ground corn-soybean meal diet was blended with water and hydrothermally processed at 150°C with direct steam application with alpha-amylase added to decrease viscosity and phosphoric and proprionic acid to terminate enzymatic action and act as an antimicrobial agent respectively. Final dry matter content was thirty-eight percent. This liquid diet was compared to an eighteen percent crude protein crumbled corn-soybean meal control diet. In a preference trial, three week old pigs consumed twice as much liquid feed on a dry matter basis during the first week after weaning. During a four week trial, average daily gains in grams were 73, 218, 254 and 368 vs. 59, 277, 340 and 413 respectively for liquid and control diet (Binder et al., 1978).

Simple vs. Complex Starter Diets

Much attention has been focused on methods for increasing diet consumption to enhance performance of the newly weaned pig by using a complex of ingredients versus a properly fortified corn or milo-soybean meal starter diet. A variety of ingredients have been used, milk products being one of the more popular.

Aherne (1981) reported that pigs weaned at three weeks of age performed best when fed a complex diet, however the economical seven week weight was obtained with pigs fed the simple starter. For pigs weaned at five weeks of age, there was no significant difference in performance between pigs fed simple, semi-complex, or complex starter diets.

Okai et al., (1976) observed that with pigs weaned at three weeks of age "recovery to weight at weaning was achieved by pigs fed the complex diets in three days, while it took pigs fed the simple and semi-complex diets six to seven days to recover their weaning weights." Thus it is possible to reduce, but not eliminate the post-weaning growth check of early weaned pigs by

using a complex starter diet.

Okai et al.,(1976) also compared the effect of preweaning treatment (no creep; simple, semi-complex, or complex creep) on post weaning daily gains. With any particular preweaning treatment, the complex postweaning diet had greater daily gains than the simple or semi-complex diets.

With pigs weaned at five weeks of age, feed intake and weight gain were increased with increased diet complexity, but the increase was not significant (P .05). Okai et al., (1967) therefore agreed with Meade (1967) that "complex diets are generally uneconomic for pigs weaned at five weeks of age." Pigs above the mean weight showed no significant difference in weight gains on the complex diet while pigs weighing less than the mean weight had significantly higher average daily gains when fed the complex starter than pigs fed the simple starter. This may suggest that Zimmerman (1972) was right when he said "age at weaning is not as important as is weight in determining the response of pigs to starter diets of differing complexity." A check in growth rate occurs with five week weaning, but not as severe as with three week weaning. Complex starters can reduce post-weaning growth check of pigs weaned at three or five weeks of age.

Knabe et al.,(1980) used a simple diet of sorghum, soybean meal, minerals, and vitamins and compared this to a complex diet with 2.5% corn distiller's grain with solubles, 10% dried whole whey, and 10% ground oats added. Both diets contained 1.03% lysine. Average daily gain and average daily feed intake was higher (P .01) for the complex diet. Feed efficiency was equal for simple and complex diets. There was no difference in performance of the heavyweight replicates (9.6 kilograms), but differences were seen between the simple and complex diets in the lightweight replicates (7.8 kilograms).

Protein digestibility and nitrogen retention were found significantly higher for dried skim milk than soybean meal. (Pekas et al., 1964). There was a higher digestibility for soybean meal at 56 days of age compared with

25 days of age. Digestibility of dried skim milk remained relatively unchanged.

A diet containing five percent sucrose, five percent dried skim milk, or three percent fishmeal fed to three week old weaned pigs showed no advantage over a control diet. (Meade et al., 1969). This may be too small an amount to increase acceptibility.

Bayley and Carlson (1970) reported that pigs gained faster on a complex diet. Crumbling the simple diet improved performance, but crumbling the complex diet decreased performance. This suggests that the proteins in the complex diet are more susceptible to heat damage.

For pigs weaned at fourteen, twenty-one, or twenty-eight days of age, feeding a fat added diet (6% lard, 1.1% lysine) did not alter average daily gain, metabolizable energy intake, or metabolizable energy per pound of gain of pigs from weaning to seventy days of age when compared to an added six percent dextrose-starch diet. (Frohardt et al., 1980).

Milk Product in Complex Starter Diets

Diets that had 91.4% of the protein from dried skim milk or soybean meal (with the other 8.6% of the protein from the ground yellow corn) were fed to pigs that were weaned at seven days of age in a thirty-five day trial. (Pekas et al., 1964). The pigs on the dried skim milk diet grew significantly faster and required significantly less feed per pound of gain. Dried skim milk diet pigs gained more weight and required less feed per pound of gain during each of the five one week intervals, except the feed per pound of gain during week four. The relative difference (Dried skim milk vs soybean meal based diet) was greatest during the first week and was depressed each subsequent week so by the fifth week (pigs six weeks of age), the diets performed similarily.

Graham and Mahan (1980) reported that pig gains, feed intakes, and feed

efficiency is significantly affected by diet and length of time the starter is provided. A twenty percent crude protein control diet composed of corn, soybean meal, and rolled oats was compared with treatment diets of:

a.) 25% dried whey

b.) 15% dried skim milk

c.) 12.5% dried whey, 7.5% dried skim milk, and 5% cerelose

d.) 12.5% dried whey, 7.5% dried skim milk, 5% cerelose and 4% fish solubles.

Pigs were weaned at two weeks of age and carried to six weeks of age. Pigs fed diets with dried whey had greater feed intakes and gains for both the zero to fourteen days and the fourteen to twenty-eight days postweaning, resulting in superior forty-two day weights as compared to pigs consuming the 15% dried skim milk diet. Improved gains and feed efficiencies for the fourteen to twenty-eight day postweaning period were seen with milk containing diets compared to changing to the basal at fourteen days. Feed efficiencies for the overall period were similiar for all treatments. Results indicate that postweaning diets with dried whey are superior to diets containing dried skim milk and equal to more complex diets.

In trials using 4.3 kilogram pigs, Danielson et al., (1960) compared rations of dried skim milk and dried whey for starter pig rations. Feed grade lactose, corn, and soybean meal levels were varied to equalize lactose and protwin levels between treatments. All experimental rations, except the control diet, were formulated to contain lactose at the level present in the forty percent dried whey diet. The diets were:

a.) control

b.) 30% dried skim milk and 10% dried whey

c.) 20% dried skim milk and 20% dried whey

d.) 10% dried skim milk and 30% dried whey

e.) 40% dried whey

The smallest gain was seen with the control diet, the greatest gain for the first fourteen days was on the 30% dried skim milk and 10% dried whey diet. Gains decreased when dried whey was included in the diet over the 10% level. Feed:gain was least with the 30% dried skim milk and 10% dried whey diet. There was a significant linear effect that as the level of dried whey increased above 10%, feed:gain increased. As whey increased, soybean meal was added to maintain the protein level. The decreased gains and increased feed:gain with greater than 10% whey may have been caused by a decrease in the portion of total protein from milk sources.

Wahlstrom et al., (1974) found no significant differences in average daily gain or feed efficiency between pigs fed diets containing low lactose whey, dried skim milk, or control. Low lactose whey and dried skim milk were included in the diet at the 10% level.

Kornegay et al., (1979) concluded that 17.5% dried whole whey in a corn soybean meal ration initially improved gain and feed efficiency in a majority of trials. "Under conditions of good sanitation, poor performance following weaning is probably the result of inadequate feed consumption."

Becker et al., (1957) fed 3.6 kilogram two week old pigs for a four week period and found no beneficial or deleterious effects of feeding dried whey at either thirty or sixty percent of the diet. Whey was substituted for dextrose. Whey fed pigs grew slightly faster, but not significantly.

Crane (1953) working with pigs weaned at 4.5 kilograms or less and ending the trial when pigs were six weeks of age, found that forty percent dried skim milk produced the most rapid gains when compared to zero, thirteen and twenty percent dried skim milk diets.

In trials using three to eight week old pigs, Sewell and West (1965) looked at diets containing equal levels of lactose from dried skim milk, whey, and beta-lactose and equal protein levels. The added lactose diets

significantly increased the rate of gain for isolated soy protein versus isolated soy protein diets without lactose. There was no significant difference for gains from the various lactose sources. The isolated soy protein plus lactose diets required less feed per pound of gain than those without lactose. There was a significant increase in apparent protein digestibility for lactose containing diets, ether extract digestibility was also increased. Sewell and West (1965) concluded that "lactose has a physiologically important role in nutrient absorption and utilization by the very young pig and accounts for at least part of the response difference to protein from a dried skim milk source compared to a soybean source.

Armstrong and Clawson (1980) concluded that thirty percent dried skim milk added to a dry diet fed ad lib improves performance of pigs weaned at three to four weeks of age.

Energy and Calorie:Protein Ratio

Armstrong and Clawson (1980) found that with a calorie:protein ratio of twenty-two Kcal ME/gram of protein, average daily gain and feed efficiency was poorer (P .05) than for ration of twenty or eighteen. Feed wastage was greatest at the twenty-two Kcal ME/ gram protein ratio also. Increased energy concentrations had no beneficial effect on pig performance, while increased protein levels supported slightly improved performance.

Menge and Frobish (1976) used three to seven week old pigs in a 2 X 7 factorial arrangement ot determine the effects of energy, protein, and their interrelationships on growth. Two energy levels 3 and 3.5 Mcal ME/ Kg and seven crude protein levels 12,14,16,18,20,22, and 24%, with protein sources varied so that amino acid profile remained the same, were used. It was concluded that pigs weaned at three weeks of age can be started on a diet containing 20 to 24% crude protein with a calorie:protein ration of fifteen to eighteen Kcal ME/gm protein.

Leibbrandt et al, (1975) found that baby pigs seem to utilize calories from fat as well as from carbohydrates and that the efficiency of calorie utilization increases with age. Average daily energy intakes were found similiar for all treatments during all periods.

O'Grady and Bowland (1972) used two week old, 3.8 kg pigs to test diets with energy concentraions of 2.8 to 3.6 Mcal/Kg with a protein level constant at 15.2 Kcal DE/gram protein. The optimum DE for maximum gain in the first trial was 3.2 Mcal/Kg and the second trial 3.4 Mcal. There was very high mortality on lower energy levles, inclusion of five percent molasses decreased mortality. Digestibility of protein increased with increased dietary DE, but nitrogen retention as a percent of nitrogen intake or of digestible nitrogen was not significantly influenced by DE in the diet.

EXPERIMENTAL PROCEDURE

Animals

All pigs used in these trials were from the Kansas State University swine herd. The pigs in trial 1 were purebred Yorkshires. Pigs in trials 2, 3, and 4 were crossbreds. All pigs were allowed access to pelleted creep feed from two weeks of age until weaning. Pigs ranged in age at weaning from fifteen to twenty-four days, with the vast majority twenty-one plus or minus two days. To get this age distribution in the first three trials, weaning was done on two different days. For the fourth trial, all pigs were weaned the same day. Pigs were allotted to treatment by litter and weight. Excessively large or small pigs and obviously sick or injured pigs were not used. One hundred and fifty pigs were used per trial.

The range and average age and weight at weaning are shown in table 1.

Housing

Pigs were reared in a totally confined environmentally controlled nursery with woven wire floors over a U flush gutter. Pens were four feet by five feet with five pigs per pen. Each pen was equipped with a nipple waterer. Feeders for trials 1,2, and 3 were five hole stainless steel, feeders for trial 4 were four hole plastic.

Temperature was controlled to approximately 33°C the first week after weaning and dropped 2°C per week.

Diets

All diets were fed in meal form and were mixed at the KSU feed mill.

TABLE 1. AGE AND WEIGHT OF PIGS AT WEANING

	Range	Average
	Age, days	
Trial 1	15-23	19.31
Trial 2	18-22	19.81
Trial 3	18-23	20.85
Trial 4	17-24	20.95
	Weight, kilograms	
Trial 1	2.5-7.0	4.99
Trial 2	3.6-6.6	4.94
Trial 3	3.4-6.6	5.20
Trial 4	3.4-6.8	5.14

TABLE 2. COMPOSITION OF DIETS (Trials 1-3)

Ingredient	563 A (%)	563B (%)	563C (%)	563D (%)
Sorghum grain	54.95	48.35	41.35	34.75
Soybean meal (44%)	37.10	34.10	31.50	28.60
Dried whole whey		10.00	20.00	30.00
Corn oil	4.00	4.00	4.00	4.00
Limestone	1.30	1.20	1.00	0.90
Dicalcium phosphate	1.50	1.30	1.20	0.90
Trace mineral premix[a]	0.10	0.10	0.10	0.10
Vitamin premix[b]	0.50	0.50	0.50	0.50
Salt	0.30	0.20	0.10	
ASP-250	0.25	0.25	0.25	0.25
	100.00	100.00	100.00	100.00
Calculated analysis:				
Lysine	1.21%	1.20%	1.21%	1.21%
Crude protein	21.21%	20.67%	20.26%	19.74%
Calcium	.90%	.91%	.90%	.89%
Phosphorus	.72%	.71%	.73%	.70%

[a]Containing 5.5% manganese, 10% iron, 1.1% copper, 20% zinc, 0.15% iodine, and 0.1% cobalt.

[b]Each kilogram of mix contained the following: Vitamin A, 880,000 USP units; vitamin D_3, 66,000 USP units; riboflavin, 990 mg; d-pantothenic acid, 2,640 mg; choline, 88 mg; niacin, 5,500 mg; vitamin E, 4,400 IU; vitamin B_{12}, 4.84 mg; menadione dimethylpyrimidinol bisulfide, 550 mg; ethoxyquin, 6,270 mg.

TABLE 3. COMPOSITION OF DIETS (Trial 4)

Ingredient	564A (%)	564B (%)	564C (%)	564D (%)	564E (%)	564F (%)
Sorghum grain	54.95	41.35	41.35	38.58	50.97	40.70
Soybean meal (44%)	37.10	31.50	31.50	30.19	30.65	37.90
Corn oil	4.00	4.00	4.00	4.00	4.00	4.00
Dried whole whey		20.00				
Delactosed whey			20.00	20.00	10.90	
Lactose				4.17		13.65
Limestone	1.30	1.00	1.00	0.96	1.20	1.20
Dicalcium phosphate	1.50	1.20	1.20	1.15	1.33	1.60
Trace mineral premix[a]	.10	.10	.10	.10	.10	.10
Vitamin premix[b]	.50	.50	.50	.50	.50	.50
Salt	.30	.10	.10	.10	.10	.10
ASP-250	.25	.25	.25	.25	.25	.25
	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrient values:						
Lysine	1.21%	1.21%	1.37%	1.31%	1.20%	1.20%
Crude protein	21.21%	19.94%	21.94%	21.03%	20.42%	20.30%
Calcium	.90%	.90%	.90%	.96%	.91%	.90%
Phosphorus	.71%	.73%	.73%	.69%	.70%	.70%
Lactose		13.60%	9.80%	13.56%	5.34%	13.60%

[a]Containing 5.5% manganese, 10% iron, 1.1% copper, 20% zinc, 0.15% iodine, and 0.1% cobalt.

[b]Each kilogram of mix contained the following: Vitamin A, 880,000 USP units; vitamin D, 66,000 USP units; riboflavin, 990 mg; d-pantothenic acid, 2,640 mg; choline, 88 mg; niacin, 5,500 mg; vitamin E, 4,400 IU; vitamin B_{12}, 4.84 mg; menadione dimethylpyrimidinol bisulfide, 550 mg; ethoxyquin, 6,270 mg.

GENERAL PROCEDURE

Pigs were weaned in the afternoon and placed immediately into their respective pens. Feed was made available to them within one to two hours after weaning and nipple waterers were blocked open to allow free flowing water for approximately 36 to 48 hours. Thereafter pigs were appraised visually four times a day and pens with pigs that appeared to not be consuming water had the nipples blocked open periodically until all pigs had learned to drink.

The feed bridged in the self feeders and was manually worked down as required.

Pigs were weighed and feed consumption was determined weekly.

Some pigs developed injection site abcesses from atrophic rhinitis vaccinations, these were lanced and drained as required with no apparent effect on performance.

All trials were five weeks in length.

Trial 1

The first trial was conducted to establish the optimum level of whey in the diet and as a preliminary study of the effects of dry and liquid hand feeding for the first week after weaning.

The thirty percent whey diet was used to evaluate the effects of hand feeding. Stainless steel feeders with five feeding holes were used so all hand fed pigs could eat at one time. Hand fed pigs were fed four times a day at 0600, 1000, 1400, and 1800 hours. Pigs fed the dry diet were given slightly more than they would consume in four hours so there would usually be a small amount of feed at the end of each four hour period.

The liquid diet was prepared by combining one part of the thirty percent whey diet with one and one-half parts water. It was fed at the rate of four hundred grams of dry feed per pen at each feeding. The feeders were cleaned

before the first feeding of each day and the unconsumed feed discarded. During the day unconsumed feed was refed. Pigs on the liquid feed also had access to a self-feeder of dry thirty percent whey diet at all times.

After the first week, all hand fed pigs were placed on a self-feeder with the thirty percent whey diet.

The four whey levels (zero, ten, twenty and thirty percent) were evaluated using ad lib feeding.

Trial 2

This trial was conducted to further compare dry and liquid hand feeding to ad lib feeding. The control diet (zero percent whey) and the whey added diet that was shown optimal in trial one (twenty percent whey) were used. Each diet was fed ad lib, hand fed dry, and hand fed as a liquid.

Pigs fed ad lib had access to a five hole stainless steel self-feeder.

Pigs were hand fed dry and liquid diets in homemade feeders made by splitting a four inch diameter PVC pipe into two equal sections and then capping the ends. These were stabilized with wooden supports and attached to the pen wall bordering the middle alleyway.

Pigs hand fed the dry diet were given slightly more than they would consume in four hours.

Liquid hand fed pigs were fed four times a day at 0600, 1000, 1400, and 1800 hours at the rate of four hundred grams of dry feed at each feeding. One and one-half parts of water was added to each part of dry feed to make the liquid diet. Unconsumed liquid feed was discarded twice a day at the first and third feeding, at other times it was mixed with fresh feed and refed. Feeders were washed clean before the first feeding of each day.

At the end of the first week of the trial, the hand fed pigs were placed on a self-feeder containing their respective control or whey added diet.

Trial 3

This trial again compared ad lib, dry hand feeding, and liquid hand feeding for the first week after weaning. It also compared the effects of length of time on the 20% whey diet before switching pigs to the control diet.

Five hole stainless steel feeders were used for all treatments in this trial. The dry diet hand fed pigs were given slightly more than they would consume in four hours so there would usually be a small amount of unconsumed feed at the end of each four hour period. Pigs were fed at 0600, 1000, 1400, and 1800 hours.

The feeders for the liquid diet were modified by cutting a 3/8" by 1 1/4" wooden lathe to fit under the feeder adjustment to keep all feed out in the trough where the pigs had access to it.

Liquid hand fed pigs were fed four times a day at 0600, 1000, 1400 and 1800 hours. The liquid feeders were washed out each morning before the first feeding of the day, unconsumed feed was discarded. Consumption dicatated the amount fed with unconsumed feed collected and refed during the day. Approximately 250 grams of dry feed and 500 milliliters of water per pen were mixed at each feeding.

There were six treatments in this trial. The control diet was fed ad lib as one treatment. The twenty percent whey diet was fed ad lib. One treatment of each dry and liquid hand fed twenty percent whey diet was put on the control diet after the first week. Another treatment consisted of one week of hand feeding the twenty percent whey diet as a liquid followed by one week of ad lib feeding of the whey diet, then switching to the control diet for the last three weeks of the trial. The last treatment was one week of hand fed dry twenty percent whey diet, followed by one week of whey diet fed ad lib, followed by three weeks of control diet ad lib.

Trial 4

Four hole plastic self feeders were used in this trial with the diets being fed ad lib through the entire trial.

Diets were:
1.) Control
2.) Twenty percent whole whey
3.) Twenty percent delactosed whey
4.) Twenty percent delactosed whey plus lactose (to the lactose level of 2.)
5.) Delactosed whey (to milk protein level of 2.)
6.) Control plus lactose (to lactose level of 2.)

RESULTS

Trial 1

The addition of ten percent whole whey gave no advantage over performance of pigs fed the control diet (table 4). Twenty percent whole whey was shown to be optimal level of addition. There was no response from further increasing the whole whey level to thirty percent. Addition of twenty percent whole whey significantly increased: a.) gain the first week after weaning

b.) gain the second week after weaning

c.) gain for the first two weeks after weaning

d.) gain for the entire five week trial

e.) average daily gain for the entire trial

Hand-feeding the 30% whey diet as a liquid increased feed intake the first and second weeks after weaning. Weight gain was increased by hand feeding a liquid diet over hand feeding a dry diet and ad lib feeding for the first week after weaning.

Dry hand feeding increased the gain:feed ratio the first week after weaning and increased the gain during the first week after weaning over ad lib feeding.

Hand feeding both liquid and dry increased gain during the first two weeks after weaning.

Trial 2

Results of trial 2 are shown in table 5. Feeding method appeared to have an effect with dry hand feeding having greater feed intakes for week one and two than wet hand fed or ad lib fed. Wet hand feeding showed greater feed intake for week one than ad lib feeding. Pigs fed the 20% whey diet ad lib had greater week one gain:feed than pigs hand fed the whey diet.

With ad lib feeding, gain was greater for the whey diet than control during the first week after weaning. Gains for week one and two were greater for whey

TABLE 4. EFFECT OF LEVEL OF WHEY AND METHOD OF FEEDING ON PERFORMANCE OF PIGS WEANED AT 15-23 DAYS OF AGE (Trial 1)[a]

Level of Whey		0%	10%	20%	30%	30%	30%
Feeding Method		Ad lib	Ad lib	Ad lib	Ad lib	Hand fed (dry)	Hand fed (wet)
FI1	(kg)	.94	1.18	1.20	1.21	1.21	2.19
FI2	(kg)	2.25	2.10	2.41	2.33	2.85	2.84
F	(kg)	3.18	3.13	3.61	3.54	4.05	5.03
FI	(kg)	19.25	19.73	20.99	21.70	22.30	24.26
GF1		.292	.282	.494	.392	.672	.460
GF2		.618	.674	.700	.738	.764	.692
GF		.586	.582	.584	.592	.610	.566
GW1	(kg)	.27	.32	.60	.55	.84	1.04
GS2	(kg)	1.34	1.40	1.70	1.70	2.19	1.96
G	(kg)	1.61	1.72	2.30	2.25	3.03	3.00
Gain	(kg)	11.04	11.35	12.33	12.73	13.63	13.88
ADG	(kg)	.31	.32	.35	.36	.39	.39

FI1 = Feed intake during first week after weaning.
FI2 = Feed intake during second week after weaning.
F = Feed intake for first and second weeks.
FI = Feed intake for entire five week trial.
GF1 = Gain:Feed during first week after weaning.
GF2 = Gain:Feed during second week after weaning.
GF = Gain:Feed for entire five week trial.
GW1 = Weight gain during first week after weaning.
GW2 = Weight gain during second week after weaning.
G = Weight gain for first and second weeks.
Gain = Weight gain for entire five week trial.
ADG = Average daily gain for entire five week trial.

[a]Each value is the mean of 5 pens with 5 pigs per pen.

TABLE 5. EFFECT OF 20% WHOLE WHEY ADDITION AND METHOD OF FEEDING ON PERFORMANCE OF PIGS WEANED AT 18-22 DAYS OF AGE (Trial 2)[a]

Level of Whey	0%	0%	0%	20%	20%	20%
Feeding Method	Ad lib	Hand fed (dry)	Hand fed (wet)	Ad lib	Hand fed (dry)	Hand fed (wet)
FI1 (kg)	1.02	2.33	1.45	1.01	2.59	1.73
FI2 (kg)	1.96	2.27	1.95	2.39	2.15	2.34
F (kg)	2.98	4.60	3.40	3.40	4.74	4.06
FI (kg)	17.54	19.05	17.45	20.14	21.79	20.46
GF1	.254	.148	.146	.442	.168	.226
GF2	.486	.574	.608	.674	.692	.664
GF	.582	.620	.628	.646	.574	.606
GW1 (kg)	.26	.35	.19	.46	.45	.42
GW2 (kg)	.96	1.31	1.17	1.58	1.47	1.48
G (kg)	1.22	1.65	1.36	2.05	1.91	1.90
Gain (kg)	10.25	11.86	10.89	12.99	12.42	12.38
ADG (kg)	.30	.35	.32	.38	.37	.36

[a]Each value is the mean of 5 pens with 5 pigs per pen.

diets regardless of feeding method.

For the entire trial, pigs fed diets containing 20% whey showed greater feed intakes. Gain:feed ratio was significantly improved by the addition of 20% dried whey with ad lib feeding.

Average daily gains were greater for whey diet versus control for both ad lib and hand fed wet first week feeding methods. Gain was greater for pigs fed the whey diet regardless of feeding method.

Trial 3

Results of trial 3 are shown on table 6. Feeding method had no significant effect on pig performance. Pigs fed dried whole whey had significantly ($P < .05$) greater gains during the first and second weeks after weaning. Pigs fed the whey diet for both the first and second weeks had greater gains the second week than pigs fed whey the first week and control diet the second week.

Pigs fed the whey diet for two weeks had greater total gains, feed intakes, and average daily gains than pigs fed control diet or whey for only one week.

Trial 4

Pig gain during week one was greater for pigs fed twenty percent delactosed whey plus lactose than twenty percent whole whey (table 7). Whey addition increased gain during week one, and feed intake and gains during weeks one and two. Gain:feed ratio was improved on all whey diets when compared to the control diet.

Lactose addition to the control diet did not increase feed intake or improve pig performance. Similarly, lactose addition to the delactosed whey diets did not increase feed intake or pig performance.

TABLE 6. EFFECT OF 20% WHOLE WHEY ADDITION, METHOD OF FEEDING, AND DURATION OF WHEY FEEDING ON PERFORMANCE OF PIGS WEANED AT 18-23 DAYS OF AGE (Trial 3)[a]

Week 1	Level of Whey Feeding Method	Control Ad lib	20% Ad lib	20% Hand fed (dry)	20% Hand fed (dry)	20% Hand fed (wet)	20% Hand fed (wet)
Week 2	Level of Whey Feeding Method	Control Ad lib	20% Ad lib	20% Ad lib	Control Ad lib	Control Ad lib	20% Ad lib
Week 3-5	Level of Whey Feeding Method	Control Ad lib	20% Ad lib	Control Ad lib	Control Ad lib	Control Ad lib	Control Ad lib
	FI1 (kg)	1.15	1.29	1.18	1.15	1.29	1.23
	FI2 (kg)	2.30	2.48	2.42	2.25	2.63	2.34
	F (kg)	3.45	3.77	3.60	3.41	3.92	3.56
	FI (kg)	18.50	20.48	20.94	18.46	20.16	19.35
	GF1	.242	.448	.446	.442	.368	.304
	GF2	.468	.556	.552	.402	.386	.478
	GF	.590	.577	.584	.590	.578	.592
	GW1 (kg)	.30	.60	.52	.52	.46	.37
	GW2 (kg)	1.09	1.39	1.30	.90	1.01	1.11
	G (kg)	1.39	1.99	1.83	1.42	1.47	1.49
	Gain (kg)	10.95	11.75	12.03	10.84	11.62	11.45
	ADG (kg)	.31	.33	.34	.31	.33	.33

[a]Each value is the mean of 5 pens with 5 pigs per pen.

TABLE 7. EFFECT OF WHOLE WHEY, DELACTOSED WHEY, AND LACTOSE ON PERFORMANCE OF PIGS WEANED AT 17-24 DAYS OF AGE (Trial 4)[a]

	Control	20% Whole whey	20% Delactosed whey	20% Delactosed whey & lactose	10.9% Delactosed whey	Control + lactose
FI1 (kg)	1.24	1.36	1.75	1.75	1.44	1.13
FI2 (kg)	2.05	2.18	2.49	2.25	2.34	2.04
F	3.28	3.55	4.24	4.00	3.77	3.16
FI (kg)	17.29	19.79	20.71	19.69	19.70	17.33
GF1	.236	.478	.460	.548	.550	.302
GF2	.510	.588	.500	.580	.542	.490
GF	.570	.554	.548	.588	.590	.510
GW1 (kg)	.32	.65	.78	.96	.78	.36
GW2 (kg)	1.08	1.29	1.25	1.31	1.31	1.00
G (kg)	1.40	1.94	2.03	2.27	2.09	1.36
Gain (kg)	9.93	10.44	11.25	11.51	11.63	8.88
ADG (kg)	.28	.30	.32	.33	.33	.25

[a]Each value is the mean of 5 pens with 5 pigs per pen.

In 4 trials involving 600 pigs, mortality was 0%.

Beginning weight had an effect on total gain and average daily in all four trials. Total gain increased from .859 (Trial 3) to 1q233 (Trial 4) kilograms per kilogram initial weight increase. Average daily gain increased from .011 (Trail 3) to .016 (Trial 4) kilograms for each kilogram increase in weaning weight. These values would be valid only for pigs weaned at 2.5 kilograms to 7 kilograms.

The advantages of hand feeding seen in trial one were not duplicated in trials two and three. The effects of feeding method seen in trial 2 on feed intake and gain:feed was probably a function of feed wastage.

The advantages of hand feeding seen in trial 1 were not duplicated in trials 2 and 3. The different feeders used in trial 2 could possibly explain the different results between trials 1 and 2. Also thirty percent whey was hand fed in the first trial while twenty percent whey was used in trials 2 and 3.

Twenty percent whey increased gains the first two weeks and for the entire period over the control diet. Gain:feed was not different between whey and control diets.

Pigs fed the twenty percent whey diet for only week one and the control weeks two thru five had reduced gains during the second week compared to pigs fed the whey diet for the first two weeks. Pigs fed the whey diet for two weeks and the control diet for the last three weeks of the trial had greater total feed intakes, gains, and average daily gains than pigs fed control diet through the entire trial or the whey diet for only one week. Performance for pigs fed whey diet during the entire trial was not significantly different from pigs fed whey diet the first two weeks than control the last three weeks of the trial.

Response from whey added diets appears to be due the milk protein rather than the lactose. Delactosed whey at the milk protein level of twenty percent

whole whey may be the most economical source for improved pig performance.

SUMMARY

Four trials involving 600 pigs weaned at 15 to 23 days were conducted to evaluate the effect of added whey and method of feeding for the first week after weaning on pig performance. Pigs fed 20% dried whole whey gained faster the first two weeks after weaning and during the 35 day trial when compared to pigs fed a milo-soybean meal diet with no whey. The percent dried whole whey did not improve performance over the control diet and thirty percent dried whey showed no advantage to the percent whey diet. Delactosed whey substituted on protein basis for twenty percent dried whole whey gave the same level of performance as twenty percent whole whey.

The twenty percent whey diet fed for the first two weeks and the control diet for the last three weeks of the trial gave similar performance to the twenty percent whey diet for the entire 35-day trial. By feeding the whey diet for only two weeks, total cost of gain is greatly decreased.

No consistent advantage was observed from hand feeding a liquid or dry diet over ad lib feeding of a dry diet. With the small range of weaning ages in these trials, no consistent effect of weaning age on performance during the started period was shown.

Weight at weaning and gain for the 35-day trial was positively correlated in all trials. Total gain during the 35-day period increased from .859 kg to 1.323 kg for each kilogram increase in weaning weight of pigs from 2.5 to 7 kilograms.

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FACTORS AFFECTING PERFORMANCE OF PIGS WEANED AT THREE WEEKS OF AGE

BY

JERRY R. CLARKSON

B.S., Kansas State University, 1978
D.V.M., Kansas State University, 1980

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Abstract

Four trials involving 600 pigs weaned at 15 to 23 days were conducted to evaluate the effect of added whey and method of feeding for the first week after weaning on pig performance. Pigs fed 20% dried whole whey gained faster the first two weeks after weaning and during the 35 day trial when compared to pigs fed a milo-soybean diet with no whey. Ten percent dried whole whey did not improve performance over the control diet and thirty percent dried whey showed no advantage to the twenty percent whey diet. Delactosed whey substituted on a protein basis for twenty percent dried whole whey gave the same level of performance as twenty percent whole whey.

The twenty percent whey diet fed for the first two weeks and the control diet for the last three weeks of the trial gave similar performance to the twenty percent whey diet for the entire 35-day trial. By feeding the whey diet for only two weeks, total cost of gain is greatly decreased.

No consistent advantage was observed from hand feeding a liquid or dry diet over ad lib feeding of a dry diet. With the small range of weaning ages in these trials, no consistent effect of weaning age on performance during the starter period was shown.

Weight at weaning and gain for the 35-day trial was positively correlated in all trials. Total gain during the 35-day period increased from .859 kg to 1.323 kg for each kilogram increase in weaning weight of pigs from 2.5 to 7 kilograms.