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# Evaluation of Milk Chocolate Product as a Substitute for Whey in Pig Starter Diets[1,2]

H. Yang*, J. A. Kerber*, J. E. Pettigrew*, L. J. Johnston†, and R. D. Walker‡

*Department of Animal Sciences; †West Central Experiment Station; and ‡Southern Experiment Station, University of Minnesota, St. Paul 55108

**ABSTRACT:** Four experiments were conducted to study the effects of substituting milk chocolate product (MCP) for dried whey (DW) on growth performance of starter pigs. In Exp. 1 (4 wk) and 2 (5 wk), 440 pigs (age, 25 d) were assigned to one of four diets: 1) 0% DW + 0% MCP, 2) 20% DW + 0% MCP, 3) 10% DW + 10% MCP, or 4) 0% DW + 20% MCP. Linear reductions ($P < .06$) in ADG, ADFI, and gain/feed (G/F) were detected as MCP increased. Replacement of DW with 10% MCP had little effect on ADG or ADFI in Exp. 1, but it reduced them in Exp. 2. In Exp. 3 (5 wk), 192 pigs (age, 20 d) were fed one of four complex diets: 1) 15% DW + 0% MCP, 2) 10% DW + 5% MCP, 3) 5% DW + 10% MCP, or 4) 0% DW + 15% MCP. As MCP increased, ADG and ADFI decreased linearly ($P < .01$), but growth performance was similar between pigs fed the 0 and 5% MCP diets. Experiment 4 was a 14-d preference trial in which the four diets from Exp. 3 and 270 pigs (age, 24 d) were used to make three comparisons: a) diet 1 vs diet 2, b) diet 1 vs diet 3, and c) diet 1 vs diet 4. Pigs consumed between 65 and 77% of their total feed intake as MCP-containing diets ($P < .01$). In summary, MCP could replace DW at a dietary level of 5% without reducing pig performance, but MCP at dietary levels of 10% or more reduced pig performance. Pigs strongly preferred MCP over DW.

Key Words: Pigs, Whey, Chocolate, Performance, Palatability

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## Introduction

Weanling pigs perform better when fed milk-based nursery diets rather than simple corn-soy nursery diets (Tokach et al., 1995). Producers often use dried whey (**DW**) in diets for weanling pigs. However, the relatively high and variable cost of dried whey encourages pork producers and feed manufacturers to seek more economical feedstuffs that will support rapid growth of pigs.

Milk chocolate product (**MCP**) is a dried by-product of milk chocolate, candy, and food industries. This by-product consists of approximately one-third whole milk, one-third cocoa, and one-third sucrose. Because MCP contains a high proportion of milk and is less expensive than dried whey, it may be an economical replacement for dried whey. With this in mind, four experiments were conducted to study the effects of substituting MCP for DW on growth performance of starter pigs.

## Materials and Methods

*Experiments 1 and 2.* Experiment 1 used 216 Hampshire × (Yorkshire × Landrace) pigs averaging 7.4 kg (5.6 to 9.1 kg) and 25 d (21 to 27 d) of age at weaning. Pigs were divided into two groups weaned 1 wk apart and blocked by initial weight. Gender and litter were balanced within blocks. Four dietary treatments were randomly assigned within blocks. Each treatment was randomly assigned to six pens, with nine pigs per pen. Experiment 2 used 224 Duroc × (Yorkshire × Landrace) pigs that averaged 6.4 kg (4.8 to 7.6 kg) and 25 d (22 to 28 d) of age at weaning. Pigs were divided into two groups weaned 1 wk apart and allotted to one of four treatments using a randomized complete block design with four treatments in eight initial weight blocks. Gender and litter were balanced within blocks. There were a total of 32 pens, with seven pigs per pen and eight pens per treatment. Both experiments used the same four dietary treatments: 1) 0% DW + 0% MCP, 2) 20% DW + 0% MCP, 3) 10% DW + 10% MCP, and 4) 0% DW +

[1]Appreciation is expressed to International Ingredient Corp., St. Louis, MO for financial support and provision of the milk chocolate product, and to American Protein Corporation, Ames, IA for provision of the spray-dried porcine plasma (AP 920) and spray-dried porcine blood meal (AP 300).

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Table 1. Diet composition (as-fed basis) for Experiments 1 and 2[a]

| | Phase 1 | | | | Phase 2 | | | |
|---|---|---|---|---|---|---|---|---|
| Ingredient, % | A | B | C | D | E | F | G | H |
| Corn | 60.30 | 46.70 | 44.50 | 42.10 | 65.60 | 52.00 | 49.80 | 47.40 |
| Soybean meal (46% CP) | 36.15 | 30.90 | 32.85 | 34.80 | 30.75 | 25.50 | 27.45 | 29.40 |
| Dried whey | — | 20.00 | 10.00 | — | — | 20.00 | 10.00 | — |
| Milk chocolate product | — | — | 10.00 | 20.00 | — | — | 10.00 | 20.00 |
| Dicalcium phosphate | 1.70 | 1.25 | 1.45 | 1.70 | 1.85 | 1.40 | 1.60 | 1.80 |
| Limestone | .85 | .65 | .70 | .70 | .80 | .60 | .65 | .70 |
| Vitamin premix[b] | .40 | .40 | .40 | .40 | .40 | .40 | .40 | .40 |
| Trace mineral premix[c] | .10 | .10 | .10 | .10 | .10 | .10 | .10 | .10 |
| Salt | .50 | — | — | .20 | .50 | — | — | .20 |
| Calculated analysis, % | | | | | | | | |
| Crude protein | 22.1 | 21.2 | 21.6 | 21.9 | 20.1 | 19.2 | 19.5 | 19.8 |
| Lysine | 1.25 | 1.25 | 1.25 | 1.25 | 1.10 | 1.10 | 1.10 | 1.10 |
| Calcium | .80 | .80 | .80 | .80 | .80 | .80 | .80 | .80 |
| Total phosphorus | .70 | .70 | .70 | .70 | .70 | .70 | .70 | .70 |

[a]Diets for Exp. 2 contained 25 ppm of carbadox.
[b]Supplied per kilogram of final diet: 4,396 IU vitamin A; 439.6 IU vitamin $D_3$; 16.0 IU vitamin E; 4.4 mg vitamin K (menadione sodium bisulfite); 2.9 mg riboflavin; 26 mg niacin; 18 mg d-pantothenic acid; .6 g choline; and 18 $\mu$g vitamin $B_{12}$.
[c]Supplied per kilogram of final diet; 100 mg Zn; 100 mg Fe; 30 mg Mn; 5.5 mg Cu; .6 mg I; .3 mg Se.

20% MCP. Diet composition is presented in Table 1. Table values for nutrient levels of corn, soybean meal, and dried whey were used to calculate dietary nutrient concentrations (NRC, 1988). Nutrient levels of MCP were provided by International Ingredient Corporation. Milk chocolate product contains 95.0% dry matter, 12.0% crude protein, 1.0% lysine, 6.0% crude fat, 1.0% crude fiber, 3.5% ash, .3% calcium, and .3% phosphorus. These two experiments were divided into two phases. Phase-1 diets were fed during the initial 2 wk postweaning, and phase-2 diets during the last 2 wk in Exp. 1, and during the last 3 wk in Exp. 2. Phase-1 and phase-2 diets were calculated to contain 1.25% lysine, .8% calcium, and .7% phosphorus and 1.10% lysine, .8% calcium, and .7% phosphorus, respectively.

*Experiment 3.* A total of 192 Hampshire × (Yorkshire × Landrace) pigs with an initial BW of 6.1 kg (5.0 to 7.5 kg) and age of 20 d (17 to 22 d) were used to evaluate the effect of substituting MCP for dried whey at lower dietary inclusion rates and in more complex diets than in Exp. 1 and 2 on pig performance. Pigs were divided into two groups weaned 1 wk apart and allotted to dietary treatments using a randomized complete block design with four treatments in six blocks based on initial body weight, sex, and litter of pigs. There were 24 pens, with eight pigs per pen and six pens per treatment. Dietary treatments were randomly assigned within blocks. Dietary treatments included 1) 15% DW + 0% MCP, 2) 10% DW + 5% MCP, 3) 5% DW + 10% MCP, and 4) 0% DW + 15% MCP. The trial was divided into three phases: phase I was d 0 to 7 postweaning; phase II was d 8 to 28 postweaning; and phase III was d 29 to 35 postweaning. Lysine and methionine + cysteine levels were calculated to be 1.5% and .90% in phase-I diets, 1.25% and .75% in phase-II diets, and 1.25% and .75% in phase-III diets. All diets fed during the three phases were calculated to contain .85% calcium and .7% phosphorus. The analyzed amino acid levels of MCP were used in the diet formulations for all phases (Table 2). Nutrient levels for spray-dried porcine plasma and spray-dried blood meal were provided by American Protein Corporation. Nutrient levels for other ingredients were obtained from NRC (1988). A comparison of major nutrient levels of MCP and DW is presented in Table 3.

*Experiment 4.* A total of 270 Duroc × (Yorkshire × Landrace) pigs with an average initial BW of 6.8 kg (4.9 to 8.9 kg) and age of 24 d (21 to 27 d) were used to conduct a 2-wk preference trial. Pigs were divided into two groups weaned 6 d apart, were blocked by weight into five blocks within groups, equalized by litter and sex and allotted to one of the three comparisons (treatments) within blocks. There were 10 pigs per pen in group 1 and eight pigs per pen in group 2. The four experimental diets used in phase II of Exp. 3 were used to make three comparisons; 1) a diet with 15% DW + 0% MCP (control) vs a diet with 10% DW + 5% MCP; 2) control vs a diet with 5% DW + 10% MCP; 3) control vs a diet with 0% DW + 15% MCP. Before the start of the experiment, a 4-d adjustment period was used to avoid variation introduced by differential consumption patterns during the period of adjustment to dry feed. The diet fed during the adjustment period was a commercial starter diet and did not contain MCP. The free-choice method (Hegsted et al., 1956) was used to evaluate pig preference for different diets. Each pen had a six-hole feeder in which the trough and hopper was divided into two halves. Each divided feeder contained the control diet on one side and one of the MCP diets on the opposite side. Every 2 d, the remaining feed was removed completely from each side of the feeder

Table 2. Diet composition (as-fed basis) in Experiment 3

| | Phase I | | | | Phase II | | | | Phase IIII | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ingredient, % | I | J | K | L | M | N | O | P | Q | R | S | T |
| Corn | 43.94 | 44.58 | 45.20 | 45.84 | 50.42 | 51.05 | 51.69 | 52.31 | 45.68 | 46.31 | 46.93 | 47.55 |
| Soybean meal (46% CP) | 15.18 | 14.36 | 13.54 | 12.72 | 25.30 | 24.48 | 23.66 | 22.84 | 33.14 | 32.32 | 31.50 | 30.68 |
| Dried whey | 15.00 | 10.00 | 5.00 | — | 15.00 | 10.00 | 5.00 | — | 15.00 | 10.00 | 5.00 | — |
| Milk chocolate product | — | 5.00 | 10.00 | 15.00 | — | 5.00 | 10.00 | 15.00 | — | 5.00 | 10.00 | 15.00 |
| Dried skim milk | 12.00 | 12.00 | 12.00 | 12.00 | — | — | — | — | — | — | — | — |
| Spray-dried porcine plasma | 8.00 | 8.00 | 8.00 | 8.00 | — | — | — | — | — | — | — | — |
| Spray-dried blood meal | — | — | — | — | 3.00 | 3.00 | 3.00 | 3.00 | — | — | — | — |
| Animal fat | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Dicalcium phosphate | 1.28 | 1.42 | 1.57 | 1.72 | 1.50 | 1.65 | 1.79 | 1.94 | 1.34 | 1.49 | 1.64 | 1.79 |
| Limestone | .40 | .38 | .36 | .33 | .57 | .55 | .52 | .50 | .65 | .63 | .61 | .59 |
| Vitamin premix[a] | .42 | .42 | .42 | .42 | .42 | .42 | .42 | .42 | .42 | .42 | .42 | .42 |
| Trace mineral premix[b] | .10 | .10 | .10 | .10 | .10 | .10 | .10 | .10 | .10 | .10 | .10 | .10 |
| Salt | .20 | .25 | .30 | .35 | .20 | .25 | .30 | .35 | .20 | .25 | .30 | .35 |
| DL-Methionine | .08 | .09 | .11 | .12 | .09 | .10 | .12 | .14 | .07 | .08 | .10 | .12 |
| Carbadox premix (50%)[c] | .40 | .40 | .40 | .40 | .40 | .40 | .40 | .40 | .40 | .40 | .40 | .40 |
| Calculated analysis, % | | | | | | | | | | | | |
| Crude protein | 22.4 | 22.0 | 21.5 | 21.0 | 20.6 | 20.1 | 19.6 | 19.2 | 21.2 | 20.7 | 20.3 | 19.8 |
| Lysine | 1.50 | 1.50 | 1.50 | 1.50 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 |
| Met + Cys | .91 | .90 | .90 | .90 | .75 | .75 | .75 | .75 | .75 | .75 | .75 | .75 |
| Calcium | .85 | .85 | .85 | .85 | .85 | .85 | .85 | .85 | .85 | .85 | .85 | .85 |
| Total phosphorus | .70 | .70 | .70 | .70 | .70 | .70 | .70 | .70 | .70 | .70 | .70 | .70 |
| Analyzed content, % | | | | | | | | | | | | |
| Crude protein | 20.5 | 20.1 | 20.7 | 19.9 | 18.6 | 18.9 | 19.3 | 18.3 | 20.7 | 20.1 | 19.2 | 19.8 |
| Lysine | — | — | — | — | 1.15 | 1.19 | 1.19 | 1.21 | — | — | — | — |
| Met + Cys | — | — | — | — | .64 | .69 | .67 | .69 | — | — | — | — |
| Threonine | — | — | — | — | .74 | .72 | .70 | .68 | — | — | — | — |

[a]Supplied per kilogram of final diet: 6,600 IU vitamin A: 1,650 IU vitamin $D_3$; 27.5 IU vitamin E; 4.4 mg vitamin K (menadione sodium bisulfite); 6.6 mg riboflavin; 40 mg niacin: 17.6 mg d-pantothenic acid; 33 $\mu$g vitamin $B_{12}$; .88 mg pyridoxine; 1.1 mg folic acid; 198 $\mu$g biotin; .7 mg thiamine, and .6 g choline.
[b]Supplied per kilogram of final diet; 100 mg Zn; 100 mg Fe; 30 mg Mn; 6.6 mg Cu; .6 mg I; .1 mg Se.
[c]Provided .2% carbadox in the final diets.

separately, weighed, and returned to the opposite side of the feeder.

*Diet Formulation and Pelleting.* Lysine level was kept constant across diets in each phase of the four experiments by varying corn and soybean meal inclusion rate. DL-Methionine was added at the expense of corn to maintain the same methionine + cysteine level across diets in each phase of Exp. 3 and 4. In all diets used in the four experiments, ratios of all other amino acid concentrations to lysine concentration were calculated to be at least 10% higher than NRC (1988) ratios for 5- to 10-kg pigs. All diets were pelleted using a die that was 2.54 cm thick. The diameter of the pellet was .48 cm.

*General Management and Data Collection.* Pigs were housed in nursery pens that measured 1.0 × 1.5 m (Exp. 1 and 3: double-decked) or 1.2 × 1.5 m (Exp. 2 and 4). Room temperature was maintained at 31°C throughout the experiments. We allowed pigs ad libitum access to feed and water. Weight gain and feed intake were monitored weekly for the first three experiments. Feed consumption was recorded every 2 d and weight gain was measured on d 8 and 14 for the preference experiment (Exp. 4).

*Statistical Analyses.* Pen was used as the experimental unit for all analyses in Exp. 1, 2, and 3. Experimental data for Exp. 1, 2, and 3 were subjected to analysis of variance with repeated measures using the General Linear Models procedures of SAS (1989) appropriate for randomized complete block design. The

Table 3. A comparison of major nutrient levels (%) between milk chocolate product and dried whey[a]

| Item | Milk chocolate product | Dried whey |
|---|---|---|
| Crude protein | 11.45 | 12.21 |
| Lysine | 1.40 | .94 |
| Tryptophan | .11 | .18 |
| Threonine | .42 | .89 |
| Isoleucine | .46 | .78 |
| Met + Cys | .32 | .49 |
| Leucine | .84 | 1.18 |
| Histidine | .29 | .17 |
| Valine | .58 | .67 |
| Phe + Tyr | .87 | .60 |
| Arginine | .58 | .33 |
| Calcium | .23 | .83 |
| Total phosphorus | .29 | .77 |

[a]Amino acid profile for dried whey are book values from NRC (1988); other nutrient levels for milk chocolate product and dried whey are analyzed contents.

mathematical model used for analysis included the main effects of treatment, weaning group, block (nested within group), and the interactive effect of group × treatment. No effects of group and group × treatment were found. In Exp. 1 and 2, the negative control diet (0% MCP + 0% DW) was contrasted against the other three diets containing either MCP or DW. Linear and quadratic effects of MCP level were evaluated by using the three treatments containing either MCP or DW, excluding the negative control treatment. In Exp. 3, linear, quadratic, and cubic effects of MCP level were examined with single degree of freedom comparisons appropriate for equally spaced treatments (orthogonal polynomials). In Exp. 4 (preference experiment), feed intake differences between the two diets in each comparison (not the percentage of the total feed intake) were tested by a paired-comparisons *t*-test, with the two values from a pen being paired (SAS, 1989). Pig performance data with the pen as the experimental unit were analyzed by using nonorthogonal contrasts: 1) the first comparison (0% vs 5% MCP) vs the second comparison (0% vs 10% MCP), 2) the first comparison vs the third comparison (0% vs 15% MCP), and 3) the second comparison vs the third comparison.

## Results

*Experiments 1 and 2.* In Exp. 1, linear reductions in overall ADG ($P < .03$), ADFI ($P < .06$), and G/F ratio ($P < .04$) with increased replacement of DW with MCP were detected (Table 4), but no quadratic response ($P > .55$) was detected. For the overall period, pigs fed a diet containing 20% MCP grew slower, consumed less feed, and were less efficient than pigs fed a 20% DW diet. In Exp. 2, linear reductions in overall ADG ($P < .01$) and ADFI ($P < .001$) with increased MCP levels in the diets (Table 5), but no quadratic effects ($P > .10$) were observed. Over the entire experiment, pigs fed the 20% DW diet grew faster and ate more feed than those fed the two MCP diets and the diet containing 0% DW + 0% MCP. Efficiency of gain was not influenced by dietary treatments ($P > .05$). In both experiments, treatment × week interactions ($P < .05$) were observed for ADG, ADFI, and G/F, suggesting pig responses to diets were not the same during all weeks of the experimental period.

*Experiment 3.* Linear reductions ($P < .01$) in both phase II (wk 2 through 4) and overall ADG were detected when dietary MCP level was increased from 0 to 15% (Table 6). Average daily gain for phase I (wk 1), phase II (wk 2 through 4), phase III (wk 5), and the overall period were similar between pigs fed the control diet containing no MCP and the diet containing 5% MCP.

When dietary MCP level was increased from 0 to 15%, linear reductions ($P < .001$) in ADFI for both phase II and the overall period and in gain/feed ratio for phase II were observed. Overall ADFI was similar between pigs consuming the 0% MCP or the 5% MCP diet. No effect of dietary MCP levels on overall G/F ratio ($P > .10$) and no quadratic and cubic effects of dietary MCP levels on pig performance ($P > .10$) were found in this experiment.

Repeated measured analysis found a treatment × phase interaction ($P < .05$), suggesting the pigs' responses (ADG, ADFI, and G/F) to treatments were not the same during all phases.

*Experiment 4.* Within each comparison, pigs consumed more MCP diet than control diet ($P < .01$; Table 7). Pigs allowed to choose the control diet or 15% MCP diet (comparison 3; Table 8) had poorer ($P < .05$) ADG, ADFI, and G/F than pigs allowed to choose the control diet or the 10% MCP (comparison 2) or 5% MCP diet (comparison 1).

## Discussion

The results of the first two experiments indicate that MCP should not be included in starter pig diets at a level as high as 20%. As a result, lower inclusion rates of MCP were used in Exp. 3 and 4. Overall ADG and ADFI of pigs fed the diet containing 10% DW + 10% MCP were similar to those of pigs fed the diet containing 20% DW + 0% MCP in Exp. 1 but were lower in Exp. 2. In both experiments, feed conversion was similar between these two treatments. Therefore, these findings did not clearly show whether substituting MCP for DW at 10% of the diet will support acceptable pig performance. The observation that overall ADG, ADFI, and G/F ratio were similar between pigs fed the negative control diet (0% MCP + 0% DW) and positive control diet (0% MCP + 20% DW) in both Exp. 1 and Exp. 2 was unexpected, and the reason for this was unclear.

The performance of pigs fed a diet containing 5% MCP was similar to that of pigs fed the control diet containing no MCP, suggesting that when MCP is less expensive than DW, diet cost and cost of gain can be reduced by substitution of up to 5% MCP for DW. Substitution of 10% MCP reduced growth rate during most weeks of Exp. 3. However, there was some evidence of improved growth rate and feed efficiency during phase I. Inclusion of 15% MCP was clearly detrimental to growth rate of pigs.

These three experiments show that MCP levels of 15% or more result in growth performance reductions and 10% MCP may reduce growth rate. However, a previous experiment at the University of Illinois suggested that pigs fed up to 12% MCP diet had growth performance similar to that of pigs fed the control diet containing DW, but no MCP (R. A. Easter and N. L. Trottier, personal communication). The data suggest that growth performance of pigs fed 5%

Table 4. Effects of dietary MCP[a] on growth performance of nursery pigs in Experiment 1[b]

| Item | Treatment: 0%DW[c]+ 0%MCP | 20%DW+ 0%MCP | 10%DW+ 10%MCP | 0%DW+ 20%MCP | SEM | *P*-value (linear) |
|---|---|---|---|---|---|---|
| Average daily gain, g | | | | | | |
| Week 1 | 16 | 9 | 28 | 2 | 8 | .56 |
| Week 2 | 188 | 182 | 173 | 180 | 12 | .94 |
| Week 3 | 341 | 356 | 352 | 315 | 17 | .10 |
| Week 4 | 383 | 425 | 383 | 365 | 17 | .03 |
| Overall | 225 | 235 | 227 | 208 | 7 | .02 |
| Average daily feed intake, g | | | | | | |
| Week 1 | 80 | 88 | 98 | 82 | 6 | .50 |
| Week 2 | 271 | 281 | 288 | 276 | 8 | .63 |
| Week 3 | 496 | 495 | 500 | 475 | 15 | .35 |
| Week 4 | 686 | 710 | 658 | 633 | 20 | .02 |
| Overall | 373 | 383 | 376 | 357 | 9 | .06 |
| Gain/feed, g/kg | | | | | | |
| Week 1 | 200 | 102 | 286 | 24 | 96 | .63 |
| Week 2 | 694 | 648 | 601 | 652 | 42 | .95 |
| Week 3 | 687 | 719 | 704 | 663 | 25 | .22 |
| Week 4 | 560 | 598 | 582 | 577 | 15 | .30 |
| Overall | 603 | 613 | 604 | 583 | 9 | .04 |

[a]MCP = milk chocolate product.
[b]Two hundred sixteen pigs (initially 7.4 kg and 25 d of age) were used with nine pigs per pen and six pens per treatment.
[c]DW = dried whey.

MCP is similar to that of pigs fed the control diet containing no MCP, indicating that MCP can be a useful ingredient for starter diets and can replace DW at a dietary level of up to 5% without reducing pig performance.

The pigs showed a strong preference for all of the MCP diets over the control diet. When offered the choice of either the 5% or 10% MCP diets vs the control diet (side-by-side), 75% of the total feed intake was MCP-containing diets and 25% control diet, and

Table 5. Effects of dietary MCP[a] on growth performance of nursery pigs in Experiment 2[b]

| Item | Treatment: 0%DW[c]+ 0%MCP | 20%DW+ 0%MCP | 10%DW+ 10%MCP | 0%DW+ 20%MCP | SEM | *P*-value (linear) |
|---|---|---|---|---|---|---|
| Average daily gain, g | | | | | | |
| WEEK 1 | 121 | 132 | 100 | 96 | 9 | .01 |
| Week 2 | 238 | 240 | 208 | 217 | 16 | .32 |
| Week 3 | 414 | 470 | 429 | 400 | 14 | .002 |
| Week 4 | 518 | 565 | 552 | 524 | 28 | .31 |
| Week 5 | 572 | 642 | 532 | 570 | 37 | .19 |
| Overall | 373 | 410 | 364 | 361 | 10 | .003 |
| Average daily feed intake, g | | | | | | |
| Week 1 | 217 | 224 | 212 | 186 | 8 | .002 |
| Week 2 | 355 | 362 | 325 | 329 | 15 | .14 |
| Week 3 | 644 | 640 | 603 | 573 | 15 | .004 |
| Week 4 | 854 | 928 | 862 | 804 | 22 | .001 |
| Week 5 | 1,009 | 1,087 | 976 | 982 | 27 | .01 |
| Overall | 613 | 646 | 594 | 574 | 10 | .0001 |
| Gain/feed, g/kg | | | | | | |
| Week 1 | 558 | 589 | 472 | 516 | 35 | .22 |
| Week 2 | 670 | 663 | 639 | 660 | 34 | .91 |
| Week 3 | 643 | 734 | 711 | 696 | 14 | .08 |
| Week 4 | 607 | 609 | 640 | 652 | 24 | .20 |
| Week 5 | 567 | 589 | 545 | 579 | 36 | .84 |
| Overall | 609 | 635 | 612 | 630 | 12 | 1.0 |

[a]MCP = milk chocolate product.
[b]Two hundred twenty-four pigs (initially 6.4 kg and 25 d of age) were used with seven pigs per pen and eight pens per treatment.
[c]DW = dried whey

Table 6. Effects of dietary MCP[a] levels on growth performance in Experiment 3[b]

| Item | NCP level, % 15%DW[c] +0%MCP | 10%DW+ 5%MCP | 5%DW+ 10%MCP | 0%DW+ 15%MCP | SEM | P-value (linear) |
|---|---|---|---|---|---|---|
| Average daily gain, g | | | | | | |
| Phase I (wk 1) | 111 | 128 | 132 | 134 | 10 | .12 |
| Phase II[d] | 291 | 292 | 257 | 236 | 7 | .0001 |
| Phase III (wk 5) | 486 | 484 | 466 | 459 | 18 | .23 |
| Overall | 292 | 297 | 274 | 260 | 7 | .002 |
| Average daily feed intake, g | | | | | | |
| Phase I (wk 1) | 167 | 164 | 166 | 175 | 6 | .34 |
| Phase II | 450 | 449 | 424 | 399 | 9 | .0008 |
| Phase III (wk 5) | 829 | 807 | 743 | 715 | 19 | .0003 |
| Overall | 468 | 464 | 436 | 417 | 9 | .0005 |
| Gain/feed ratio, g/kg | | | | | | |
| Phase I (wk 1) | 657 | 780 | 795 | 766 | 38 | .04 |
| Phase II | 647 | 649 | 607 | 592 | 8 | .0001 |
| Phase III (wk 5) | 586 | 599 | 626 | 644 | 15 | .01 |
| Overall | 626 | 641 | 629 | 624 | 6 | .45 |

[a]MCP = milk chocolate product.
[b]One hundred ninety-two pigs (initially 6.1 kg and 20 d of age) were used with eight pigs per pen and six pens per treatment.
[c]DW = dried whey
[d]Phase II = wk 2 through 4.

the difference in consumption between MCP diets and control diet was significant ($P < .001$). There was no indication that the preference changed between the first and second stages of the experiment. The preference of the pigs for a diet containing 15% MCP over the control diet was nearly as strong (65% of the total feed intake) as their preference for diets containing a smaller amount of MCP (75% of the total feed intake).

Across dietary comparisons, the pigs did not select a constant proportion of MCP in their total diet. The percentage of MCP selected increased from 3.8 to 7.7 to 9.8 as the MCP diets offered along with the control diet increased from 5 to 10 to 15% MCP. Similarly, the total consumption of MCP per pig during the 14-d experiment increased from 204 to 413 to 486 g across the three comparisons.

Pigs offered the choice between the 15% MCP diet and the control diet (comparison 3) ate less total feed and grew more slowly than did the pigs offered other choices between diets with lower MCP levels and the control diet. This is consistent with reduced performance of pigs fed the 15% MCP diet in Exp. 3. Reduced performance occurred even though pigs could have selected the control diet instead of the high-MCP diet.

These findings suggest that there are detrimental effects of high dietary levels of MCP due to some factor(s) other than poor palatability. The identity of such a factor(s) is not known, but we offer the

Table 7. Preference of nursery pigs for control or MCP[a]-containing diets in Experiment 4[b]

| Days | ADFI, g | Diet: Control (whey) | 5% MCP | 10% MCP | 15% MCP | P-value |
|---|---|---|---|---|---|---|
| | | % of Total feed intake | | | | |
| 0–8 | 281 | 24.49 | 75.51 | — | — | .0003 |
| | 286 | 20.75 | — | 79.25 | — | .0001 |
| | 263 | 29.76 | — | — | 70.24 | .002 |
| 9–14 | 527 | 22.92 | 77.08 | — | — | .001 |
| | 504 | 23.95 | — | 76.05 | — | .0001 |
| | 477 | 38.44 | — | — | 61.56 | .06 |
| Overall | 386 | 23.57 | 76.43 | — | — | .0005 |
| | 381 | 22.58 | — | 77.42 | — | .0001 |
| | 354 | 34.75 | — | — | 65.25 | .01 |

[a]MCP = milk chocolate product.
[b]Two hundred seventy pigs (initially 6.8 kg and 24 d of age) were used with nine pigs per pen and 10 pens per treatment.

Table 8. Performance of nursery pigs given a choice of control or MCP[a]-containing diets in Experiment 4[b]

| | Comparison (control vs %MCP) | | | |
|---|---|---|---|---|
| Item | (0 vs 5) | (0 vs 10) | (0 vs 15) | SEM |
| Average daily gain, g | | | | |
| Day 0–8 | 209 | 221 | 180 | 8 |
| Day 9–14 | 314 | 302 | 290 | 10 |
| Overall | 254 | 256 | 227 | 7 |
| Average daily feed in-take, g | | | | |
| Day 0–8 | 280 | 287 | 265 | 7 |
| Day 9–14 | 528 | 503 | 475 | 13 |
| Overall | 387 | 380 | 355 | 9 |
| Gain/feed ratio, g/kg | | | | |
| Day 0–8 | 746 | 770 | 680 | 14 |
| Day 9–14 | 594 | 600 | 609 | 14 |
| Overall | 657 | 674 | 640 | 8 |

[a]MCP = milk chocolate product

[b]Two hundred seventy pigs (initially 6.8 kg and 24 d of age) were used with nine pigs per pen and 10 pens per treatment.

following suggestions. First, DW contains approximately 70% lactose and very little or no sucrose, whereas MCP contains approximately 20% lactose and 40% sucrose (Cromwell et al., 1996). Therefore, substituting MCP for DW results in decreased lactose and increased sucrose in the diets. Effects of this change in dietary sugars on growth performance of nursery pigs are unknown. Second, chocolate contains theobromine (Zoumas and Smullen, 1992), a compound similar to caffeine and theophylline (Rall, 1990). The pharmacological actions of these compounds include stimulating the central nervous system, stimulating cardiac muscle, relaxing smooth muscle, and acting on the kidney to produce diuresis (Rall, 1990). The concentration of theobromine in our experimental diets and its effects on pig performance are unknown. Third, the level of threonine may have limited performance in the diets containing higher levels of MCP. Diets in Exp. 3 were formulated to have threonine levels higher than that recommended by NRC (1988). However, the ratios of threonine/lysine calculated from the analyzed concentrations of threonine and lysine in the diets containing MCP were lower than that suggested by the ideal protein ratio of Baker and Chung (1992) for 5- to 20-kg pigs, and this ratio decreased with increased concentration of MCP in the diets. Therefore, the lower ratio of threonine/lysine in the diets containing higher levels of MCP may have adversely affected pig performance in the experiments. Fourth, there may have been differences in digestibility of amino acids between MCP and DW that influenced growth performance. We are unaware of any experiment that has evaluated amino acid digestibility of MCP.

## Implications

These experiments showed that pigs strongly preferred milk chocolate product (MCP) over dried whey (DW) and MCP could replace DW at a dietary level of 5% without reducing pig performance. However, MCP at dietary levels of 10% or more reduced pig performance. These findings suggest that the negative effects of high levels of MCP on growth performance are due to some factor other than palatability.

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