Supplemental Fermented Milk Increases Growth Performance of Early-Weaned Pigs[a]

F. R. Dunshea*, D. J. Kerton, P. J. Eason and R. H. King
Agriculture Victoria, Victorian Institute of Animal Science, Private Bag 7, Sneydes Road, Werribee 3030, Australia

ABSTRACT : Early weaning is a means of breaking the disease cycle from sow to piglet as well as capitalising on the enormous growth potential of the pig. However, the transition from milk to dry diets results in a growth check. Feeding of supplemental milk, fermented to reduce pH and enterotoxigenic bacterial proliferation, may be a means of gradually weaning pigs on to solid feed. This study involved 216 pigs weaned from the sow at 12 days of age, allocated to groups of 6 males and 6 females per weaner pen and allowed *ad libitum* access to a pelleted diet. In addition, half the pigs were given supplemental fermented skim milk for the first 8 days after weaning. Feeding supplemental fermented milk increased feed intake (104 vs. 157 g DM/d, p=0.011), average daily gain (-3 vs. 112 g/d, p<0.001) and feed conversion efficiency (0.01 vs. 0.81, p=0.003) over the first 8 days after weaning. The improvements observed in the supplemented pigs continued to be augmented such that, by 42 days of age, the pigs that had received supplemental fermented milk were heavier (9.6 vs. 11.5 kg, p=0.003) than their unsupplemented counterparts. Feeding fermented supplemental milk to early-weaned pigs can improve growth performance in the immediate and subsequent post-weaning period. ***(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 4 : 511-515)***

Key Words : Pig, Milk, Growth, Weaning, Liquid Feeding

INTRODUCTION

There is increasing interest in the use of early weaning management systems in the Australian pig industry. The main drive for this move is the possibility of using segregated early weaning to break the disease transfer cycle from sow to piglet. Another reason for early weaning is that, from about 14 days of lactation, sow milk yield and composition can limit piglet growth to well below their potential (Williams, 1995; Toner et al., 1996). Between birth and weaning, sucking pigs grow at approximately 220 g/d but this growth rate is far below the biological potential of the artificially reared pig which can grow in excess of 400 g/d (Hodge, 1974; Harrell et al., 1993; Dunshea and Walton, 1995). In addition, the process of weaning results in a growth arrest that may be ameliorated by liquid feeding (Lecce et al., 1979; Zijlstra et al., 1996; Pluske et al., 1996; Dunshea et al., 1999). However, one of the real problems with liquid feeding is that hygiene is paramount and, even when precautions are taken, enterotoxigenic bacterial invasion can occur. This is even more critical for pigs weaned at around 12-14 days, at a time when maternal antibodies obtained passively are diminished and active immunity has yet to be achieved. While antibiotics may be used to reduce bacterial proliferation, probiotics may offer a more environmentally sound means of reducing enteric bacterial invasion (Fuller, 1989). Therefore, the aim of the present study was to investigate the effects of feeding fermented skim milk to early-weaned pigs.

MATERIALS AND METHODS

Animals and housing

The litters from twenty-six first parity crossbred sows were used in this study. All sows were housed in farrowing crates in an insulated building and were offered 2.0 kg/d of a lactation diet containing 14.3 MJ DE, 185 g crude protein and 9.3 g available lysine/kg for 5 days prior to farrowing. After farrowing, daily feed allowance was increased by 0.5 kg until reaching *ad libitum* intakes. Piglets were denied access to both solid creep feed and water until weaned, on day 12 of lactation.

The experiment involved 216 piglets (108 males and 108 females) weaned from the sow at 12 days of age. Piglets were allocated to eighteen groups each of 6 males and 6 females and placed in raised pens (1.2 m×1.5 m) in a room maintained at 28℃. Each pen had an enclosed creep area with an infrared lamp to provide additional heating.

All pens of pigs were allowed *ad libitum* access to a pelleted early weaner diet (table 1). In addition, half the groups of pigs were given supplemental fermented skim milk twice per day for the first 7 days post-weaning. The skim milk was prepared by dissolving 5 kg of skim milk powder (Murray Goulburn, Melbourne) in 18 kg of water. Powdered skim milk contained 340, 26 and 8.2 g/kg crude

* Corresponding Author: F. R. Dunshea. Tel: +61-3-9-742-0438, Fax: +61-3-9-742-0400, E-mail: Frank.Dunshea@nre.vic.gov.au.

[a] The authors thank Maree Cox and Lynda Morrish for their skilled technical assistance with these studies.
Received April 7, 1999; Accepted June 21, 1999

protein, lysine and fat, respectively. After the skim milk was dissolved, 300 g of natural yoghurt containing *Lactobacillus acidopholus Lal* (Nestle, Mulgrave) was mixed with the milk and allowed to stand overnight at 28℃ before feeding to pigs. After overnight fermentation, the pH of the liquid milk was always between 5.0 and 5.5. Each pen of pigs was offered 3 kg of the fermented milk two times per day at 08:30 and 16:30 h. Pigs remained in the weaner cots until 16 days post-weaning. On day 28 of age, pigs were moved into conventional weaner accommodation in which the shed temperature was maintained at 24℃.

Table 1. Percentage composition of weaner diets (as fed)

Ingredient	Early weaner[a]	Late weaner[b]
Dehulled oats	57. 7	
Wheat		67.6
Soyabean oil	1.7	
Tallow		2.1
Raw sugar	5	
Blood meal	3	2.3
Fish meal	10	
Meat and bone meal		7.5
Skim milk powder	20.8	
Soyabean meal		15
Peas		5
L-lysine · HCl	0.2	0.056
DL-methionine	0.11	0.078
L-threonine	0.134	
Dicalcium phosphate	0.409	
Limestone	0.51	
Salt	0.2	0.2
Vitamin and mineral premix[c]	0.3	0.3
Estimated composition[d]		
Digestible energy (MJ DE/kg)	15.5	14.5
Crude protein	22.4	21.0
Lysine	1.47	1.19

[a] Early weaner diet fed as pellet from 12 until 35 days of age.

[b] Late weaner diet fed as mash from 35 until 42 days of age.

[c] Vitamin mineral premix provided the following nutrients per kilogram of air-dry diet (mg); retinol, 9.6; cholecalciferol, 0.13; α-tocopherol, 33; menadione, 0.90; riboflavin, 4.4; nicotinic acid, 25; pantothenic acid, 8.4; pyrodoxine, 1.6; biotin, 0.84; choline, 1,650; cyanocobalamin, 0.025; Fe, 132; Zn, 84; Mn, 33; Cu, 10; I, 0.33; Se, 0.15.

[d] Estimated from analysed composition of individual ingredients.

Liveweight was determined at 12, 14, 16, 20, 28, 35 and 42 days of age. All feed offered was weighed and refusals per pen of pigs were determined at 12, 14, 16, 20, 28 days of age. For the first week after transfer the pigs were fed the early weaner diet but changed to a late weaner mash diet from 35 days of age. Feed intake was not measured in the conventional housing.

Statistical analyses

Post-weaning growth performance was analysed using a split plot design with pen as the blocking factor and milk supplementation as the main factor and sex as the subplot. Since feed intake was only available on a pen basis, sex effects could not be determined for feed intake or feed:gain. For these analyses the ANOVA was conducted with pen as the experimental unit. All analyses were performed using GENSTAT (Payne et al., 1993).

RESULTS

Effects of supplemental fermented milk on performance of piglets are presented in tables 2 and 3. The average weaning weight of the pigs at day 12 of age was 4.4 kg and did not differ between sexes. There was no scouring in any pigs and provision of supplemental fermented milk ensured that pigs continued to grow in the immediate post-weaning period. For example, over the first 2 days post-weaning, pigs fed dry feed only lost considerable live weight whereas the pigs that received supplemental milk gained live weight (-90 vs. 30 g/d, $p<0.001$). Over each time period, between weaning and when the liquid feed was removed on day 8 after weaning, the pigs receiving supplemental milk grew significantly faster (table 2). Therefore, while the pigs that were weaned onto dry feed initially lost and then gained weight such that by 8 days after weaning they had almost returned to their weaning weight, pigs that received supplemental milk gained almost 900 g. The effect of previous supplemental milk on growth rate was less pronounced after removal of the milk. However, pigs that had previously received fermented milk did tend to grow more quickly between days 20 and 42 of age (239 vs. 280 g/d, $p=0.11$) and were 20% heavier at 42 days of age (9.6 vs. 11.5 kg, $p=0.003$). In particular pigs that had received supplemental milk grew more quickly between days 35 and 42 of age (273 vs. 367 g/d, $p=0.019$) after the diet was changed to the more complex late weaner mash ration. Interestingly, females grew more rapidly than males over this same period (276 vs. 363 g/d, $p=0.030$).

Weaning on to fermented skim milk diets resulted in an immediate intake of feed and ameliorated the growth check normally observed immediately post-weaning. For example, DM intake was over two times

Table 2. Effect of supplemental fermented milk feeding (M) and sex (S) on growth performance of early-weaned pigs

	- milk		+ milk		SED	Significance		
	male	female	male	female		M	S	M×S
Daily gain (g/day)								
12-14 days of age	-90	-91	14	47	24.7	<0.001	0.324	0.371
14-16 days of age	57	50	152	161	29.4	<0.001	0.971	0.705
16-20 days of age	7	17	128	133	20.3	<0.001	0.588	0.853
12-20 days of age	-5	-1	105	119	17.8	<0.001	0.464	0.669
20-28 days of age	220	215	238	240	33.7	0.360	0.942	0.885
28-35 days of age	219	196	240	234	31.1	0.184	0.507	0.694
35-42 days of age	221	324	332	401	53.6	0.019	0.030	0.662
20-42 days of age	237	242	269	290	34.1	0.113	0.596	0.744
12-42 days of age	178	173	225	244	26.1	0.003	0.520	0.699

Table 3. Effect of supplemental fermented milk feeding on feed intake and feed conversion efficiency (FCE) of early-weaned pigs

		- milk	+ milk	SED	Significance
Feed intake (g DM/d)					
12-14 days of age	Total	57	125	15.9	<0.001
	Dry	57	24	15.0	0.043
14-16 days of age	Total	117	166	25.0	0.073
	Dry	117	46	25.0	0.013
16-20 days of age	Total	114	164	21.5	0.034
	Dry	114	54	21.4	0.012
12-20 days of age	Total	104	157	18.3	0.011
	Dry	104	45	18.7	0.007
20-28 days of age	Total	211	249	22.0	0.099
FCE (g gain/g DM intake)[a]					
12-14 days of age		-2.27	0.40	0.57	0.009
14-16 days of age		0.58	1.14	0.15	0.020
16-20 days of age		0.09	0.80	0.13	0.006
12-20 days of age		0.01	0.81	0.12	0.003
20-28 days of age		1.03	0.95	0.08	0.366

[a] Total feed was used to calculate FCE.

higher over the first two days post-weaning in pigs weaned onto skim milk compared to pigs weaned onto a pelleted diet (126 vs. 57 g DM/d, p<0.001; table 3). Most of this increase in feed intake was as liquid feed, since pigs that received supplemental milk consumed significantly less dry feed than pigs weaned on to dry feed only (57 vs. 24 g DM/d, p=0.043; table 3). Dry feed intake doubled in both groups of pigs over the next 2 days post-weaning. Over the 8 days after the supplemental milk was removed, pigs that had previously received milk tended to eat more than those pigs that were weaned on to dry feed only (211 vs. 249 g DM/d, p=0.10).

Feed conversion efficiency (FCE) was significantly greater in the immediate post-weaning period in pigs fed supplemental fermented milk (table 3). There was no difference in FCE in the 8-day period after supplemental milk was removed.

DISCUSSION

The motivation for conducting this study was the desire to wean pigs at 12 days of age to enable the disease cycle between sow and piglet to be broken and to take advantage of the enormous growth potential of the early-weaned pig. Previous studies have shown that supplemental skim milk feeding could improve post-weaning growth rate in pigs weaned at 20 days of age (Dunshea et al., 1999). Therefore, it was envisaged that a similar approach could be used to minimise the considerable growth check observed in early-weaned pigs (Power et al., 1996). However, the first efforts to provide supplemental milk to early-weaned pigs resulted in quite severe *E. coli* diarrhoea occurring over the first 2 days after weaning in some pigs. The incidence of diarrhoea appeared to be more prevalent in the larger pigs in each group. Others have observed in New Zealand that when *E. coli* scours have occurred in milk fed piglets, it has generally been the larger pigs that have succumbed (J. R. Pluske, personal communication). Presumably heavier pigs consume more supplemental milk and it was postulated that the intake of milk overwhelmed gastric HCl secretion thereby increasing the pH and creating an environment that allowed proliferation of enterotoxigenic bacteria already resident in the gastro-intestinal system. Addition of organic acids (lactate, citrate, tartrate) to lower the pH of the milk, as has been investigated in solid pig feeds (Li et al., 1999), reduced the incidence of, but did not eliminate, diarrhoea. On the other hand, addition of water-soluble antibiotics to the milk did eliminate diarrhoea. However, it was decided that a probiotic approach would offer a more environmentally sustainable method of feeding supplemental milk than antibiotic inclusion (Fuller, 1989). After preliminary results with fermented skim milk proved encouraging, the present study was conducted to determine whether feeding supplemental fermented milk to early-weaned pigs could eliminate the post-weaning growth check.

Early-weaned pigs that were fed supplemental fermented milk for 8 days after weaning were 900 g heavier than the pigs that were weaned on to dry food only. Similar responses were seen in pigs gradually weaned from liquid to solid feed over 7 days after weaning at 20 days of age (Dunshea et al., 1999). Despite previous problems with *E. coli* scours in early-weaned pigs fed liquid milk supplements, there were no episodes of scouring in pigs fed fermented milk suggesting that either reducing the pH of the milk or providing *Lactobacillus* as a probiotic was protective against scours. The value of probiotics *per se* is an area of great interest and it is not within the scope of this paper to argue about their value. Rather, the aim here was to determine whether fermented skim milk could be used to gradually wean pigs on to dry feed without the proliferation of enterotoxigenic bacteria. Lecce (1986), a pioneer of artificial rearing of pigs, observed that while early-weaned pigs can be raised on liquid milk, diarrhoea was the nemesis of the artificially reared pig and remained the greatest barrier to adoption of these systems on farm. These present data suggest that acidic fermented skim milk may offer a practical means of providing a liquid milk supplement to pigs.

By day 42 of age, pigs that were fed supplemental fermented milk were 2 kg heavier than the pigs fed pelleted feed only. This was the equivalent of approximately 1 weeks growth. It could be anticipated that this difference in live weight would be augmented over the rest of the growth phase (Mahan et al., 1991) and that the supplemented pigs would reach slaughter weight at least 1 week earlier than the pigs weaned on to solid feed only. Alternatively, pigs could be sold at the same age but weigh approximately 6 kg heavier. While supplemental milk may at first appear to be an expensive management strategy, it should be noted that the FCE of 0.8 observed during the period of supplementation is almost three times greater than the FCE generally observed over the fattening phase. Therefore, the cost of feeding fermented milk can be up to three times that of finisher feed and still be economical. This is without taking into account the advantages of selling heavier pigs or marketing pigs earlier.

Another interesting observation was that the pigs that had previously been fed supplemental fermented milk grew better after switching to a less sophisticated, lower specification diet. It is possible that the nutrient requirements of the larger pigs that had previously been supplemented with fermented milk are lower than the smaller pigs which had been fed dry feed only. In general, pigs require lower specification diets as they grow (Standing Committee on Agriculture, 1987). Alternatively, the larger pigs that had been fed fermented milk had better developed gastrointestinal tract function and were able to handle a less sophisticated diet. In the immediate post-weaning period, there is substantial villous damage unless pigs are weaned onto liquid milk (Pluske et al., 1996). Also, the benefits of providing beneficial probiotics may be manifest for a considerable period after cessation of the probiotic feeding (Fuller, 1989). All of these factors could contribute to better performance of the supplemented pigs when the latter diet switch was made. It was also interesting that female pigs grew better than male pigs when the diet switch was made. Previously, we have demonstrated that female pigs better handle weaning than male pigs (Power et al., 1996; Dunshea et al., 1998), quite possibly because the female pigs have better developed gastrointestinal tract systems (Pluske et al., 1997; Cranwell et al., 1997). Therefore, it may be possible that the female pigs were also better able to handle the switch to a less sophisticated diet. The effects of sex and previous fermented milk were additive with supplemented female pigs growing much better than conventionally weaned male pigs over the week after the diet switch (401 vs. 221 g/d, table 2).

In conclusion, provision of supplemental fermented milk can ameliorate the growth check normally encountered in early-weaned pigs. Benefits in growth are augmented with time.

REFERENCES

Cranwell, P. D., S. G. Pierzynowski, C. Rippe, J. R. Pluske, G. N. Power, R. G. Campbell, D. J. Kerton, R. H. King and F. R. Dunshea. 1997. Weight and age at weaning influence pancreatic size and enzymic capacity. In: Manipulating Pig Production VI (Ed. P. D. Cranwell and D. P. Hennessy). Australasian Pig Science Association, Werribee, Australia. p. 66.

Dunshea, F. R. and P. E. Walton. 1995. Potential of exogenous metabolic modifiers for the pig industry. In: Manipulating Pig Production VI (Ed. P. D. Cranwell and D. P. Hennessy). Australasian Pig Science Association, Werribee, Australia. p. 42-51.

Dunshea, F. R., D. J. Kerton, P. J. Eason and R. H. King. 1999. Supplemental skim milk before and after weaning improves growth performance of pigs. Aust. J. Agric. Res. 50:1165-1170.

Dunshea, F. R., W. G. Brown, C. D. Gough and P. J. Eason. 1998. Female pigs better handle weaning than male pigs. Proc. Nutr. Soc. Aust. 22:103.

Fuller, R. 1989. A review. Probiotics in man and animals. J. Appl. Bact. 66:365-378.

Harrell, R. J., M. J. Thomas and R. D. Boyd. 1993. Limitations of sow milk yield on baby pig growth. In: 1993. Cornell Nutrition Conference for Feed Manufacturers. pp. 156-164. Cornell University; Ithaca, NY.

Hodge, R. W. 1974. Efficiency of food conversion and body composition of the preruminant lamb and young pig. Brit. J. Nutr. 32:113-126.

King, R. H., J. M. Boyce and F. R. Dunshea. 1998. The effect of supplemental nutrients on the growth performance of sucking pigs. Aust. J. Agric. Res. 49:883-887.

Lecce, J. G. 1986. Diarrhea: the nemesis of the artificially reared, early weaned piglet and a strategy for defense. J Anim. Sci. 63:1307-1313.

Lecce, J. G., W. D. Armstrong, E. J. Crawford and G. A. Ducharme. 1979. Nutrition and management of early-weaned piglets: Liquid vs dry feeding. J. Anim. Sci. 63:1307-1312.

Li, D. F., S. D. Liu, S. Y. Qiao, G. F. Yi, C. Liang and P. Thacker. 1999. Effect of feeding organic acid with or without enzyme on intestinal microflora, intestinal enzyme activity and performance of weaned pigs. Asian-Aus. J. Anim. Sci. 12:411-416.

Mahan, D. C. and A. J. Lepine. 1991. Effect of pig weaning weight and associated nursery feeding programs on subsequent performance to 105 kilograms body weight. J. Anim. Sci. 69:1370-1378.

Payne, R. W., P. W. Lane and Genstat 5 Committee. 1993. Genstat 5 Reference Manual. Oxford Science Publications, Oxford, UK.

Pluske, J. R., M. J. Thompson, C. S. Atwood, P. H. Bird, I. H. Williams and P. E. Hartmann. 1996. Maintenance of villus height and crypt depth, and enhancement of disaccharide digestion and monosaccharide absorption, in piglets fed on cows' whole milk after weaning. Brit. J. Nutr. 76:409-422.

Pluske, J. R., G. N. Power, P. D. Cranwell, S. G. Pierzynowski, R. G. Campbell, D. J. Kerton, R. H. King and F. R. Dunshea. 1997. Sex and age at weaning affect small intestinal histology and enzymatic capacity. In: Manipulating Pig Production VI (Ed. P. D. Cranwell and D. P. Hennessy). Australasian Pig Science Association, Werribee, Australia. p. 67.

Power, G. N., J. R. Pluske, R. G. Campbell, P. D. Cranwell, D. J. Kerton, R. H. King and F. R. Dunshea. 1996. Effect of sex, weight and age on post-weaning growth of pigs. Proc. Nutr. Soc. Aust. 20:137.

Standing Committee on Agriculture. 1987. Feeding standards for Australian Livestock. Pigs. CSIRO Publications, Melbourne, Australia.

Toner, M. S., R. H. King, F. R. Dunshea, H. Dove and C. S. Atwood. 1996. The effect of exogenous somatotropin on lactation performance of first-litter sows. J. Anim. Sci. 74:167-172.

Williams, I. H. 1995. Sow milk as a major nutrient source before weaning. In: Manipulating Pig Production VI (Ed. P. D. Cranwell and D. P. Hennessy). Australasian Pig Science Association, Werribee, Australia. pp. 103-113.

Zijlstra, R. T., K. Y. Whang, R. A. Easter and J. Odle. 1996. Effect of feeding a milk replacer to early-weaned pigs on growth, body composition, and small intestinal morphology, compared with suckled litter mates. J. Anim. Sci. 74:2948-2959.