

Short Communication

Evaluation of fat sources (lecithin, mono-glyceride and mono-diglyceride) in weaned pigs: Apparent total tract and ileal nutrient digestibilities

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Abstract

This study was conducted to investigate the effects of lecithin, mono-glyceride and mono-diglyceride on apparent total tract and ileal nutrient digestibilities in nursery pigs. Twenty [(Landrace × Yorkshire) × Duroc] barrows were surgically fitted with simple T-cannulas. Dietary treatments included 1) CON (basal diet: soy oil), 2) LO (lecithin 0.5%), 3) MO (mono-glyceride 0.5%), 4) MG (mono-glyceride 1.0%) and 5) MDG (mono-diglyceride 1.0%). In apparent total tract nutrient digestibility, dry matter (DM) and gross energy (GE) digestibilities of MDG treatments were higher than LO and MG treatments ($p < 0.05$). In nitrogen (N) digestibility, LO treatment showed the lowest compared to others ($p < 0.05$). The digestibility of crude fat was higher in MDG treatment than CON and LO treatments ($p < 0.05$). In apparent ileal nutrient digestibility, DM digestibility was higher in MDG treatment than LO and MG treatments ($p < 0.05$). GE digestibility was higher in MDG treatment than LO, MO and MG treatments ($p < 0.05$). N digestibility of MDG treatment was greater than LO treatment ($p < 0.05$). Also, the digestibility of crude fat was higher in MDG treatment than CON and LO treatments ($p < 0.05$). In conclusion, mono-diglyceride can increase apparent total tract nutrient and apparent ileal nutrient digestibilities of DM, GE, N and crude fat.

Key Words: Lecithin, monoglyceride, ileal digestibility, weaning pigs

Introduction

Dietary fat utilization for nursery pigs, especially during the first week after weaning period, is limited due to insufficient digestion and fat absorption (Cera *et al.*, 1988). The capacity of the small intestine to absorb micellar lipid exceeds normal influx into the gut in piglets (Freeman *et al.*, 1968). Therefore, entry of fatty acids into the micellar phase probably limits fatty acid digestibility (Bayley & Lewis, 1963). During postweaning time, it is important to provide a highly digestible fat source. Lecithin (phosphatidyl choline) is a phospholipid that is extracted commercially from soybeans and promotes the incorporation of fatty acid into micelles. The lecithin increased the apparent digestibility of dietary fat in diets fed to calves and humans (Aldersberg & Sobotka, 1943; Hopkins *et al.*, 1959). However, the dietary lecithin had no influence on apparent ileal or overall digestibility in small intestine and whole digestive tract of pigs (Overland *et al.*, 1993).

Monoglyceride type is absorbed and utilized in small intestine directly (Mattson & Beck, 1956). The diet containing monoglyceride increased fat digestibility, however, there were no significant differences in digestibilities of DM (dry matter), N (nitrogen) and DE (digestible energy) (Min *et al.*, 2006). Also,

the monoglyceride improved absorption of palmitic acid in chickens (Garrett & Young, 1975). The addition of lecithin or monoglyceride may enhance the utilization of fat as well as a highly digestible energy source.

Therefore, the objective of this study was to determine the effects of lecithin and monoglyceride on the apparent ileal and total tract DM, N, GE (gross energy) and crude fat digestibilities in weaning pigs.

Materials and Methods

The Animal Care and Use Committee of Dankook University approved all of the experimental protocols used in the current study.

Experimental animal and T-cannulas surgery

Twenty [(Landrace × Yorkshire) × Duroc] barrows (9.33 ± 0.33 kg average initial BW) were surgically fitted with a simple T-cannulas approximately 15 cm prior to the ileo-cecal junction. The pigs were fasted for 20 h prior to surgery. Anesthesia was induced using Stresnil™ (Janssen Pharmaceutica, Belgium) and

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Virbac Zoletil 50 Injection (Virbac Laboratory, France). After surgery, the barrows were individually housed in stainless steel metabolism crates in a temperature controlled (28°C) room. The pigs were allowed 14 d of recovery before initiation of the experiments.

Experimental design and diets

Pigs were blocked by initial body weight and randomly allocated to one of five dietary treatments in a randomized complete block design. There were five replications per treatment. Pigs were adapted 4 days to the experimental diets and 2 d (12 h/d) of ileal digesta collection. The daily feed intake allowance was $0.05 \times BW^{0.9}$, as proposed by Armstrong & Mitchell (1955). The daily feed allotment was offered as two meals at 12 h intervals (8:00 a.m. and 8:00 p.m.). Dietary

Table 1. Formula and chemical compositions of diet (as-fed basis)

Ingredient (g/kg)	CON	LO ¹⁾	MO ¹⁾	MG ¹⁾	MDG ¹⁾
Expanded corn	40.39	40.39	40.39	40.39	40.39
Dried whey	21.00	21.00	21.00	21.00	21.00
Soybean meal (45%)	19.73	19.73	19.73	19.73	19.73
Fish meal	5.00	5.00	5.00	5.00	5.00
Soybean oil	5.00	4.50	4.50	4.00	4.00
Lecithin	-	0.50	-	-	-
Monoglyceride	-	-	0.50	1.00	-
Mono-diglyceride	-	-	-	-	1.00
Spray-dried animal plasma	3.00	3.00	3.00	3.00	3.00
Sugar	3.00	3.00	3.00	3.00	3.00
Calcium carbonate	0.66	0.66	0.66	0.66	0.66
Acidifier	0.50	0.50	0.50	0.50	0.50
Phosphate defluorinated	0.44	0.44	0.44	0.44	0.44
L-Lysine · HCL	0.31	0.31	0.31	0.31	0.31
Zinc oxide	0.30	0.30	0.30	0.30	0.30
Colistin	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.12	0.12	0.12	0.12	0.12
Trace mineral premix ²⁾	0.10	0.10	0.10	0.10	0.10
Vitamin premix ³⁾	0.10	0.10	0.10	0.10	0.10
Neomycine (11%)	0.10	0.10	0.10	0.10	0.10
CuSO ₄	0.04	0.04	0.04	0.04	0.04
Antioxidant (Ethoxyquin 25%)	0.01	0.01	0.01	0.01	0.01
Chemical composition ⁴⁾					
ME, (Kcal/kg)	3,280				
Crude protein, (%)	21.50				
Lysine, (%)	1.42				
Methionine, (%)	0.54				
Calcium (%)	0.75				
Phosphorus, (%)	0.72				

¹⁾ Abbreviated LO, lecithin 0.5%; MO, monoglyceride 0.5%; MG, monoglyceride 1.0%; MDG, mono-diglyceride 1.0%

²⁾ Provided per kg diet : 20,000IU of vitamin A; 4,000IU of vitamin D₃; 80IU of vitamin E; 16 mg of vitamin K₃; 4mg of thiamine; 20mg of riboflavin; 6mg of pyridoxine; 0.08mg of vitamin B₁₂; 120mg of niacin; 50mg of Ca-pantothenate; 2mg of folic acid and 0.08mg of biotin

³⁾ Provided per kg diet : 140mg of Cu; 179mg of Zn; 12.5mg of Mn; 0.5mg of I; 0.25mg of Co and 0.4mg of Se

⁴⁾ Calculated values were derived from NRC (1998).

Table 2. Fatty acid compositions of soybean oil, lecithin, monoglyceride and mono-diglyceride

Fatty acid, %	Soybean oil	Lecithin	Monoglyceride ¹⁾	Mono-diglyceride ²⁾
C16	7.9	15.5	45.0	45.0
C18	4.6	4.0	55.0	55.0
C18:1	19.1	14.5	-	-
C18:2	59.9	60.3	-	-
C18:3	8.5	5.7	-	-

¹⁾ Included monoglyceride 95% (min) and di-triglyceride 5% (max)

²⁾ Included monoglyceride 45–55%, diglyceride 25–30% and triglyceride 20–25%

treatments included 1) CON (basal diet: soy oil), 2) LO (lecithin 0.5%), 3) MO (mono-glyceride 0.5%), 4) MG (mono-glyceride 1.0%) and 5) MDG (mono-diglyceride 1.0%). Diet composition is shown in Table 1. The diets were formulated to meet or exceed the nutrient requirements recommended by NRC (1998). Fatty acid composition of lecithin, monoglyceride and mono-diglyceride is presented in Table 2. Experimental diets were formulated to contain 3,400 kcal/kg of ME, 21.50 (%) of CP and 1.42 (%) of lysine. Chromic oxide was added (0.2 % in the diet) as an indigestible marker to allow digestibility determinations. Pigs were allowed to consume water *ad libitum* from nipple waterer.

Sampling and measurements

Ileal digesta and feces were collected during the 12 h period between the morning and evening feeding for the last 4 d (2 d: ileal and 2 d: fecal) of collection period. Ileal digesta were collected into plastic bags attached to the cannulas. Every 20 min the digesta were emptied into plastic containers and placed over ice. The collected digesta were pooled and frozen until being lyophilized and ground. Feed, fecal and ileal digesta were analyzed for DM, N and fat concentration (AOAC, 1995). Chromium was determined by UV absorption spectrophotometry (Shimadzu, UV-1201, Japan) and apparent ileal digestibilities of DM and N were calculated using the indirect method. Gross energy was analyzed by oxygen bomb calorimeter (Parr, 6100, USA).

Fat sources

Mono-glyceride (monoester concentration: over 95%; melting Pt(°C): 64-68; physical property: white thin chips) and mono-diglyceride (monoester concentration: approximately 50%; melting Pt(°C): 58-62; physical property: white thin chips) were used to evaluate the nutrient digestibility in weanling pigs. They were made by ILSHINWELLS Ltd.

Statistical analysis

In this experiment, all data were analyzed in accordance with a randomized complete block design using the GLM procedures of SAS (1996), with each pen comprising one experimental unit.

Also, data was compared according to the means of treatments via Duncan's multiple range test (Duncan, 1955).

Results and Discussion

Apparent total tract nutrient digestibility

In apparent total tract nutrient digestibility (Table 3), DM and GE digestibilities of MDG treatment were higher than those of LO and MG treatments ($p < 0.05$). N digestibility was the lowest in LO treatment compared to others ($p < 0.05$). The digestibility of crude fat was higher in MDG treatment than in CON and LO treatments ($p < 0.05$). Vegetable oil has higher digestibility than animal fat during the initial weeks of post-weaning period (Cera *et al.*, 1989). Lecithin is a phospholipid that is extracted commercially from soybeans. There was no interaction between lecithin and soy oil on apparent digestibility of fat in piglets, and lecithin had no significant effect on apparent digestibility of DM, GE and N (Overland *et al.*, 1993). However, there was a greater percentage of N retained as a percentage of intake. In this experiment, lecithin treatment did not show significant difference in apparent nutrient digestibility of DM and GE compared to soybean oil treatment, while N digestibility was decreased, which matches with the study by Jones *et al.* (1992). The results from researches mentioned above indicated that N digestibility was reduced for pigs fed tallow plus lysolecithin. When the unsaturated fatty acid was added with monoglyceride, the absorption of long chain saturated fatty acid was improved

Table 3. Effects of fat sources on apparent total tract nutrient digestibility in weaning pigs (n=20)

Items, %	CON	LO ¹⁾	MO ¹⁾	MG ¹⁾	MDG ¹⁾
Dry matter	85.58 ± 1.37 ^{ab}	85.12 ± 1.38 ^b	85.89 ± 2.39 ^{ab}	84.831.37 ± ^b	86.63 ± 1.11 ^a
Gross energy	87.11 ± 1.59 ^{ab}	85.93 ± 1.64 ^b	86.37 ± 1.27 ^{ab}	85.96 ± 0.98 ^b	87.57 ± 1.25 ^a
Nitrogen	86.56 ± 3.42 ^a	84.85 ± 3.25 ^b	86.25 ± 3.54 ^{ab}	86.73 ± 3.38 ^a	87.45 ± 2.43 ^a
Fat	80.21 ± 2.13 ^c	81.88 ± 3.59 ^{bc}	84.92 ± 3.12 ^{ab}	86.19 ± 3.26 ^{ab}	87.11 ± 3.06 ^a

¹⁾ Abbreviated LO, lecithin 0.5%; MO, monoglyceride 0.5%; MG, monoglyceride 1.0%; MDG, mono-diglyceride 1.0%

^{a,b,c} Means in the same row with different superscripts differ, $p < 0.05$

Table 4. Effects of fat sources on apparent ileal nutrient digestibility in weaning pigs (n=20)

Items, %	CON	LO ¹⁾	MO ¹⁾	MG ¹⁾	MDG ¹⁾
Dry matter	75.62 ± 3.72 ^{ab}	74.03 ± 3.59 ^b	74.83 ± 2.73 ^{ab}	73.89 ± 2.21 ^b	77.43 ± 1.63 ^a
Gross energy	76.09 ± 2.06 ^{ab}	74.04 ± 2.53 ^b	73.64 ± 2.37 ^b	73.36 ± 2.90 ^b	77.50 ± 1.54 ^a
Nitrogen	67.44 ± 3.34 ^{ab}	65.47 ± 3.02 ^b	68.25 ± 2.90 ^{ab}	68.92 ± 4.98 ^{ab}	70.78 ± 3.59 ^a
Fat	71.50 ± 2.22 ^b	72.15 ± 1.68 ^b	74.62 ± 2.20 ^{ab}	74.90 ± 2.65 ^{ab}	76.25 ± 2.03 ^a

¹⁾ Abbreviated LO, lecithin 0.5%; MO, monoglyceride 0.5%; MG, monoglyceride 1.0%; MDG, mono-diglyceride 1.0%

^{a,b,c} Means in the same row with different superscripts differ, $p < 0.05$

(Young & Garrett, 1963). Similarly in MO and MG treatments, the apparent total tract digestibility of fat was significantly higher than control treatment.

Apparent ileal nutrient digestibility

In apparent ileal nutrient digestibility (Table 4), DM digestibility was higher in MDG treatment than in LO and MG treatments ($p < 0.05$). GE digestibility was higher in MDG treatment than in LO, MO and MG treatments ($p < 0.05$). N digestibility of MDG treatments was greater than that of LO treatment ($p < 0.05$). Also, the digestibility of crude fat was higher in MDG treatment than in CON and LO treatments ($p < 0.05$). Lecithin is a type of exogenous emulsifying agent for lipids. The major function is emulsification, which means to transform fat into fat micelle. In this experiment, LO treatment did not show significant difference in apparent ileal nutrient digestibility of DM, GE and N compared to soy oil treatment. Those results were consistent with studies of Jones *et al.* (1992). They used soybean oil, tallow, lard, and coconut oil, and with lysolecithin as 10 % of the added fat. Also, the overall digestibilities of DM, GE and N were not affected by lecithin supplementation and lecithin could not increase digestibility of soybean oil (Overland *et al.*, 1993). This study showed that the apparent ileal nutrient digestibility of fat was not affected by monoglyceride treatments. The diet containing monoglyceride (12.5 and 25 %) showed increased fat digestibility compared to diet containing dried palm oil powder and had no significant difference compared to diet containing soy oil (Min *et al.*, 2006). Also, the apparent N, DM, and GE digestibilities were not affected by treatments (soybean oil, tallow, lecithin and monoglyceride) (Jones *et al.*, 1992). This experiment showed similar results, and there was no effect among SO, LO, MO and MG treatments in apparent ileal nutrient digestibilities of DM, GE, N and fat. Soy oil contains more unsaturated, long-chain fatty acids (Li *et al.*, 1990), which makes it easier to enter into fat micelle and be digested and absorbed. The apparent fat digestibility was greater in diets containing medium-chain triglyceride (MCT) or coconut oil compared to soybean oil or roasted soybean diets during the first 2 weeks of post-weaning (Cera *et al.*, 1990).

In conclusion, mono-diglyceride could improve apparent total tract and ileal nutrient digestibility of DM, GE, N and fat.

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