Liquid diets accelerate the growth of early-weaned pigs and the effects are maintained to market weight[1,2]

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ABSTRACT: Piglets (n = 240, 11.0 ± 0.1 d old, 3.93 ± 0.05 kg) were allotted to one of four treatments in a 2 × 2 factorial arrangement to examine the effects of diet physical form and nursery environment during the first 14 d after weaning on growth to market weight. During the treatment period, pigs were housed (10 pigs/pen) in either a conventional hot nursery (30°C) or a segregated-temperature nursery (cool ambient temp. of 24°C, with enclosed hot-box hovers at 32°C). Pigs in each environment were fed nutritionally identical diets in either liquid or dry-pellet form for 14 d. Subsequently, all pigs were fed identical dry diets and were housed in common grower-finisher facilities (penned by sex, five pigs/pen). At the end of the treatment period (d 14), pigs fed the liquid diet were 21% heavier than pigs fed the dry pellet diet (9.22 vs 7.60 kg; $P < 0.001$). Similarly, gain, feed intake, and gain/feed of liquid-fed pigs were 44%, 18%, and 22% greater, respectively, than observed for pigs fed the dry pellet diet. No main effect of environment was observed ($P > 0.10$); however, an interaction with diet physical form occurred during the early-nursery period ($P < 0.01$). Pigs fed the liquid diet showed better performance in the conventional nursery, whereas pigs fed the dry pellet diet were favored in the segregated-temperature nursery. No major differences in growth performance or in ultrasound carcass measurements were detected during the growing-finishing period; however, the advantage in body weight of liquid-fed pigs gained during the first 2 wk postweaning was maintained to the end of the trial (113.9 vs 110.6 kg; $P < 0.05$). Pigs that were fed the early-nursery diet in liquid form reached market weight (110 kg) 3.7 d sooner than the dry-fed controls ($P < 0.01$). Estimates of lean gain (calculated from live ultrasound data) were unaffected, suggesting that composition of growth was not altered. Collectively, these results show that liquid feeding during early life can markedly accelerate piglet growth performance and that the growth advantage is maintained to market weight, with no evidence of compensatory gain in the dry-fed control pigs.

Key Words: Environment, Growth, Liquid Diets, Pigs

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Introduction

Postweaning management of early-weaned pigs has undergone significant change within the U.S. swine industry during the last 5 yr. Segregated early weaning (**SEW**) of piglets at 10 to 14 d of age has become increasingly popular as a means of limiting disease transfer from the sow herd to the nursery. Among the challenges of SEW management is the provision of adequate nutritional support as the young pigs are abruptly switched from sow milk to dry feed (Nessmith et al., 1997; Veum and Odle, 2000 for review). The use of phase-feeding strategies, involving complex initial diets enriched with milk-products and animal plasma proteins has generally worked well to minimize postweaning growth stasis, especially when health status is high and when animals are of sufficient size and(or) age (Dritz et al., 1996b). However, it is not uncommon for very young and lightweight pigs to suffer prolonged growth retardation. Similarly, nutritional stress, when superimposed on health challenges (e.g., porcine reproductive and respiratory syndrome), can result in high morbidity and mortality in the nursery. Reduced growth performance of animals compromised early in life may be exacerbated during the subsequent growing-finishing phases, add-

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ing significantly to the time required to reach market weight (Mahan et al., 1998). Collectively, this problem scenario has prompted our laboratory to examine the efficacy of liquid feeding as means to facilitate the weaning transition of young SEW pigs (Zijlstra et al., 1996, Heo et al., 1999). However Heo et al. (1999) suggested that the segregated-temperature environment may not be essential to achieve enhanced performance of the milk-fed pigs. The current study was designed to delineate the effects of diet physical form (liquid vs dry) and nursery environment (conventional hot vs segregated-temperature) on growth performance of very early-weaned piglets, and to determine whether early growth advantages could be maintained throughout the growing and finishing periods.

Materials and Methods

A total of 240 piglets (11.0 ± 0.1 d of age, 3.93 ± 0.05 kg initial body weight) were obtained from the swine farm of the Lake Wheeler Field Laboratory (North Carolina State University, Raleigh, NC). The genetic background was derived from Pig Improvement Company lines 326 × 231 or 326 × 233. The animal protocols used in this study were approved by the Institutional Animal Care and Use Committee. Piglets were removed from the sow without prior access to creep feed and were allotted (10/pen) to one of four treatments according to 2 × 2 factorial, randomized complete block design (blocked by body weight and gender). Factors examined in this experiment included physical form of the diet (liquid vs dry pellet) and nursery environment (conventional hot nursery vs specialized segregated-temperature nursery). The liquid milk replacer and dry pelleted diets (Table 1) were formulated to be nutritionally identical and to exceed NRC (1998) requirements. Pigs on all treatments had ad libitum access to fresh feed, and water was available through a nipple waterer (Lixit, Napa, CA 94558). Our studies have employed a specialized commercial nursery building (Intensive Care Nursery, Inc. Colfax, IL) in which automated milk machines provide milk ad libitum to subdivided nursery pens containing segregated hot (32°C) and cool (24°C) compartments. The milk machines were adjusted to reconstitute the powdered milk replacer to 15 to 16% dry matter. The liquid milk replacer delivery system and the housing conditions within the segregated-temperature nursery have been described in detail previously (Zijlstra et al., 1996; Heo et al., 1999). The segregated-temperature nursery was located approximately 450 m from the other swine housing units, and personnel traffic to it was restricted. In contrast, the conventional nursery was located immediately adjacent to farrowing and finishing facilities. During the first 2 wk after weaning, the ambient temperature in the segregated-temperature nursery was maintained at 23.6 to 25.2°C (with enclosed hovers maintained at 32°C) and that of the conventional nursery was maintained at 27.0 to 33.8°C. The ambient temperature of the segregated-temperature nursery was selected based on previous results (Heo et al., 1999), suggesting 24°C to be optimal.

Pig body weights and feed intakes were recorded on d 3, 6, 10, and 14 of experimentation when liquid and dry pelleted diets were fed separately. Piglets allotted to the liquid-diet treatment were offered dry pellets also (400 g/pen each day) on d 12 to 14 to facilitate the transition to dry feed. After 14 d, all pigs were moved into the conventional nursery facilities and fed identical diets (Table 1) until they reached 60 d of age (trial d 49). The commercial nursery diets were pelleted except for the diet fed during d 36 to 49, which was in mash form. Body weights and feed intakes were recorded weekly from d 21 to 49. During d 15 to 49, temperature within the conventional nursery was maintained at 21 to 24°C. At the end of the nursery period (60 d of age), all pigs were measured for 10th-rib backfat thickness (**BF**) and longissimus muscle area (**LMA**) via real-time ultrasound (Aloka model 500; Aloka Co., Ltd., Wallingford, CT) and moved into grower-finisher facilities. Within the grower-finisher facilities, pigs were grouped by gender (five/pen) into pens (1.8 m × 1.8 m) with concrete-slatted floors. The calculated ME (megacalories per kilogram) and lysine (%) of the commercial diets (as-fed basis) during the grower-finisher period were 3.3 and 1.16, 3.4 and 1.15, 3.4 and 0.93, and 3.4 and 0.78 for d 36 to 49, d 50 to 91, d 92 to133, and d 133 to 143, respectively. All diets were formulated to exceed NRC (1998) nutrient requirements, with protein exceeding by at least 10%. During the grower-finisher period, body weight, feed intake, and real-time ultrasound measurement of 10th-rib BF and LMA were recorded on d 70, 91, 112, 133, and 143. The data for BF and LMA were employed to estimate carcass fat-free lean index (**CFFLI**) and lean gain (**CFFLG**) rates according to the methods described by the NRC (1998; appendix 2). In brief, the value of carcass fat-free lean (**CFFL**) was calculated from data on measurements of the 10th-rib BF and LMA, and the hot carcass weight (estimated from the live body weight by multiplying 0.74). The carcass fat-free lean index was calculated by dividing the CFFL by estimated hot carcass weight and multiplying 100. The average daily CFFLG rate was obtained by dividing the difference between the final and initial CFFL weights by number of days in the corresponding period. Because the initial and(or) final weight differ from 20 and(or) 120 kg, the average daily CFFLG rate was adjusted using factors described by the NRC (1998; appendix 2).

Data were subjected to analysis of variance using the GLM procedure of SAS (SAS Institute, Inc., Cary, NC), according to 2 × 2 factorial arrangement of treatments (Steel et al., 1997). The model included replicate, environment, diet physical form, and environment × diet during the nursery phase, and gender also was included in analysis of the grower-finisher data. Pen was considered the experimental unit. Treatment means were compared using the LSMEANS subprocedure of SAS

Table 1. Formula and chemical composition (as-fed basis) of experimental diets (d 0 to 35)

Feeding interval:	d 0 to 14		d 15 to 28	d 28 to 35
Item Form:	Liquid	Dry pellet	Dry pellet	Dry pellet
Ingredient, %				
Corn	—	—	13.11	29.80
Oat meal	—	—	20.00	10.00
Edible lard	11.86	11.37	4.00	4.00
Whey proteins	69.83	70.32	29.41	22.06
Soybean meal (48%)	—	—	20.00	25.00
Modified wheat protein (80%)	8.13	8.13	—	—
Fish meal (Menhaden)	—	—	8.00	5.05
Plasma protein (78%)	5.00	5.00	4.11	2.00
L-Lysine·HCl	0.31	0.31	0.03	0.04
DL-Methionine	0.11	0.11	0.16	0.12
Limestone	0.75	0.75	0.17	0.45
Dicalcium phosphate	0.55	0.55	0.08	0.56
Mineral premix[a]	0.50	0.50	0.50	0.50
Copper sulfate	—	—	0.08	0.08
Salt	—	—	0.10	0.10
Vitamin premix[b]	0.13	0.13	0.10	0.10
Antibiotics[c]	0.14	0.14	0.15	0.15
Other[d]	2.69	2.69	—	—
Composition (calculated)				
ME, Mcal/kg	3.7	3.7	3.2	3.2
Lactose, %	43.2	43.4	20.9	15.7
Crude protein, %	24.9	24.9	25.1	23.1
Crude fat, %	13.0	13.0	6.4	5.9
Crude fiber, %	0.10	0.10	1.66	1.91
Crude Ash, %	8.34	7.58	6.77	6.17
Lysine, %	1.98	1.97	1.77	1.56
Methionine, %	0.60	0.60	0.59	0.51
Calcium, %	0.91	0.91	0.80	0.80
Phosphorus, %	0.78	0.78	0.83	0.76
Composition (analyzed), %				
Crude protein	24.4	24.6	26.5	23.4
Crude fat	13.2	12.2	6.5	6.9
Crude ash	7.7	8.0	6.7	5.9

[a]Provided the following (g/kg premix): choline, 60; Zn, 23.5; Fe, 20.0; K, 20.0; S, 16.3: Ca, 10.0; P, 5.5; Mn, 5.0; Na, 2.8; Cu, 1.8; Mg, 1.0; I, 0.4; Cl, 0.4; Co, 0.2; Se, 0.06.
[b]Provided the following per kilogram of premix: vitamin A, 33,000,000 IU; vitamin D_3, 6,600,000 IU; vitamin E, 55,000 IU; vitamin K, 5.12 g; vitamin C, 117 g; niacin, 33.07 g; pantothenate, 29.98 g; riboflavin, 8.38 g; vitamin B_6, 4.00 g; folic acid, 2.76 g; thiamin, 2.04 g; biotin 66 mg; vitamin B_{12}, 44 mg.
[c]Provided the following per kilogram of diet: oxytetracycline, 154 mg (d 0 to 14) and 165 mg (d 15 to 35); neomycin base, 154 mg (d 0 to 14) and 115.5 mg (d 15 to 35).
[d]Provided the following per kilogram of diet: citric acid, 13.8 g; potassium sorbate, 4.5 g; vitamin E, 66 IU; flavor additive, 300 mg; Fe, 60 mg; Zn, 71 mg; Mn, 31 mg; flow agent, 7.5 g; (d 0 to 14, liquid diet only); bentonite, 7.5 g (d 0 to 14, dry pellet diet only).

following a significant protecting F-test (Steel et al., 1997).

Results

Growth Performance. Physical form of the diet had a large impact on growth performance of early-weaned pigs. At d 14 after weaning, pigs fed the liquid diets were 21% heavier ($P < 0.001$; Figure 1, line graph) and had 44% greater ADG ($P < 0.01$; Table 2) than pigs fed the nutritionally identical diet in the form of dry pellets. The advantage of liquid feeding was most pronounced during the first 3 d after weaning (Figure 2); during this time, liquid-fed pigs gained almost four times faster than the dry-fed controls (248 vs 64 g/d; $P < 0.01$). However, the difference in ADG between liquid- and dry-fed pigs decreased as the animals aged (Figure 2). Indeed, during the last 4 d on treatment (d 10 to 14), all pigs reared in the segregated-temperature nursery grew at similar rates, regardless of diet physical form, whereas liquid-fed animals in the conventional nursery continued to out-perform their dry-fed controls (environment × diet interaction, $P < 0.05$). This interaction was maintained throughout the 49-d nursery period (Table 2 and Figure 1, bar graph), even after pigs were switched to a common diet and housed in a common hot-nursery environment. The accelerated growth rates were supported by increased feed intakes and gain/feed ratios. At the end of the nursery period, the diet main effect persisted ($P < 0.001$), with liquid-fed pigs weighing 2.4

kg more than dry-fed pigs (Figure 1, bar graph), but the difference was predominant among pigs reared in the conventional hot nursery (environment × diet interaction, $P < 0.01$, Table 2). It also is noteworthy that, during d 15 to 49, pigs fed the liquid diet within the conventional hot nursery continued to out-perform their dry-fed controls; however, the added stress of diet change and relocation of the liquid-fed pigs from the segregated-temperature nursery caused their performance to lag behind the dry-fed pigs during this time interval.

During growing and finishing periods (Table 2), pigs generally showed only modest (and temporary) differences in growth performance. During the early grower period (d 50 to 91), feed intake was greater ($P < 0.01$), and gain/feed was lesser in pigs from the conventional hot nursery that had been fed the liquid diet. No carryover treatment differences were detected ($P > 0.23$) in the later grower-finisher period (d 92 to 143). Overall (d 0 to 143), pigs fed the liquid diet during the first 2 wk postweaning showed greater ADG ($P < 0.05$) and ADFI ($P < 0.01$) and thus required fewer days ($P < 0.05$) to reach a market weight of 110 kg (150.9 vs 154.6 d for liquid vs dry-pellet fed pigs, respectively). No difference in feed efficiency was detected ($P = 0.93$).

Carcass Measures and Protein Deposition. At d 49, backfat depth was affected by diet physical form (diet main effect, $P < 0.01$). Piglets fed the liquid diet had thicker backfat compared with piglets that had been fed the dry pelleted diet during the first 2 wk postweaning (Table 3). Congruent with the growth response described previously, the effect of postweaning diet on backfat was predominant in animals housed within the hot nursery environment (environment × diet interaction, $P < 0.05$). Although effects of environment and diet form on backfat and longissimus muscle area were detected on d 91, effects were modest and transient. The CFFLI also was not different among treatments throughout the growing-finishing period (Table 3). Similarly, estimated average daily CFFLG rates were not affected by treatments except d 70 to 91.

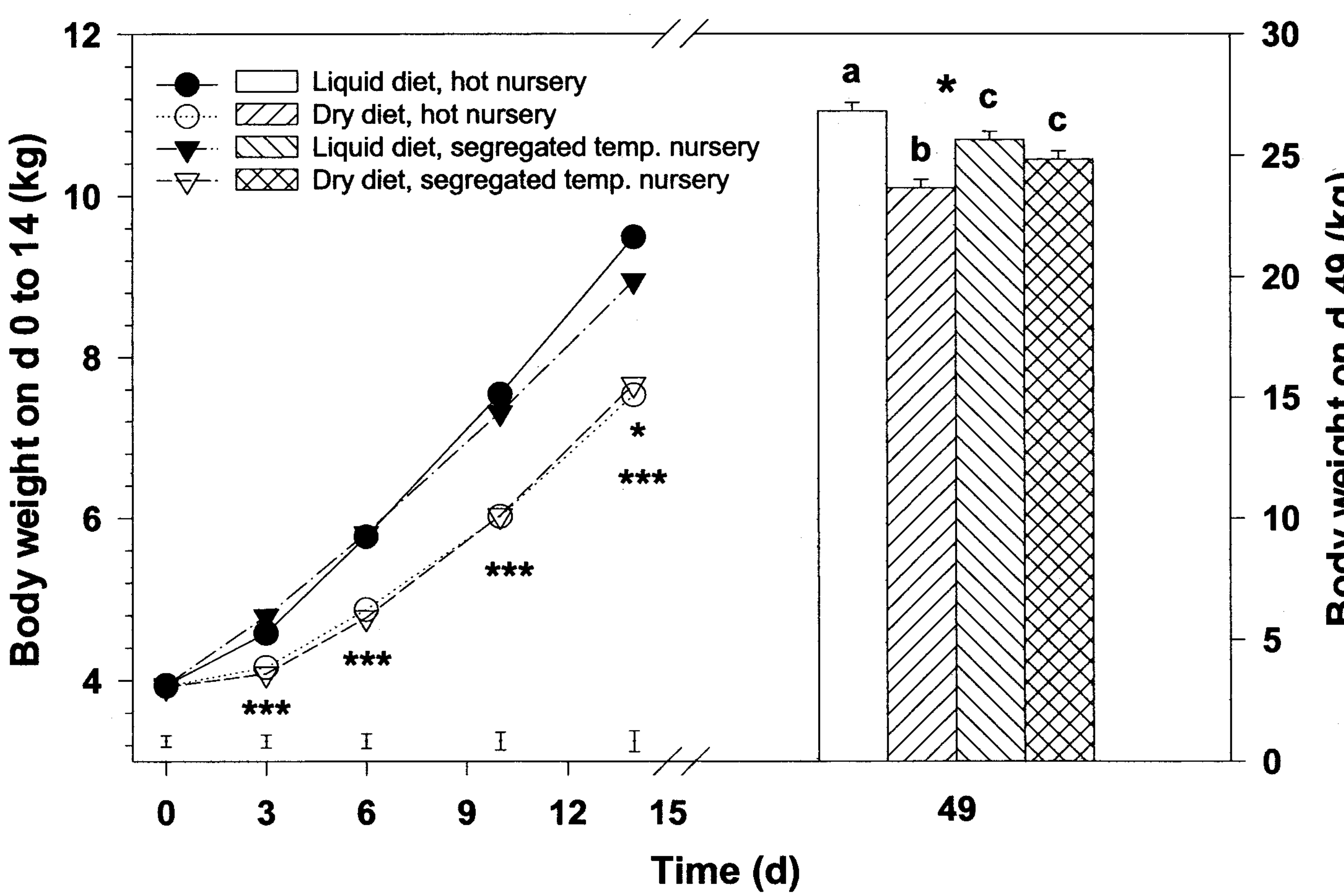

Figure 1. Effects of diet physical form (liquid vs dry) and nursery environment (hot vs segregated-temperature) during the first 2 wk postweaning on piglet body weight. Line graphs (left axis) show weight during the treatment period, and the bar graph (right axis) shows body weights at the end of the nursery period (d 49). After 14 d on treatment, all animals were housed within the conventional hot nursery and fed dry feed. Error bars represent ± SEM. *Interaction between diet physical form and nursery environment, $P < 0.05$. ***Main effect of diet physical form, $P < 0.001$. [a,b,c]Bars lacking a common superscript differ, $P < 0.05$.

Table 2. Effects of diet physical form and nursery environment (Env) during the first 14 d after weaning on growth performance of pigs during nursery (d 0 to 49), growing (d 50–91), and finishing (d 92 to 143) phases[a]

		Environment							
		Conventional hot nursery		Segregated-temperature nursery			Statistical significance[b]		
Item	Diet form:	Liquid	Dry	Liquid	Dry	SEM	Env	Diet	Env × Diet
d 0 to 14									
ADG, g		397	257	358	268	10.0	NS	**	**
ADFI, g		369	292	337	309	4.9	NS	—	—
Gain/feed, g/kg		1,076	878	1,061	867	20.2	NS	—	—
d 15 to 49									
ADG, g		495	462	478	491	5.7	NS	NS	**
ADFI, g		852	786	812	843	8.3	NS	NS	**
Gain/feed, g/kg		582	587	588	583	4.9	NS	NS	NS
d 50 to 91									
ADG, g		894	878	884	851	10.2	NS	NS	NS
ADFI, g		1,928	1,779	1,789	1,759	18.9	**	**	*
Gain/feed, g/kg		463	495	494	483	4.2	NS	NS	**
d 92 to 143									
ADG, g		968	966	969	964	9.3	NS	NS	NS
ADFI, g		2,625	2,617	2,653	2,577	26.0	NS	NS	NS
Gain/feed, g/kg		369	369	367	375	2.7	NS	NS	NS
d 0 to 143									
ADG, g		774	745	763	747	6.3	NS	*	NS
ADFI, g		1,760	1,689	1,715	1,685	12.9	NS	**	NS
Gain/feed, g/kg		439	441	446	443	2.3	NS	NS	NS
Age of pigs at 110 kg, d		150.6	154.7	151.2	154.4	1.27	NS	**	NS

[a]Values are means of 6 pens during nursery and 12 pens during growing-finishing phases.
[b]NS: not statistically significant. $P > 0.05$.
*$P < 0.05$.
**$P < 0.01$.

Discussion

Nutrition during the early life of pigs is very important because, in addition to influencing early growth performance, it also may affect subsequent growth (Pollmann et al., 1992; Pluske et al., 1995; Azain, 1997). Nutritional problems associated with early weaning have led to the development of complex starter diets containing large amounts of expensive milk products and plasma proteins (Cline, 1991; Hansen et al., 1993; Dritz et al., 1996a) as well as various management schemes to improve the performance of early-weaned piglets. Improving feed intake during the immediate postweaning period is very important for the development of the small intestine and subsequent growth performance (Pluske et al., 1995; Zijlstra et al., 1996; McCracken et al., 1999). As evidenced in the research reported herein, the physical form of the diet during the immediate postweaning period can have an immediate and lasting impact on pig growth performance.

Our findings are consistent with other recent reports showing greatly accelerated growth of young pigs fed liquid milk replacer (Zijlstra et al., 1996; Azain, 1997; Heo et al., 1999). However, to our knowledge, the study reported herein is the first to attribute the accelerated performance definitively to the physical form of the diet (liquid vs dry). Indeed, our liquid and dry diets were formulated to be nutritionally identical. This also is the first large-scale study to document that the growth advantage of liquid-fed pigs is maintained to market weight. Indeed, consistent with the results of Mahan et al. (1998) and Bikker et al. (1996), there was no evidence of compensatory gain by the dry-fed control pigs. It was noted that pigs fed the liquid diet within the conventional hot nursery grew better than pigs within the segregated-temperature nursery. This was surprising because the segregated-temperature nursery was 450 m off-site and represented a cleaner environment than the conventional hot nursery. The superior performance was mainly due to greater feed intake. Elevated feed intake of the liquid diet in higher ambient temperatures was suggested in previous research (Heo et al., 1999). In contrast to the results of our previous study, pigs did not show any sign of diarrhea when the ambient temperature was maintained at 30°C. Among pigs fed the dry pelleted diet, those housed within the segregated-temperature nursery showed better performance through the entire nursery period. This is assumed to be the result of the cleaner environment of the segregated-temperature nursery. Pigs within the segregated-temperature nursery that were fed the dry diet consumed more feed during the last 8 d of the treatment period than dry-fed pigs within the conventional hot nursery. Again, because the segregated-temperature nursery also was remote from the main farm (450 m away), with restricted animal and personnel traffic, this growth improvement may reflect the advantage of a site-segregated weaning system. Furthermore, it appears that the disadvantage of the on-farm conventional hot nursery was overcome by the higher feed intake of pigs fed the liquid diet within this environment.

The growth advantage achieved by liquid feeding during the first 2 wk after weaning was maintained through the growing and finishing periods. It has been recognized that the nutrition during the early life of pigs can influence subsequent growth rates (Mahan, 1993; Pluske et al., 1995; Mahan et al., 1998). Harrell et al. (1993) reported that pigs fed liquid milk replacer from 2 to 23 d of age reached market weight (110 kg) 10 d earlier than the best sow-reared controls. Azain (1997) also showed that early-weaned pigs (7 to 10 d of age at weaning) fed liquid milk replacer for 1 wk right after weaning maintained higher body weight when pigs were 6 to 7 wk of age. The magnitude of the advantage afforded by liquid feeding in our study was not quite large as previously observed (Heo et al., 1999), probably due to the very high quality of the dry pelleted diet used as the control in this study. Indeed, all pigs in this study (liquid- and dry-fed alike) showed very good growth during the nursery period (when compared with that projected from the NRC 1998 growth model), especially considering the very early weaning age. The average age when pigs reached 110 kg in this study was 152.7 ± 6.4 d, which is much better than 165 to 170 d of usual production time in the swine unit where this study was conducted.

The potential for lean tissue growth in the baby pig is probably restricted by the composition of sow's milk, which contains high fat and relatively low protein (Pluske et al., 1995). This relatively low protein:energy ratio encourages piglets to deposit more fat, which serves as energy source and insulation layer. With the use of liquid milk replacer, it is possible to encourage piglets to deposit more protein with manipulation of nutrient composition. Zijlstra et al. (1996) reported that, at 46 d of age, pigs fed liquid milk replacer had accreted more protein, fat, and water than sow-suckled pigs. Our results also showed that pigs fed a liquid diet during the early nursery period deposited more fat in their body, as shown in thicker backfat compared with dry pellet-fed counterparts. But the present study showed that apparent body composition alterations produced during the nursery period were not maintained through the growing-finishing period. Pluske et al. (1995) similarly indicated that the body composition in early life had little influence on body composition at slaughter weight.

Implications

This study clearly shows that liquid diet feeding is beneficial for early-weaned piglets and suggests that liquid feeding could be applied within conventional hot

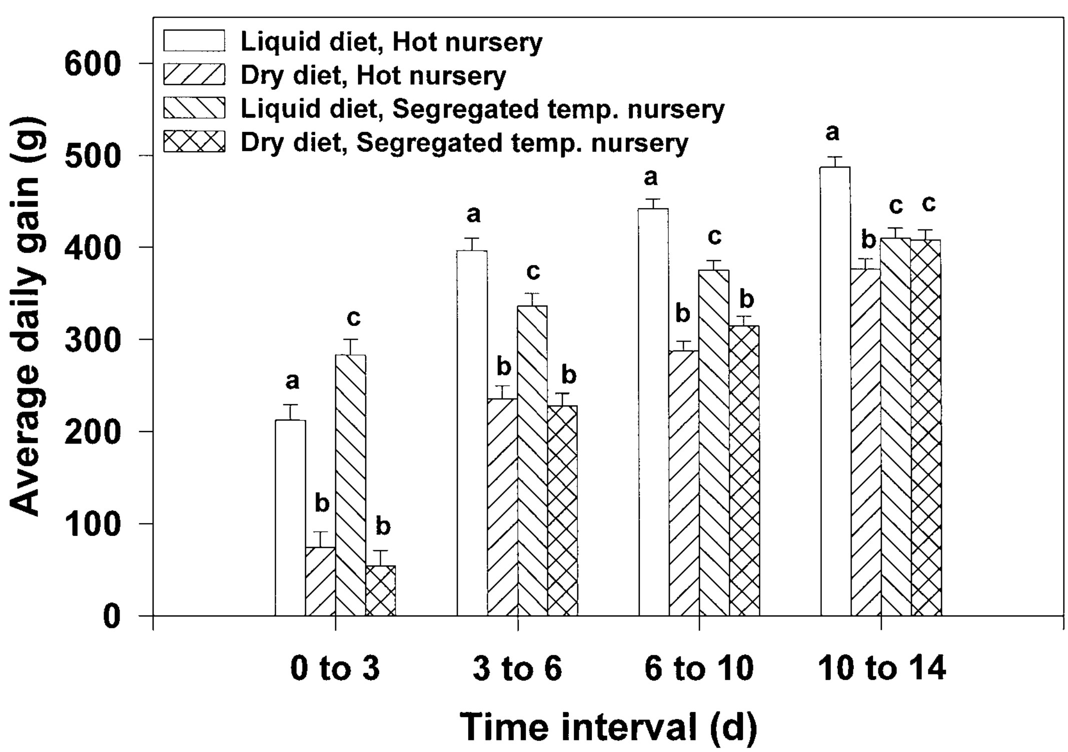

Figure 2. Effects of diet physical form (liquid vs dry) and nursery environment (hot vs segregated-temperature) during the first 2 wk postweaning on piglet average daily gain. Error bars represent the pooled SEM. Environment × diet form interaction during all time intervals ($P < .05$). [a,b,c]Bars within a time interval lacking a common superscript differ, $P < .05$.

Table 3. Effects of diet physical form and nursery environment (Env) during the first 14 d after weaning on live-ultrasound body measurements, and calculated carcass fat-free lean index and lean gain of pigs during growing and finishing phases (d 49 to 143)[a]

	Environment							
	Conventional hot nursery		Segregated-temperature nursery			Statistical significance[b]		
Item[c] Diet form:	Liquid	Dry	Liquid	Dry	SEM	Env	Diet	Env × Diet
d 49								
Backfat, mm	7.7	6.9	7.4	7.4	0.01	NS	**	*
LMA, cm^2	16.9	15.4	15.9	15.4	0.33	NS	NS	NS
CFFLI, %	50.8	50.5	50.2	50.0	0.44	NS	NS	NS
d 70								
Backfat, mm	10.2	10.1	9.8	9.9	0.02	NS	NS	NS
LMA, cm^2	19.5	21.3	21.0	20.9	0.32	NS	NS	NS
CFFLI, %	41.9	42.9	43.0	42.8	0.22	NS	NS	NS
CFFLG (d 49 to 70), g/d	290	301	306	295	8.0	NS	NS	NS
d 91								
Backfat, mm	12.7	12.0	11.9	11.6	0.02	*	NS	*
LMA, cm^2	28.2	26.9	26.3	25.8	0.29	**	**	NS
CFFLI, %	40.9	40.7	40.5	40.4	0.17	NS	NS	NS
CFFLG (d 71 to 90), g/d	312	287	287	284	8.1	NS	*	NS
d 112								
Backfat, mm	16.4	16.6	15.5	15.9	0.03	NS	NS	NS
LMA, cm^2	32.0	32.7	32.7	32.2	0.29	NS	NS	NS
CFFLI, %	38.3	38.4	38.9	38.5	0.20	NS	NS	NS
CFFLG (d 91 to 112), g/d	251	284	292	288	11.0	NS	NS	NS
d 133								
Backfat, mm	20.6	20.2	20.3	19.5	0.05	NS	NS	NS
LMA, mm^2	36.6	36.6	38.3	38.5	0.49	NS	NS	NS
CFFLI, %	36.7	36.8	37.3	37.5	0.25	NS	NS	NS
CFFLG (d 112 to 133), g/d	277	275	293	302	22.3	NS	NS	NS
d 143								
Backfat, mm	22.9	23.0	22.7	21.9	0.04	NS	NS	NS
LMA, cm^2	41.1	41.3	43.0	42.0	0.41	NS	NS	NS
CFFLI, %	36.5	36.5	37.0	37.0	0.18	NS	NS	NS
CFFLG (d 133 to 143), g/d	295	297	302	301	6.8	NS	NS	NS

[a]Values are means of 12 pens.
[b]NS: not statistically significant. $P > 0.05$.
*$P < 0.05$.
**$P < 0.01$.
[c]LMA: longissimus muscle area, CFFLI: carcass fat-free lean index, CCFLG: carcass fat-free lean gain.

nurseries to accelerate piglet growth performance. The study also documents that the improved growth performance is maintained until market weight. If selectively applied to pigs having lighter weaning weight, liquid feeding in the nursery could be useful in reducing variation in market weight and days to market weight. No main effect of environment was found, indicating that liquid feeding could be applied within practical swine husbandry without requiring any special environmental modifications.

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