JOURNAL OF ANIMAL SCIENCE
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J Anim Sci published online Apr 9, 2010;

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[1]Approved for publication by the director of the Louisiana Agric. Exp. Stn. as Publ. No. 2009-230-4032.
[2]The authors extend their gratitude to Zamorano's intern, D. Pantoja, and the following Louisiana State University Agricultural Center personnel: S. Powell, A. Waguespack, E. Frugé, G. Romero, and R. Lirette for their assistance with data collection.
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Published Online First on April 9, 2010 as doi:10.2527/jas.2009-2726

ABSTRACT: Experiments were conducted to assess the effect of dried whey (DW; 70% lactose) or milk chocolate product (MCP; 20% lactose and 60% sugars) on wk-1 feed intake and growth performance of pigs. Diets contained 1.60, 1.40, 1.40, and 1.20% total Lys for phase 1 (d 0 to 7), 2 (d 7 to 14), 3 (d 14 to 21), and 4 (d 21 to 35), respectively. Pigs were blocked by initial BW; sex and littermates were balanced across treatment; treatments were replicated with a minimum of 5 pens of 4 pigs each. Pigs were weaned at 24, 19, and 24 d of age with an initial BW of 6.5, 6.0, or 6.3 kg for Exp. 1 to 3, respectively. In Exp. 1 and 2, the treatments were: 1) negative control (NC), no lactose added, 2) positive control (PC) with DW, 3) 25% replacement of the level of DW of the PC diet with MCP (25MCP), and 4) 50% replacement of the level of DW of the PC diet with MCP (50MCP). The level of DW or combinations of DW and MCP were 20, 10, and 5% for phases 1, 2, and 3 respectively. A common diet with no lactose was fed during phase 4. In Exp. 3, the treatments were: 1) NC, 2) PC, and 3) 100% replacement of the level of DW of the PC diet with MCP (100MCP). In the combined data of Exp. 1 and 2, daily collected feed intake during wk 1 was increased ($P < 0.10$) from d 3 to 7 for the PC pigs, on d 2, 3, 4, and 7 for the 25MCP pigs, and from d 2 to 7 for the 50MCP pigs compared with the NC pigs. There was no difference ($P > 0.10$) on any day of wk 1 among pigs fed the PC and MCP diets. During phase 1, ADG and ADFI were increased ($P < 0.10$) for the PC, 25MCP, and 50MCP pigs compared with the NC pigs, but G:F was not affected ($P > 0.10$). During phases 2, 3, 4, and overall there were no differences ($P > 0.10$) in growth performance among pigs fed the PC and MCP diets. In Exp. 3, collected daily feed intake during wk 1 was increased ($P < 0.10$) from d 2 to 5 for PC pigs and on d 1 and 2 for the 100MCP pigs compared with the NC pig. However, there was no difference ($P > 0.10$) on any day of wk 1 between the PC and 100MCP pigs. Growth performance was not affected ($P > 0.10$) during any phase of the experiment.

Combined data from Exp. 1, 2, and 3 using the NC and PC diets indicated that dietary DW increased (P < 0.10) final BW and increased ADG and ADFI during phases 1, 2, 3, and overall. These results indicate that partial or total replacement of DW with MCP had no effect on wk-1 feed intake or growth performance of weanling pigs, and that MCP could be considered as a formulation alternative to DW.

Key words: chocolate, lactose, nursery, pigs

INTRODUCTION

Weaning is recognized as a period of high stress for pigs. It is characterized by reduced feed intake, and therefore, a deficient supply of energy and nutrients. Increased feed intake during the first week post-weaning has been associated with enhanced growth performance and health status of weanling pigs. Highly palatable and digestible ingredients are used in diets of weanling pigs to promote feed intake, especially during the first week post-weaning.

Dried whey (**DW**), which contains 70% lactose, is widely used in diets for weanling pigs as it has been reported to increase feed intake and growth performance (Mahan, 1993; Cromwell et al., 2008). Milk chocolate product (**MCP**), which contains 20% lactose and 60% total sugars, is a by-product from the food and candy industries that contains approximately one third each of whole milk, sucrose, and cocoa (Sullivan et al., 1992; Yang et al., 1997). Several researchers (Sullivan et al., 1992; Yang et al., 1997) have shown that pigs preferred diets with MCP over diets with DW in feed preference trials. However, the effect of MCP on growth performance of weanling pigs has been inconsistent. Sullivan et al. (1992) reported that MCP can effectively replace DW at a dietary level of 12% without affecting growth performance of weanling pigs. In contrast, Yang et al. (1997) reported that ADG, ADFI, and G:F were linearly decreased with increasing levels of MCP as a replacement of DW.

More research is needed to elucidate the efficacy of MCP to stimulate feed intake during the first wk post-weaning and on growth performance of weanling pigs. Milk chocolate product is less expensive than DW and may be an economical replacement in diets for weanling pigs. Therefore, the objectives of these experiments were to determine the effect of partial or total replacement of DW with MCP on daily-collected feed intake during the first week post-weaning and subsequent growth performance of weanling pigs.

MATERIALS AND METHODS

General

All experimental protocols were approved by the Louisiana State University Agricultural Center Animal Care and Use Committee. Pigs (Yorkshire, Yorkshire × Landrace, or Yorkshire × Landrace × Duroc) were obtained from the Louisiana State Agricultural Center Swine Unit and housed in an environmentally controlled nursery building. Each pen (0.97 x 1.47 m in size) had hard plastic slotted flooring, 1 nipple waterer, and a 4-hole self-feeder. Feed in meal form and water were provided for *ad libitum* intake.

In all experiments, weanling pigs were blocked by initial BW and allotted to dietary treatments in a randomized complete block design. Littermates were balanced across treatments and sex was equalized among pens within replicates. Pigs were fed in a 4-phase feeding program that lasted from d 0 to 7 for phase 1, d 7 to 14 for phase 2, d 14 to 21 for phase 3, and d 21 to 35 for phase 4. All pigs and feeders were weighed at the beginning and end of each growth phase for ADG, ADFI, and G:F determination. All feeders were weighed daily starting at 0700 during the first 7 d post-weaning to determine daily-collected feed intake.

Dietary treatments were formulated based on the AA and nutrient concentrations provided by International Ingredient Corporation (St. Louis, MO) for DW and MCP. The nutrient values used for DW and MCP were: CP, 12.2 and 12.0%; crude fat, 1.0 and 6.0%; lactose, 70 and 20%; salt, 3.0 and 1.5%; Ca, 0.86 and 0.30%; P, 0.76 and 0.30%; Lys, 0.95 and 1.10%; Met, 0.21 and 0.22%; TSAA, 0.44 and 0.36%; Thr, 0.73 and 0.55%; Trp, 0.18 and 0.19%; and Ile, 0.64 and 0.56%, respectively. Nutrient values reported in the Aminodat 3.0 database by Evonik-Degussa (Hess et al., 2006) were used for all other ingredients. Diets were formulated to contain 1.60, 1.40, 1.40 and 1.20% total Lys for phases 1, 2, 3, and 4 respectively, and to meet or exceed the AA ratios suggested by Baker (1997) for 10-to 20-kg pigs. To keep dietary treatments isocaloric, fat levels were reduced with increasing levels of MCP as DW provides less ME (kcal/kg) than MCP. Because DW provides 2 times more salt than MCP (3.0 vs. 1.5% respectively), salt levels fluctuate among diets in order to keep the percentage of Na and Cl within an acceptable range. Dietary inclusion levels of nutrients and ingredients are expressed on an as-is basis.

Exp. 1 and 2

Experiments were conducted to determine the effect of partially replacing the dietary level of DW with MCP on wk-1 feed intake and growth performance of weanling pigs. In Exp. 1, 80 weanling pigs with an average initial BW of 6.5 ± 0.8 kg and weaned at an average age of 24 ± 2 d were used. Each treatment was replicated with 5 pens of 4 pigs per replicate pen. In Exp. 2, 120 weanling pigs with an average initial BW of 6.0 ± 0.9 kg and weaned at an average age of 19 ± 2 d were used. Each treatment was replicated with 6 pens of 5 pigs per replicate pen.

In Exp. 1 and 2, pigs were assigned to 4 dietary treatments that followed the same treatment arrangement during phases 1, 2, and 3 (Tables 1 to 3). Dietary treatments included: 1) negative control diet (**NC**), no lactose added, 2) positive control diet (**PC**) with DW, 3) 25% replacement of DW used in the PC diet with MCP (**25MCP**), and 4) 50% replacement of DW used in the PC diet with MCP (**50MCP**). The inclusion levels of DW or the sum of DW and MCP in combination were 20, 10, and 5% for phases 1, 2, and 3 respectively. During phase 4, all pigs were fed the same corn-soybean meal diet with no lactose added (Table 3). Because the same dietary treatments were used in Exp. 1 and 2, data from both experiments were combined and analyzed together. Combined data from Exp. 1 and 2 resulted in a total of 200 weanling pigs with an average initial BW of 6.2 ± 0.9 kg and 21 ± 3 d of age. There were a total of 11 replicates with 4 or 5 pigs per replicate pen.

Exp. 3

This experiment was conducted to determine the effect of totally replacing the dietary level of DW with MCP on wk-1 feed intake and growth performance of weanling pigs. Eighty-four weanling pigs with an average initial BW of 6.3 ± 1.3 kg and weaned at an average age of 21 ± 2 d were allotted to 3 dietary treatments (Tables 1 to 3): 1) NC diet, 2) PC diet, and 3) 100% replacement of DW used in the PC diet with MCP (**100MCP**). Each treatment was replicated with 7 pens of 4 pigs per replicate pen. The NC, PC, and phase 4 diets were the same as in Exp. 1 and 2. Because Exp. 1, 2, and 3 included the same NC and PC diets, data were combined and analyzed together to determine the efficacy of DW to improve growth performance of weanling pigs compared with pigs fed diets with no lactose added.

Statistical Analysis

Data from all experiments were analyzed as randomized complete block designs using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Initial BW was used as the blocking factor and each pen of pigs served as the experimental unit. Combined data from Exp. 1 and 2, and combined data from Exp. 1, 2, and 3 (NC vs. PC) were analyzed using initial BW (block), dietary treatment, and experiment as sources of variation. The treatment × experiment interaction was not significant, and therefore, was removed from the model. In Exp. 3, data were analyzed using initial BW and dietary treatment as sources of variation. For all experiments, treatment means were separated using preplanned, pairwise comparisons (PDIFF option of SAS) with an α at 0.10.

RESULTS

Exp. 1 and 2

There were no treatment × experiment interactions ($P > 0.10$) in any of the growth variables of the combined data. Thus, results and discussion are based on the combined data of Exp. 1 and 2.

Week-one feed intake

Feed intake was increased ($P < 0.10$) from d 3 to 7 for pigs fed the PC diet, on d 2, 3, 4, and 7 for pigs fed the 25MCP diet, and from d 2 to 7 for pigs fed the 50MCP compared with pigs fed the NC diet (Table 4, Figure 1). There was no difference ($P > 0.10$) in feed intakes on any day among pigs fed the PC, 25MCP and 50MCP diets.

Growth performance

During phase 1, pigs fed the PC, 25MCP, and 50MCP diets had increased ($P < 0.10$) ADG and ADFI compared with pigs fed the NC diet, but G:F was not affected ($P > 0.10$; Table 5). There was no difference ($P > 0.10$) in ADG, ADFI, and G:F among pigs fed the PC diet and pigs fed the 25MCP and 50MCP diets. During phase 2, pigs fed the PC, 25MCP, and 50MCP diets had increased ($P < 0.10$) ADFI compared with pigs fed the NC diet. Daily gain was increased (*P* < 0.10) for pigs fed the PC diet compared with pigs fed the NC diet. However, ADG was similar (*P* > 0.10) among pigs fed the 25MCP and 50MCP diets compared with pigs fed the PC diet. Gain:feed was not affected (*P* > 0.10) by dietary treatment. During phase 3, pigs fed the PC and 50MCP diets had increased (*P* < 0.10) ADFI compared with pigs fed the NC diet, but ADG was not affected (*P* > 0.10). Gain:feed was reduced (*P* < 0.10) for pigs fed the PC and 25MCP diets compared with pigs fed the NC diet. However, ADG, ADFI, and G:F were not different (*P* > 0.10) among pigs fed the PC, 25MCP, and 50MCP diets. During phase 4, when all pigs were fed the same diet, ADG, ADFI, and G:F were not affected (*P* > 0.10) by dietary treatment.

The combined overall data from Exp. 1 and 2 indicated that partial replacement of DW with MCP did not affect (*P* > 0.10) ADG, ADFI, or G:F of weanling pigs. There was no difference (*P* > 0.10) in ADG and G:F among pigs fed the NC diet and pigs fed the PC and MCP diets. Daily feed intake was increased (*P* < 0.10) for pigs fed the PC and 50MCP diets compared with pigs fed the NC diet, but similar to pigs fed the 25MCP diet. Final BW at the end of the 35 d nursery period was not affected (*P* > 0.10) by dietary treatment.

Exp. 3

Week-one feed intake

Daily feed intake was increased (*P* < 0.10) from d 2 to 5 for pigs fed the PC diet and on d 1 and 2 for pigs fed the 100MCP diet compared with pigs fed the NC diet (Table 6, Fig 1). However, there was no difference (*P* > 0.10) between pigs fed the PC and 100MCP diets.

Growth performance

Total replacement of DW with MCP did not affect (*P* > 0.10) ADG, ADFI, or G:F during any growth phase of the experiment (Table 7). During phase 1, pigs fed the PC diet had increased ($P < 0.10$) ADG and ADFI compared with pigs fed the NC diet. Pigs fed the 100MCP diet had similar ($P > 0.10$) ADG and ADFI compared with pigs fed the PC diet.

Daily feed intake was increased ($P < 0.10$) for pigs fed the PC diet during phases 2 and 3 compared with pigs fed the NC diet, but pigs fed the 100MCP and PC diets had similar ADFI. Daily gain and G:F were not different ($P > 0.10$) among pigs fed the NC, PC, and 100MCP diets during phases 2, 3, 4, and overall. At the end of the 35-d nursery period, final BW was not affected ($P > 0.10$) by dietary treatment.

Effect of dried whey

Data from Exp. 1, 2, and 3 using the NC and PC diets were combined and analyzed to determine the efficacy of DW to increase growth performance of weanling pigs (Table 8). Daily gain and ADFI were increased ($P < 0.10$) for pigs fed the PC diet during phases 1, 2, 3, and overall. During phase 2, G:F was reduced ($P = 0.01$) for pigs fed the PC diet, but it was not affected ($P > 0.10$) in any other phase of the experiment. At the end of the 35-d nursery period, final BW was increased ($P < 0.10$) for pigs fed diets with DW.

DISCUSSION

Weaning represents a stressful event that commonly results in reduced feed intake and inadequate supply of energy and nutrients for the weanling pig. Bark et al. (1986) reported that the unfamiliar method of feed acquisition and the unfamiliar source of feed (liquid vs. dry feed) were the main causes for the reduced feed intake. Improving feed palatability with the use of sweeteners such as sucrose, whey, or artificial flavors may improve feed intake immediately after weaning. Research has shown that weanling pigs strongly preferred a diet with MCP over a diet with DW (Sullivan et al., 1992; Yang et al., 1997).

Results from our experiments indicated that weanling pigs had greater growth performance when fed diets with DW or MCP compared with pigs fed the NC diet. However, no further improvements were obtained with increasing levels of MCP as a replacement of DW on daily collected wk-1 feed intake post-weaning. The inclusion of DW or its partial replacement with 25 or 50% MCP improved feed intake during all days of wk-1 post-weaning compared with pigs fed a diet with no lactose added. These results are in agreement with published literature (Mahan, 1993; Mahan and Newton, 1993) that have reported increased feed intake in pigs fed diets with lactose or other highly digestible carbohydrate sources compared with pigs fed diets with no sugars added.

Because no additional benefits or detrimental effects were obtained with partial replacements of DW with MCP in Exp. 1 and 2, a 100% replacement with MCP was conducted in Exp. 3. Feed intake was increased on more days (d 2 to 5) in pigs fed the PC diet than pigs fed the 100MCP diet (d 1 and 2) compared with pigs fed the NC diet. However, feed intake between pigs fed the PC and 100MCP diets were not different during any day of wk-1 post-weaning. Dried whey contains 70% lactose whereas MCP contains 20% lactose and 60% total sugars, mainly from lactose, sucrose, and glucose. Previous studies from our laboratory have shown that products containing a combination of lactose, sucrose, and glucose stimulate feed intake in a similar manner as a high-lactose product. The cocoa portion of MCP seems not to have an additional effect on increasing feed intake compared with DW. However, strong preference of weanling pigs for MCP over DW has been reported (Sullivan et al., 1992; Yang et al., 1997) using a single stimulus preference trial and free choice trials. However, in our experiments, pigs within each replicate pen were exposed to a single dietary treatment rather than allowing pigs to choose among 2 or more diets at the same time.

Our results indicated that partial or total replacement of DW with MCP did not affect growth performance of weanling pigs. Results from the combined data of Exp. 1 and 2, indicated no detrimental effects on ADG, ADFI, or G:F with increasing levels of MCP. Additionally, final BW at the end of the nursery period was not affected in any of the 3 experiments. Similarly, Sullivan et al. (1992) reported that MCP could totally replace DW at a dietary level of 12% with no detrimental effects on growth performance of weanling pigs.

In contrast, Yang et al. (1997) reported that increasing levels of MCP from 0 to 100% replacement of DW linearly decreased growth performance of weanling pigs. These authors recommended that MCP could replace DW at a dietary level no greater than 5% (5% MCP and 15% DW) without affecting growth performance. Greater replacement levels were associated with decreased growth performance. However, results from our Exp. 3 indicated that MCP could totally replace DW with no detrimental effects on growth performance. A possible explanation for the inconsistency of these results may be that in our experiments, supplemental Thr was added to the diets with increasing levels of MCP to meet the Thr:Lys recommended by Baker (1997) for 10- to 20-kg pigs, whereas, Yang et al. (1997) did not include any supplemental Thr. Yang et al. (1997) reported that their analyzed Thr:Lys ratio decreased with increasing levels of MCP and were lower than those recommended by Baker (1997). Therefore, the reduction in growth performance with increased levels of MCP may have been related to a deficiency in Thr. Additionally, our diets were fed in meal form whereas those used by Yang et al. (1997) were pelleted. However, no research has been published evaluating the effect of pelleting on the availability of nutrients in MCP. Also in our experiments, all pigs were offered a common diet with no lactose during the last 2 wks of the nursery period, whereas DW and MCP dietary treatments were fed until the end of the nursery period in Yang et al. (1997), either in 2 or 3 phase feeding programs.

Combined data from Exp. 1, 2, 3 using NC and PC diets demonstrated that the inclusion of DW in diets of weanling pigs improved growth performance and final BW at the end of the nursery period. These data are in agreement with the literature (Mahan, 1993; Tokach et al., 1995; Nessmith et al., 1997; Cromwell et al., 2008) that have reported enhanced growth performance of pigs fed diets with added lactose. Interestingly, this effect was not evident when analyzing each experiment independently, which suggest that increased numbers of replicates are required to elucidate the effects of lactose.

In conclusion, results indicate that partial or total replacement of DW with MCP does not affect overall growth performance of weanling pigs. The inclusion of DW, MCP, or the combination of both improved wk-1 feed intake compared with pigs fed a diet with no lactose added. Milk chocolate product could be considered as an alternative to DW.

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Table 1. Composition of phase 1 experimental diets that were fed to weanling pigs in Exp. 1, 2, and 3 (as-fed basis)

	Exp. 1, 2, and 3		Exp. 1 and 2		Exp. 3
Ingredients, %	NC[1,3]	PC[2,3]	25MCP	50MCP	100MCP[3]
Corn	53.04	40.85	41.25	41.60	42.30
Soybean meal (48% CP)	25.98	20.44	20.15	19.86	19.28
Fishmeal menhaden	6.00	6.00	6.00	6.00	6.00
SDPP[4]	4.00	4.00	4.00	4.00	4.00
Dry fat[5]	4.76	3.57	3.28	3.02	2.50
Red blood cells[6]	2.00	2.00	2.00	2.00	2.00
Dried whey (DW)	---	20.00	15.00	10.00	---
Milk chocolate product (MCP)	---	---	5.00	10.00	20.00
Monocalcium phosphate	1.02	0.64	0.75	0.87	1.10
Limestone	0.77	0.56	0.58	0.60	0.65
Sodium bentonite	0.50	0.50	0.50	0.50	0.50
Vitamin premix[7]	0.50	0.50	0.50	0.50	0.50
Zinc oxide	0.28	0.28	0.28	0.28	0.28
Salt	0.61	0.10	0.13	0.17	0.26
Trace mineral premix[8]	0.10	0.10	0.10	0.10	0.10
Antibiotic[9]	0.25	0.25	0.25	0.25	0.25
Choline chloride	0.05	0.05	0.05	0.05	0.05
DL-Met	0.14	0.17	0.17	0.18	0.19
L-Thr	---	---	0.003	0.016	0.04
Calculated composition					
ME, kcal/kg	3,534	3,534	3,534	3,534	3,534
Lys, %	1.60	1.60	1.60	1.60	1.60
TSAA, %	0.96	0.96	0.96	0.96	0.96
Thr, %	1.04	1.05	1.04	1.04	1.04
Trp, %	0.31	0.31	0.31	0.31	0.30
Ca, %	0.90	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80	0.80
Na, %	0.42	0.43	0.42	0.43	0.44
Cl, %	0.53	0.50	0.49	0.49	0.49

[1]NC = negative control diet.

[2]PC = positive control diet.

[3]Dietary treatments were used in Exp. 3.

[4]SDPP = blood plasma (AP-920) was obtained from American Protein Corp., Ames, IA.

[5]Fat Pak 100, Milk Specialties Co., Dundee, IL.

[6]Innomax Porcine RBC, Innovative Proteins: A division of PMI Nutrition International LLC, Brentwood, MO.

[7]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D_3 3,307 IU; vitamin E, 88 IU; niacin, 88 g; pantothenic acid, 50 mg; riboflavin, 13 mg; menadione, 8 mg; pyridoxine, 4 mg; thiamin, 4 mg; folic acid, 3 mg; vitamin B_{12}, 61 µg; biotin, 441 µg; vitamin C, 110 µg.

[8]Provided the following per kilogram of diet: Fe, 127 mg; Zn, 127 mg; Cu, 12.7 mg; Mn,

20 mg; I, 0.80 mg; and Se, 0.30 mg.

[9]Neo-terra 10/10 from Nutra Blend LLC, Neosho, MO. Provided 165 mg oxytetracycline and 116 mg neomycin per kilogram of diet.

Table 2. Composition of phase 2 experimental diets that were fed to weanling pigs in used in Exp. 1, 2, and 3 (as-fed basis)

	Exp. 1, 2, and 3		Exp. 1 and 2		Exp. 3
Ingredients, %	NC[1,3]	PC[2,3]	25MCP	50MCP	100MCP[3]
Corn	55.81	49.68	49.87	50.04	50.40
Soybean meal (48% CP)	30.39	27.62	27.48	27.33	27.04
Dry fat[4]	3.62	3.03	2.90	2.77	2.50
Fishmeal menhaden	6.00	6.00	6.00	6.00	6.00
Dried whey (DW)	---	10.00	7.50	5.00	---
Milk chocolate product (MCP)	---	---	2.50	5.00	10.00
Monocalcium phosphate	1.20	1.01	1.07	1.12	1.24
Limestone	0.66	0.56	0.57	0.58	0.60
Sodium bentonite	0.50	0.50	0.50	0.50	0.50
Vitamin premix[5]	0.50	0.50	0.50	0.50	0.50
Zinc oxide	0.28	0.28	0.28	0.28	0.28
Salt	0.33	0.10	0.12	0.14	0.18
Trace mineral premix[6]	0.10	0.10	0.10	0.10	0.10
Antibiotic[7]	0.25	0.25	0.25	0.25	0.25
Choline chloride	0.05	0.05	0.05	0.05	0.05
L-Lys·HCl	0.15	0.15	0.15	0.15	0.15
DL-Met	0.12	0.13	0.14	0.14	0.15
L-Thr	0.04	0.04	0.05	0.05	0.07
Calculated composition					
ME, kcal/kg	3,446	3,446	3,446	3,446	3,446
Lys, %	1.40	1.40	1.40	1.40	1.40
TSAA, %	0.84	0.84	0.84	0.84	0.84
Thr, %	0.91	0.91	0.91	0.91	0.91
Trp, %	0.26	0.26	0.26	0.26	0.26
Ca, %	0.90	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80	0.80
Na, %	0.18	0.19	0.18	0.20	0.20
Cl, %	0.28	0.28	0.27	0.27	0.27

[1]NC = negative control diet.

[2]PC = positive control diet.

[3]Dietary treatments were used in Exp. 3.

[4]Fat Pak 100, Milk Specialties Co., Dundee, IL.

[5]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D_3 3,307 IU; vitamin E, 88 IU; niacin, 88 g; pantothenic acid, 50 mg; riboflavin, 13 mg; menadione, 8 mg; pyridoxine, 4 mg; thiamin, 4 mg; folic acid, 3 mg; vitamin B_{12}, 61 µg; biotin, 441 µg; vitamin C, 110 µg.

[6]Provided the following per kilogram of diet: Fe, 127 mg; Zn, 127 mg; Cu, 12.7 mg; Mn, 20 mg; I, 0.80 mg; and Se, 0.30 mg.

[7]Neo-terra 10/10 from Nutra Blend LLC, Neosho, MO Provided 165 mg oxytetracycline and 116 mg neomycin per kilogram of diet.

Table 3. Composition of phase 3 and 4 experimental diets that were fed to weanling pigs in Exp. 1, 2, and 3 (as-fed basis)

	Phase 3					Phase 4
	Experimental diets[1]					
Ingredients, %	NC[2]	PC[3]	25MCP	50MCP	100MCP	
Corn	54.80	51.70	51.83	51.92	52.21	60.50
Soybean meal (48% CP)	35.11	33.73	33.66	33.58	33.43	32.31
Dry fat[4]	3.16	2.88	2.80	2.73	2.50	2.50
Fishmeal menhaden	3.00	3.00	3.00	3.00	3.00	---
Dried whey (DW)	---	5.00	3.75	2.50	---	---
Milk chocolate product (MCP)	---	---	1.25	2.50	5.00	---
Monocalcium phosphate	1.01	0.92	0.95	0.98	1.03	1.46
Limestone	0.86	0.80	0.81	0.81	0.83	1.08
Sodium bentonite	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin premix[5]	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.35	0.25	0.24	0.25	0.27	0.50
Trace mineral premix[6]	0.10	0.10	0.10	0.10	0.10	0.10
Antibiotic[7]	0.25	0.25	0.25	0.25	0.25	0.25
Choline chloride	0.05	0.05	0.05	0.05	0.05	0.05
L-Lys·HCl	0.15	0.15	0.15	0.15	0.15	0.15
DL-Met	0.13	0.13	0.14	0.14	0.14	0.09
L-Thr	0.03	0.03	0.03	0.04	0.04	0.01
Calculated composition						
ME, kcal/kg	3,432	3,432	3,432	3,432	3,432	3,376
Lys, %	1.40	1.40	1.40	1.40	1.40	1.20
TSAA, %	0.84	0.84	0.84	0.84	0.84	0.72
Thr, %	0.91	0.91	0.91	0.91	0.91	0.78
Trp, %	0.28	0.27	0.27	0.27	0.27	0.24
Ca, %	0.80	0.80	0.80	0.80	0.80	0.80
P, %	0.70	0.70	0.70	0.70	0.70	0.70
Na, %	0.18	0.19	0.18	0.18	0.19	0.23
Cl, %	0.27	0.28	0.27	0.27	0.27	0.35

[1]NC and PC diets were used in Exp. 1, 2, and 3; 25MCP and 50MCP diets were used in Exp. 1 and 2; 100MCP diet was used in Exp. 3

[2]NC = negative control diet.

[3]PC = positive control diet.

[4]Fat Pak 100, Milk Specialties Co., Dundee, IL.

[5]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D_3 3,307 IU; vitamin E, 88 IU; niacin, 88 g; pantothenic acid, 50 mg; riboflavin, 13 mg; menadione, 8 mg; pyridoxine, 4 mg; thiamin, 4 mg; folic acid, 3 mg; vitamin B_{12}, 61 µg; biotin, 441 µg; vitamin C, 110 µg.

[6]Provided the following per kilogram of diet: Fe, 127 mg; Zn, 127 mg; Cu, 12.7 mg; Mn, 20 mg; I, 0.80 mg; and Se, 0.30 mg.

[7]Neo-terra 10/10 from Nutra Blend LLC, Neosho, MO. Provided 165 mg oxytetracycline and 116 mg neomycin per kilogram of diet.

Table 4. Effect of dietary dried whey (DW) and its partial replacement with milk chocolate product (MCP) on feed intake (g/day) during the first 7 d post-weaning in the combined data from Exp. 1 and 2[1]

	Experimental diets					
Days post-weaning	NC[2]	PC[3]	25MCP	50MCP	SEM	*P*-value[4]
1	22	23	32	35	11	0.74
2	120[b]	165[ab]	187[a]	203[a]	22	0.06
3	200[b]	265[a]	253[a]	261[a]	17	0.04
4	235[b]	286[a]	288[a]	306[a]	21	0.10
5	266[b]	336[a]	300[ab]	317[a]	20	0.10
6	300[b]	382[a]	346[ab]	388[a]	24	0.05
7	313[b]	399[a]	381[a]	398[a]	23	0.03

[1]Data are means of 11 replicates with 4 and 5 pigs per replicate pen in Exp. 1 and 2, respectively.

[2]NC = negative control diet.

[3]PC = positive control diet.

[4]Overall treatment *P*-value.

[a,b]Treatment means with different superscripts on the same row are significantly different, $P < 0.10$.

Table 5. Effect of dietary dried whey (DW) and its partial replacement with milk chocolate product (MCP) on growth performance of weanling pigs in the combined data from Exp. 1 and 2[1]

Item	Experimental diets				SEM	*P*-value[4]
	NC[2]	PC[3]	25MCP	50MCP		
Initial BW, kg	6.4	6.4	6.4	6.4	0.04	0.61
Final BW, kg	21.3	21.9	21.6	22.0	0.31	0.33
Phase 1, d 0 to 7						
ADG, g	133[b]	165[a]	171[a]	181[a]	12	0.04
ADFI, g	211[b]	265[a]	255[a]	276[a]	14	0.02
G:F	0.62	0.63	0.67	0.66	0.03	0.56
Phase 2, d 7 to 14						
ADG, g	383[b]	418[a]	398[ab]	390[ab]	13	0.28
ADFI, g	553[b]	643[a]	603[a]	614[a]	18	0.01
G:F	0.69[a]	0.64[b]	0.65[ab]	0.63[b]	0.02	0.09
Phase 3, d 14 to 21						
ADG, g	520	551	520	550	16	0.29
ADFI, g	783[b]	877[a]	829[ab]	836[a]	21	0.03
G:F	0.67[a]	0.64[b]	0.63[b]	0.66[ab]	0.01	0.15
Phase 4, d 21 to 35						
ADG, g	567	561	561	575	14	0.88
ADFI, g	1,036	1,033	1,012	1,046	23	0.74
G:F	0.55	0.54	0.56	0.55	0.01	0.66
Overall, d 0 to 35						
ADG, g	433	450	441	452	9	0.43
ADFI, g	716[b]	762[a]	737[ab]	759[a]	16	0.15
G:F	0.60	0.60	0.60	0.60	0.01	0.5

[1]Data are means of 11 replicates with 4 and 5 pigs per replicate pen in Exp. 1 and 2, respectively.

[2]NC = negative control diet.

[3]PC = positive control diet.

[4]Overall treatment *P*-value.

[a,b]Treatment means with different superscripts on the same row are significantly different, $P < 0.10$.

Table 6. Effect of dietary dried whey (DW) and its total replacement with milk chocolate product (MCP) on feed intake (g/day) during the first 7 d post-weaning in Exp. 3[1]

	Experimental diets				
Days post-weaning	NC[2]	PC[3]	100MCP	SEM	*P*-value[4]
1	14[b]	20[ab]	37[a]	9	0.21
2	146[b]	243[a]	274[a]	18	0.01
3	261[b]	337[a]	321[ab]	25	0.12
4	308[b]	379[a]	345[ab]	27	0.22
5	386[b]	486[a]	418[ab]	29	0.08
6	444	502	485	23	0.23
7	490	523	488	25	0.55

[1]Data are means of 7 replicates with 4 pigs per replicate pen.

[2]NC = negative control diet.

[3]PC = positive control diet.

[4]Overall treatment *P*-value.

[a,b]Treatment means with different superscripts on the same row are significantly different, $P < 0.10$.

Table 7. Effect of dietary dried whey (DW) and its total replacement with milk chocolate product (MCP) on growth performance of weanling pigs in Exp. 3[1]

Item	Experimental diets			SEM	*P*-value
	NC[2]	PC[3]	100MCP		
Initial BW, kg	6.3	6.3	6.3	0.05	0.58
Final BW, kg	20.8	21.5	21.3	0.35	0.4
Phase 1, d 0 to 7					
ADG, g	183[b]	227[a]	211[ab]	12	0.07
ADFI, g	293[b]	355[a]	337[a]	17	0.06
G:F	0.62	0.64	0.63	0.02	0.77
Phase 2, d 7 to 14					
ADG, g	302	313	302	16	0.86
ADFI, g	496[b]	547[a]	517[ab]	12	0.03
G:F	0.61	0.57	0.58	0.03	0.54
Phase 3, d 14 to 21					
ADG, g	292	320	296	17	0.45
ADFI, g	602[b]	681[a]	651[ab]	20	0.04
G:F	0.49	0.47	0.46	0.02	0.69
Phase 4, d 21 to 35					
ADG, g	647	655	670	18	0.66
ADFI, g	1,160	1,186	1,177	26	0.77
G:F	0.56	0.55	0.57	0.01	0.43
Overall, d 0 to 35					
ADG, g	414	434	429	11	0.45
ADFI, g	742	785	761	17	0.25
G:F	0.56	0.55	0.56	0.01	0.78

[1] Data are means of 7 replicates with 4 pigs per replicate pen.
[2]NC = negative control diet.
[3]PC = positive control diet.
[2]Overall treatment *P*-value.
[a,b]Treatment means with different superscripts on the same row are significantly different, *P* < 0.10.

Table 8. Effect of dietary dried whey (DW) on growth performance of weanling pigs, combined data from Exp. 1, 2, and 3[1]

Item	Experimental diets		SEM	*P*-value
	NC[2]	PC[3]		
Initial BW, kg	6.6	6.6	0.03	0.73
Final BW, kg	21.5	22.1	0.22	0.03
Phase 1, d 0 to 7				
ADG, g	149	187	8	0.01
ADFI, g	237	294	10	0.01
G:F	0.63	0.64	0.02	0.58
Phase 2, d 7 to 14				
ADG, g	359	384	10	0.07
ADFI, g	537	612	11	0.01
G:F	0.66	0.62	0.02	0.01
Phase 3, d 14 to 21				
ADG, g	440	470	11	0.01
ADFI, g	720	809	14	0.01
G:F	0.60	0.58	0.01	0.15
Phase 4, d 21 to 35				
ADG, g	602	601	11	0.97
ADFI, g	1,093	1,101	17	0.72
G:F	0.55	0.55	0.01	0.45
Overall, d 0 to 35				
ADG, g	429	448	6	0.04
ADFI, g	731	776	10	0.01
G:F	0.59	0.58	0.01	0.20

[1] Data are means of 18 replicates with 4 or 5 pigs per replicate pen.
[2]NC = negative control diet.
[3]PC = positive control diet.

Figure 1. Daily feed intake (g/pig) of pigs fed diets with no lactose (NC), with 20% dried whey (PC), with 5% dried whey and 15% MCP (25MCP), and with 10% dried whey and 10% milk chocolate product (50MCP) in the combined data of Exp. 1 and 2 (Panel A; Table 4). Daily feed intake of pigs fed the NC, PC, and 20% MCP (100MCP) diets in Exp. 3 (Panel B; Table 6).