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Effect of Medium-chain Triglyceride (MCT) on Growth Performance, Nutrient Digestibility, Blood Characteristics in Weanling Pigs

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ABSTRACT: One hundred and twenty weanling pigs in experiment 1 (Exp. 1) (6.91±0.99 kg; 21 d of age) and Exp. 2 (10.20±1.09 kg; 28 d of age) were used in two 42-d and 35-d experiments to evaluate the effect of medium-chain-triglyceride (MCT) on growth performance, apparent total tract digestibility (ATTD) of nutrients and blood profile. In both of Exp. 1 and Exp. 2, the same dietary treatments were utilized as follows : i) negative control (NC), ii) positive control (PC), NC+antibiotics (40 mg/kg Tiamulin, 110 mg/kg Tylosin, and 10 mg/kg Enramycin, iii) MCT3, NC+0.32% (phase 1, 2 and 3) MCT, and iv) MCT5, NC+0.55% (phase 1), 0.32% (phase 2 and 3) MCT. In Exp. 1, the pigs fed MCT5 diets had higher ($p<0.05$) ADG compared to NC treatment during the first 2 wk. From d 15 to 28, the ATTD of energy was improved ($p<0.05$) by MCT3 compared to the PC treatment. No effect has been observed on the blood profiles [red blood cell (RBC), white blood cell (WBC), immunoglobulin-G (IgG), lymphocyte concentration] measured in this study. In Exp. 2, the ADG were increased ($p<0.05$) by the MCT5 treatment than the PC treatment from d 0 to 14. Pigs fed PC treatment diet had lower ADFI ($p<0.05$) and better FCR ($p<0.05$) than NC treatment, whereas no differences were shown between MCT treatments and NC or PC treatment from d 15 to 35 and overall phase. The ATTD of DM and nitrogen were improved ($p<0.05$) by the effect of MCT5 related to the NC and PC treatment at the end of 2nd and 5th wk. The pigs fed MCT3 had higher ($p<0.05$) energy digestibility than PC treatment. No effects were seen in the blood profiles we measured (WBC, RBC, lymphocyte and immunoglobulin-G). In conclusion, the addition of MCT in the weanling pigs diet can improve the ADG and digestibility during the earlier period (first 2 wks), but had little effect on the blood characteristics. (**Key Words:** Blood Profile, Digestibility, Growth Performance, Medium-chain-triglyceride (MCT), Pig)

INTRODUCTION

The stress of weaning and the immature development of the digestive tract make newly weaned pigs susceptible to digestive disorders and diarrhea. Due to concern about the feed safety and the development of antibiotic-resistant pathogens, the use of most antibiotic as growth promoters has been banned in the EU since January 2006 (Regulation 1983/2003/EC) and prohibited in July 2011 in Korea. A number of alternative have been proposed: enzymes, probiotics, fermentable carbohydrates (prebiotics), phytogenic agents, and dietary acidifiers (Roth and Kirchgessner, 1998; Partanen and Mroz, 1999).

Midium-chain triglycerides (MCTs) are high-chain (6 to 12 carbons) fatty acid esters of glycerol. The fatty acids found in MCTs are called medium-chain fatty acids (MCFAs), such as caproic acid (C6), caprylic acid (C8), capric acid (C10) and lauric acid (C12). They are digested, absorbed and metabolized differently from long-chain fatty acids (LCFAs), which include fatty acids of 12 to 22 carbons, because MCFAs are absorbed directly into portal circulation and transported to the liver for rapid oxidation (Babayan, 1987; Odle, 1998). MCFAs can rapidly supply energy for the newborn piglets (Lee and Chiang, 1994). Gatlin et al. (2002) found that the piglets form sows fed supplemental MCTs had greater ADG and weaning weights by the improving efficiency of energy utilization.

Also, MCFAs were reported to have antibacterial function as the similar way showing by the short-chain fatty acids (Isaacs et al., 1995; Skrivanova et al., 2006). To date there is a general lack of information about the optimum dose of MCT needed in a standard post-weaning diet to cause an antibacterial effect.

Therefore, we conducted 2 experiments to evaluate the effects of the inclusion of MCT in the diet of weanling pigs on growth performance, nutrient digestibility, and blood profile.

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MATERIALS AND METHOD

The protocol used for the current experiment was approved by the Animal Care and Use Committee of Dankook University.

The preparation of medium-chain triglyceride

The MCT (AveMix) was prepared and supplied in the form of powder by Aveve Group (Minderbroedersstraat 8, 3000 Leuven, Belgium). The composition of the final product contained 55% MCT oil (C6: 50%, C8: 50%) and Silica carrier 45%.

Experiment design, animals and facilities

In Exp. 1 and Exp. 2, a total of 120 barrows ((Landrace ×Yorkshire)×(Duroc)) with an average BW of 6.91±0.99 kg (21 d of age) and 10.20±1.09 kg (28 d of age) were used in a 42-d and 35-d experiment. Pigs were randomly allotted to 4 experiment diets according to their initial BW. Each pen held 5 pigs, and there were 6 pens per treatment.

All pigs were housed in an environmentally-controlled room, which provided 0.34 m^2 for each pig in Exp. 1 and 2, respectively. Each pen was equipped with a one-sided, stainless steel self-feeder and a nipple drinker that allowed pigs unlimited access to feed and water. Individual pig BW and feed disappearance were recorded weekly for both experiments to determine ADG, ADFI, and feed/gain (F/G).

Dietary treatments

Both of Exp. 1, and Exp.2 used the same experiment design, following the dietary treatments were: i) negative control (NC), ii) positive control (PC), NC+antibiotics (positive control diet with 40 mg/kg Tiamulin, 110 ppm Tylosin, and 10 mg/kg Enramycin. iii) MCT3, NC+0.32% (phase 1, 2 and 3) medium-chain-triglyceride, and iv) MCT5, NC+0.55% (phase 1), 0.32% (phase 2 and 3) medium-chain-triglyceride. The diets were fed during the experiment in 3 phases (Exp. 1) and 2 phases (Exp. 2): d 0 to 14, 15 to 28, and 29 to 42 (Exp. 1) and d 0 to 14, 15 to 35 (Exp. 2).

All diets were formulated to meet or exceed the nutrient requirements (NRC, 1998) for weanling pigs and fed in a crumble form. All diets were dried at 100°C for 12 h to determine DM and, then, ground through a 1-mm screen in a Wiley mill before analyzing for CP, P, and Ca (AOAC, 2000).

Sampling and measurements

Apparent total tract digestibility (ATTD) of DM, nitrogen (N) and gross energy was determined using chromic oxide (0.2%) as an inert indicator. Pigs were fed diets mixed with chromic oxide on d 7, 21, and 35 for Exp. 1 and d 7 and 28 for Exp. 2. Fresh fecal grab samples collected from 2 pigs per pen (Exp. 1, d 13, 27 and 41; Exp. 2, d 13, and 34) were mixed and pooled, and a representative sample was stored in a freezer at -20°C until

Table 1. Compositions of basal nursery pig diets for Exp. 1 and 2 (as-fed basis)[1]

Item	Phase 1	Phase 2	Phase 3
Corn		44.84	43.20
Barley	15.00		
Wheat			2.00
Rice bran			2.00
Extrude corn	47.23	25.00	15.00
Soybean meal 45%	7.50	17.00	31.81
Fermented soybean meal	2.50		
Fish meal	2.00	2.66	
Potato protein	2.00	2.00	
Plasma protein	3.00		
Milk product	10.00	3.00	
Milk replacer	5.00		
Animal fat			3.32
Soybean oil	2.50	2.37	
DL-met (99%)	0.11	0.05	0.06
L-lys (78%)	0.23	0.11	0.10
Dicalcium phosphate	1.18	1.07	0.62
Salt	0.25	0.40	0.40
Premix[1]	1.50	1.50	1.50
Analyzed composition			
CP (%)	19.83	19.99	19.38
EE (%)	7.56	5.93	6.00
CF (%)	2.55	2.56	3.04
Ash (%)	5.13	4.70	4.70
Ca (%)	0.68	0.65	0.66
P (%)	0.59	0.50	0.52
Lys (%)	1.54	1.30	1.17
Met (%)	0.49	0.46	0.32

[1] Phase 1: The vitamin and mineral premix supplied per 1 kg of the diet: 20,000 IU of vitamin A, 3,000 IU of vitamin D_3, 80 IU of vitamin E, 12 mg of vitamin K, 150 mg of vitamin C, 20 mg of riboflavin, 60 μg of vitamin B_{12}, 50 mg of d-pantothenic acid, 60 mg of biotin, 80 mg of niacin, 2 mg of vitamin B_6, 110 mg of Cu from $CuSO_4 \cdot 5H_2O$, 250 mg of Fe from $FeSO_4 \cdot 7H_2O$, 70 mg of Mn from MnO_2, 2,340 mg of Zn from ZnO, 0.2 mg of Se from $Na_2SeO_3 \cdot 5H_2O$, 0.3 mg of Co from $CoSO_4 \cdot 7H_2O$. Phase 2: The vitamin and mineral premix supplied per 1kg of the diet: 15,000 IU of vitamin A, 2,500 IU of vitamin D_3, 60 IU of vitamin E, 10 mg of vitamin K, 150 mg of vitamin C, 15 mg of riboflavin, 50 μg of vitamin B_{12}, 40 mg of d-pantothenic acid, 60 mg of biotin, 80 mg of niacin, 2 mg of vitamin B_6, 110 mg of Cu from $CuSO_4 \cdot 5H_2O$, 250 mg of Fe from $FeSO_4 \cdot 7H_2O$, 70 mg of Mn from MnO_2, 2,340 mg of Zn from ZnO, 0.2 mg of Se from $Na_2SeO_3 \cdot 5H_2O$, 0.3 mg of Co from $CoSO_4 \cdot 7H_2O$. Phase 3: The vitamin and mineral premix supplied per 1 kg of the diet: 10,000 IU of vitamin A, 2,000 IU of vitamin D_3, 40 IU of vitamin E, 8 mg of vitamin K, 100 mg of vitamin C, 10 mg of riboflavin, 50 μg of vitamin B_{12}, 30 mg of d-pantothenic acid, 50 mg of biotin, 60 mg of niacin, 2 mg of vitamin B_6, 110 mg of Cu from $CuSO_4 \cdot 5H_2O$, 120 mg of Fe from $FeSO_4 \cdot 7H_2O$, 50 mg of Mn from MnO_2, 2,340 mg of Zn from ZnO, 0.2 mg of Se from $Na_2SeO_3 \cdot 5H_2O$, 0.5 mg of Co from $CoSO_4 \cdot 7H_2O$.

Table 2. Effect of medium-chain-triglyceride on performance of weanling pigs (Exp. 1)[1]

Items	NC	PC	MCT3	MCT5	SE[2]
0 to 14 d (phase 1)					
ADG (g)	239[b]	279[ab]	272[ab]	293[a]	14
ADFI (g)	274	298	299	335	20
F/G	1.146	1.068	1.099	1.205	0.08
15 to 28 d (phase 2)					
ADG (g)	481	432	438	476	23
ADFI (g)	727	677	677	715	31
F/G	1.511	1.567	1.546	1.502	0.141
29 to 42 d (phase 3)					
ADG (g)	542	550	560	535	47
ADFI (g)	960	886	879	888	36
F/G	1.771	1.611	1.570	1.660	0.156
0 to 42 d (Overall phase)					
ADG (g)	426	420	422	436	18
ADFI (g)	644	621	616	643	22
F/G	1.512	1.479	1.460	1.475	0.072

[a,b] Within a row, mean with different superscripts differ ($p<0.05$).

[1] Each mean represents 6 pens with 5 pigs each per treatment. Dietary treatments were as follows: NC = Negative control diet; PC = Positive control diet with 40 mg/kg Tiamulin, 110 ppm Tylosin, and 10 mg/kg Enramycin. MCT3 = NC+0.32% medium-chain-triglyceride. MCT5 = NC+0.55% (phase 1), 0.32% (phase 2, 3) medium-chain-triglyceride.

[2] Standard errors.

analyzed. Before chemical analysis, the fecal samples were thawed and dried at 50°C for 72 h, after which they were finely ground to a size that could pass through a 1-mm screen. All feed and fecal samples were, then, analyzed for DM and N following the procedures outlined by the AOAC (1995). Chromium was analyzed via UV absorption spectrophotometry (Shimadzu, UV-1201, Shimadzu, Kyoto, Japan) following the method described by Williams et al. (1962).

For the serum profile, 2 pigs (1 gilt and 1 barrow) from each pen were randomly selected and blood samples were collected via anterior vena cava puncture on d 0, 14, 28, and 42 for Exp. 1 and d 0, 14 and 35 for the Exp. 2. At the time of collection, blood samples were collected into both nonheparinized tubes and vacuum tubes containing K_3EDTA (Becton, Dickinson and Co., Franklin Lakes, NJ, USA) to obtain serum and whole blood, respectively. After collection, serum samples were centrifuged (2,000×*g*) for 30 min at 4°C. Serum total protein was determined using an automatic biochemistry analyzer (HITACHI 747, Hitachi, Tokyo, Japan). Serum immunoglobulin-G (IgG) was analyzed using nephelometry (Dade Behring, Marburg, Germany). The white blood cells (WBC), red blood cells (RBC) and lymphocyte percentage in the whole white blood were determined using an automatic blood analyzer (ADVIA 120, Bayer, NY, USA).

Statistical analysis

All data were subjected to statistical analysis in a randomized complete block design using the GLM procedures (SAS, 2001), with the pen serving as the experimental unit. Duncan's multiple range test was used to compare the means of the treatments. Variability in the data is expressed as the standard error (SE) and probability level of $p<0.05$ was considered to be statistically significant.

RESULTS

Experiment 1

Growth performance: The growth performance data are presented in Table 2. The ADG were higher in MCT5 treatment than NC treatment during phase 1 ($p<0.05$). There were no differences in ADG, ADFI and FCR among treatments ($p>0.05$) during phase 2 and overall period.

The ATTD of DM, nitrogen, and gross energy: From 15 to 28 d, the ATTD of energy was higher ($p<0.05$) in NC and MCT3 treatments than PC treatment (Table 3). No difference has been observed on the nutrients digestibility during d 0 to 14 and d 29 to 42.

Blood characteristics: No differences were shown in WBC, RBC, IgG, and lymphocyte concentration among treatments throughout the experiment (Table 4).

Experiment 2

Growth performance: The pigs fed diet containing MCT5 had a higher ($p<0.05$) ADG than those fed PC diet during phase 1. For phase 2, the ADFI was higher ($p<0.05$) in NC treatment than PC treatment, where the ADG didn't differ among treatments, which led to a depression ($p<0.05$) in FCR when compare to PC treatment. MCT improved FCR ($p<0.05$) in the overall phase when compared to the no antibiotics treatment.

Table 3. Effect of medium-chain-triglyceride on apparent total tract nutrient digestibility (ATTD) of weanling pigs (Exp. 1)[1]

Items	NC	PC	MCT3	MCT5	SE[2]
0 to 14 d (phase 1)					
DM	78.13	78.48	79.65	79.56	0.61
Nitrogen	78.63	78.64	78.67	78.86	0.79
Gross energy	79.79	80.99	80.24	79.85	0.67
15 to 28 d (phase 2)					
DM	78.84	77.23	78.66	78.51	0.73
Nitrogen	78.44	76.95	78.30	78.08	0.80
Energy	80.36[a]	78.00[b]	80.38[a]	78.53[ab]	0.72
29 to 42 d (phase 3)					
DM	78.99	79.72	79.45	80.45	0.68
Nitrogen	78.20	79.15	78.67	79.49	0.56
Gross energy	78.86	79.00	78.75	80.60	0.92

[a,b] Within a row, mean with different superscripts differ ($p<0.05$).
[1] Each mean represents 6 pens with 5 pigs each per treatment. Dietary treatments were as follows: NC = Negative control diet; PC = Positive control diet with 40 mg/kg Tiamulin, 110 ppm Tylosin, and 10 mg/kg Enramycin. MCT3 = NC+0.32% medium-chain-triglyceride. MCT5 = NC+0.55% (phase 1), 0.32% (phase 2, 3) medium-chain-triglyceride.
[2] Standard errors.

The ATTD of DM, nitrogen, and gross energy: Throughout the experimental period, the ATTD of DM, and of nitrogen were enhanced ($p<0.05$) by MCT5 treatment when compared to PC, and NC treatments, whereas the energy digestibility was higher ($p<0.05$) in both MCT3 and MCT5 treatments than PC treatment.

Blood characteristics: For blood profiles, WBC, RBC, IgG, and lymphocyte concentration were not different among treatments throughout the experiment.

Table 4. Effect of medium-chain-triglyceride on blood characteristics of weanling pigs at d 42 (Exp. 1)[1]

Items	NC	PC	MCT3	MCT5	SE[2]
WBC (10^3/μl)					
0 d	12.26	12.26	12.26	12.26	-
14 d	14.38	13.87	14.78	14.83	1.09
28 d	14.40	14.25	15.96	16.20	0.78
42 d	18.62	19.27	17.49	17.86	0.65
RBC (10^6/μl)					
0 d	5.38	5.38	5.38	5.38	-
14 d	5.83	5.58	5.68	5.62	0.21
28 d	6.45	6.14	6.08	6.04	0.21
42 d	7.07	7.09	6.82	6.83	0.13
Lymphocyte[3] (%)					
0 d	55.5	55.5	55.5	55.5	-
14 d	55.6	56.8	60.7	57.1	2.99
28 d	60.0	59.5	63.8	63.2	3.59
42 d	57.9	59.3	60.7	57.6	1.6
IgG (mg/dl)					
0 d	207	207	207	207	-
14 d	277	302	268	274	18.2
28 d	354	414	384	368	48.4
42 d	498	553	491	510	47.5

[a,b] Within a row, mean with different superscripts differ ($p<0.05$).
[1] Each mean represents 6 pens with 5 pigs each per treatment. Dietary treatments were as follows: NC = Negative control diet; PC = Positive control diet with 40 mg/kg Tiamulin, 110 ppm Tylosin, and 10 mg/kg Enramycin. MCT3 = NC+0.32% medium-chain-triglyceride. MCT5 = NC+0.55% (phase 1), 0.32% (phase 2, 3) medium-chain-triglyceride.
[2] Standard errors.
[3] Values are presented as a percentage of total white blood cell count.

DISCUSSION

In this study, MCT was found to improve the ADG for the first 2 wk of post-weaning, which is similar (Exp. 1) or better (Exp. 2) with the weaning pigs fed antibiotics. Similarly, Rodas and Maxwell (1992) reported that MCFAs (20 to 60 g/kg) inclusion can linearly enhance ADG and G/F for weaning pigs during the first weeks after

Table 5. Effect of medium-chain-triglyceride on growth performance of weanling pigs (Exp. 2)[1]

Items	NC	PC	MCT3	MCT5	SE[2]
0 to 14 d (phase 1)					
ADG (g)	490[ab]	476[b]	517[ab]	521[a]	14
ADFI (g)	609	620	628	661	21
F/G	1.243	1.303	1.215	1.269	0.046
15 to 35 d (phase 2)					
ADG (g)	625	636	635	641	13
ADFI (g)	1,095[a]	1,000[b]	1,043[ab]	1,045[ab]	27
F/G	1.752[a]	1.572[b]	1.643[ab]	1.630[ab]	0.04
0 to 35 d (Overall phase)					
ADG (g)	571	572	590	593	8
ADFI (g)	901	848	877	891	19
F/G	1.578	1.483	1.486	1.503	0.031

[a,b] Within a row, mean with different superscripts differ ($p<0.05$).
[1] Each mean represents 6 pens with 5 pigs each per treatment. Dietary treatments were as follows: NC = Negative control diet; PC = Positive control diet with 40 mg/kg Tiamulin, 110 mg/kg Tylosin, and 10 mg/kg Enramycin. MCT3 = NC+0.32% medium-chain-triglyceride. MCT5 = NC+0.55% (phase 1), 0.32% (phase 2, 3) medium-chain-triglyceride.
[2] Standard errors.

Table 6. Effect of medium-chain-triglyceride on apparent total tract nutrient digestibility (ATTD) of weanling pigs (Exp. 2)[1]

Items	NC	PC	MCT3	MCT5	SE[2]
0 to 14 d					
DM	78.76[b]	78.79[b]	79.53[ab]	80.82[a]	0.502
Nitrogen	78.99[b]	78.90[b]	80.19[ab]	81.62[a]	0.613
Gross energy	80.41[ab]	79.58[b]	81.87[a]	81.77[a]	0.620
15 to 35 d					
DM	79.39[b]	79.00[b]	79.70[ab]	79.99[a]	0.501
Nitrogen	80.50[b]	79.48[b]	79.85[ab]	80.77[a]	0.613
Gross energy	80.13[ab]	79.86[b]	79.94[a]	80.48[a]	0.621

[a,b] Within a row, mean with different superscripts differ ($p<0.05$).
[1] Each mean represents 6 pens with 5 pigs each per treatment. Dietary treatments were as follows: NC = Negative control diet; PC = Positive control diet with 40 mg/kg Tiamulin, 110 ppm Tylosin, and 10 mg/kg Enramycin. MCT3 = NC+0.32% medium-chain-triglyceride. MCT5 = NC+0.55% (phase 1), 0.32% (phase 2, 3) medium-chain-triglyceride.
[2] Standard errors.

Table 7. Effect of medium-chain-triglyceride on blood characteristics of weanling pigs at d 35 (Exp. 2)[1]

Items	NC	PC	MCT3	MCT5	SE[2]
WBC (10^3/μl)					
0 d	17.82	17.82	17.82	17.82	-
14 d	17.35	19.18	19.79	19.57	1.13
35 d	20.97	21.72	20.69	20.84	0.99
RBC (10^6/μl)					
0 d	5.74	5.74	5.74	5.74	-
14 d	6.14	6.28	6.25	6.44	0.16
35 d	7.20	7.19	7.15	7.19	0.16
Lymphocyte[3] (%)					
0 d	46.5	46.5	46.5	46.5	-
14 d	65.3	64.1	64.9	64.6	1.75
35 d	54.1	56.7	52.1	55.7	2.40
IgG (mg/dl)					
0 d	234	234	234	234	-
14 d	221	260	240	237	24.7
35 d	360	366	405	370	32

[a,b] Within a row, mean with different superscripts differ ($p<0.05$).
[1] Each mean represents 6 pens with 5 pigs each per treatment. Dietary treatments were as follows: NC = Negative control diet; PC = Positive control diet with 40 mg/kg Tiamulin, 110 ppm Tylosin, and 10 mg/kg Enramycin. MCT3 = NC+0.32% medium-chain-triglyceride. MCT5 = NC+0.55% (phase 1), 0.32% (phase 2, 3) medium-chain-triglyceride.
[2] Standard errors.

supplementation, which had a greater effect than tallow or milk fat. One of the reason is the that piglet can utilize MCFAs effectively, which can be easily digested and absorbed to supply energy by oxidation (Odle et al., 1989; Odle et al., 1991). The explanation for MCFAs being absorbed faster than long-chain fatty acid are (LCFA): i) esterification of MCFAs is low and most MCFAs can be directly absorbed without hydrolysis by lipase; ii) MCFAs enter the liver directly and rapidly via the portal vein, whereas LCFAs first enter the blood and then into a variety of tissues via the lymph system; iii) glycerides composed of MCFAs can be hydrolyzed faster and more completely and have a higher digestibility and faster clearing from the circulation and iv) MCFAs can be dispersed relatively easily in water and the ratio of re-esterification into chyle particles is low, thus MCFAs and their glycerides are mostly dispersed in intestinal solution and cell membranes and can be absorbed without particle formation (Odle, 1998).

The other explanation may be that the MCFAs were reported to exert antimicrobial activity that can reduce the pathogenic flora of the gut, which would have beneficial effects on the utilization of nutrients. Bacteria need nutrients for their own use and compete with the host for nutrients in the stomach and small intestine. In pigs, caproic (hexanioc) acid also was reported to depress the growth of *Lactobacillus* and *Steptococcus spp.*, while capric (decanoic) and lauric (C12) acids only depressed *Lactobacillus* and *Streptococcus spp*. The results from these previous studies also confirm that the positive effects of MCFA on digestibility and growth performance are a result of successful inhibition of the proliferation of pathogenic bacteria. However, there are contrary findings. Chi and Lepine (1993) supplemented the diets of piglets weaned at 3 weeks old with 100 g maize oil, coconut oil, tallow or MCFAs/kg 3 wks and found that the MCFA group had the lowest ADG of all the treatments. Fakler et al. (1993) also suggested that supplementing the diets of weanling piglets with 80 g MCFAs or coconut oil/kg resulted in ADG to decrease significantly first week postweaning compared with piglets given soya bean oil or tallow. These inconsistent results may be attributed to the quality and supplementation levels of the fats used.

Moreover, MCT are used directly for the acyl-modification (activation) of ghrelin within the gut of rats (Nishi et al., 2005). Ghrelin is primarily produced by endocrine cells of the gastric mucosa for secretion into the circulation. Studies have identified multiple physiological functions for ghrelin, including growth hormone (GH) release, appetite stimulation, cellular proliferation, apoptosis inhibition, and regulation of lipid metabolism and tissue fat distribution in muscle (Nishi et al., 2005). Ghrelin is also reported to be involved in the inhibition of pro-inflammatory cytokine production and gastro-protection against stress-induced gastric damage in rats (Konturek et al., 2004). Furthermore, exogenous ghrelin administration for 5 days to 18 day-old weaned pigs increased their weight gain (Salfen et al., 2004).

The feed intake of weanling pigs was unaffected by the MCT addition in the current study. However, Dierick et al. (2002) reported that lower feed intake occurred when *Cuphea* seeds (80% is capric acid C10:0) were added at 50

g/kg. This may due to the different dosage and composition of MCFAs used in these investigations. It is said that the high levels of free MCFA with a known strong rancid (C4: 0-C6:0), goat-like (C8:0), goat-cheesy (C8:0) and averse taste most probably should have resulted in a lower feed intake (Cera et al., 1989). This may due to the different levels used in these investigations.

None of the metabolites measured in blood indicated a difference caused by MCT and improved the energy status of pigs, The gastrointestinal system and its associated lymphoid tissue is the largest immunologically competent organ in the body, and maturation and optimal development of the immune system after birth depends on the development and composition of the indigenous microflora and vice versa (Michael and Marteau, 2007). Although the action of organic acid on the immune responses has not been well documented, it has been clearly established that many types of organic acids can influence the population of gut intestinal microorganisms, which are necessary for development of the gut immune system (Blum et al., 2002). In addition, a reduction in subclinical infections because of antimicrobial effects may contribute to improved nutrient digestibility and a reduction in the demand for nutrients by the gut-associated immune tissue.

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