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Short communication

An evaluation of metabolizable energy content of main feed ingredients for growing pigs when adding dietary lysophospholipids

M.J. Kim[a,1], A.R. Hosseindoust[a,1], Y.H. Choi[a], A. Kumar[a], S.M. Jeon[a], S.H. Lee[b], B.Y. Jung[c], D.Y. Kill[d], B.J. Chae[a,*]

[a] Department of Animal Resources Science, College of Animal Life Sciences, Kangwon National University, Chuncheon 24341, South Korea
[b] Department of Swine and Poultry Science, Korea National College of Agriculture and Fisheries, Jeonju 54874, South Korea
[c] Easy Bio Inc., 310 Gangnam-daero, Gangnam-gu, Seoul 135-754, South Korea
[d] Department of Animal Science and Technology, Chung-Ang University, Anseong-si, Gyeonggi-do 17546, Republic of Korea

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ABSTRACT

The present study was conducted to test whether the dietary supplementation of lysophospholipids (LPL) affects digestible energy (DE) content of feed ingredients, nutrient digestibility, and growth performance of growing pigs. In Exp. 1, 8 growing pigs were alternatively used for 8 dietary treatments including 4 feed ingredients (corn, soybean meal, distiller's dried grains with solubles, and animal fat), and 2 LPL concentrations (0% and 0.1%) in 6 periods to determine DE and metabolizable energy (ME) content. In Exp. 2, 200 growing pigs were randomly allotted to 4 treatments on the basis of body weight with 2 concentrations of fat (high and low) and 2 concentrations of LPL (0% and 0.1%). The experimental diets were fed for 42 d in 2 phases. In Exp. 1, gross energy (GE) digestibility, feed DE, and ME were increased in animal fat when LPL were added to the diet. In Exp. 2, the pigs fed LPL showed greater ($P < .05$) digestibility of EE, GE, crude protein (CP), and DM In phase 2. Pigs fed a high-fat diet had greater ($P < .05$) digestibility of EE, and GE. Gross energy retention was greater ($P < .05$) in pigs fed the high-fat diet compared with those fed the low-fat diet in phase 2. During phase 1, the average daily gain (ADG) of pigs fed the high-fat diet was greater ($P < .05$) than that for pigs fed the low-energy diet. During the second phase, ADG was increased in LPL and high-fat diets ($P < .05$). The overall results showed that pigs fed the LPL or high-fat treatments had greater ADG and feed to gain ratio (F/G). Considering the 2 experiments, it can be concluded that LPL increase the ME of animal fat and improves ADG and F/G in pigs.

1. Introduction

The mode of action of emulsifiers refers to the incorporation of fatty acids into micelles, which is able to improve fat digestibility in pigs (Udomprasert and Rukkwamsuk, 2006). Among emulsifiers, lysophospholipids (LPL) are known to be one of the most important micelle enhancers. Emulsification for the micellar formation of fat is essential in fat digestion within the gastrointestinal tract because fatty acids are insoluble in water. Lysophospholipids alter membrane fluidity as a membrane transducer to accelerate the diffusion through the cell lipids (Lundbæk et al., 1994). The first aim of this study is to investigate the effect of LPL on common feed materials and predict the true digestible energy (DE) to re-balance the diet based on changes in feed ingredients.

The DE and metabolizable energy content (ME) in corn, soybean meal (SBM), distiller's dried grains with solubles (DDGS), and animal fat have been previously estimated and presented in standard references (NRC, 2012). To our knowledge, DE and ME have not been reported for corn, SBM, DDGS, and animal fat when an emulsifier was used in the diet. The additional amount of animal fat is less than 5% in pigs' diet; this is a relatively small inclusion, but changing the digestibility may be able to increase the total DE considerably. Jones et al. (1992) used LPL in pig diet to improve the digestibility of the fat of lipids, but reported a minimal effect on pig performance. There are many other studies on the positive influence of emulsifiers on the digestibility of energy in pigs (Jin et al., 1998; Zhao et al., 2015) and chickens (Gheisar et al., 2015), however, the excess dietary DE may produce nutritional imbalance. In addition, most performance studies did not consider the exact altered DE, which may give further insight into the effects of LPL on DE. Therefore, it can be concluded that there is room for upgrading the DE of feed ingredients following supplementation with LPL. Experiments were conducted with the aim of

* Corresponding author.
E-mail address: bjchae@kangwon.ac.kr (B.J. Chae).
[1] These authors contributed equally to this work.

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Table 1
Ingredient and composition of experimental diets, as-fed basis (Exp. 1).[a]

Item	Corn		SBM		DDGS		Animal fat	
LPL:	-	+	-	+	-	+	-	+
Ingredients (%)								
Corn	96.48	96.48	67.05	67.05	47.05	47.05	87.05	87.05
SBM	-	-	30.00	30.00	-	-	-	-
DDGS	-	-	-	-	50.00	50.00	-	-
Animal fat	-	-	-	-	-	-	10.00	10.00
Celite	0.10	-	0.10	-	0.10	-	0.10	-
LPL	-	0.10	-	0.10	-	0.10	-	0.10
Limestone	1.38	1.38	1.00	1.00	1.00	1.00	1.00	1.00
MDCP	1.19	1.19	1.00	1.00	1.00	1.00	1.00	1.00
Choline chloride (50%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Mineral premix[b]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin premix[c]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Calculated composition								
ME (kcal/kg)	3,090	3,090	3,141	3,141	3,208	3,208	3,589	3,589
Crude protein (%)	6.52	6.52	18.33	18.33	16.78	16.78	5.88	5.88
Ca (%)	0.70	0.70	0.62	0.62	0.57	0.57	0.53	0.53
Available P (%)	0.32	0.32	0.32	0.32	0.45	0.45	0.27	0.27
P (%)	2.87	2.87	2.44	2.44	6.16	6.16	12.47	12.47

[a] LPL: Lysophospholipids; SBM: soybean meal; DDGS: distiller's dried grains with solubles; MDCP: mono-dicalcium phosphate; ME: metabolizable energy.
[b] Supplied per kilogram diet: 62.1 mg Fe; 4.1 mg Cu; 59 mg Zn; 2.1 mg Mn; 0.19 mg Se; and 0.14 mg I.
[c] Supplied per kilogram diet: 1,400 IU vitamin A; 160 IU vitamin D_3; 12 IU vitamin E; 0.51 mg vitamin K_3; 1.1 mg thiamine; 2.7 riboflavin; 9 mg pantothenic acid; 35 mg niacin; 1.1 mg pyridoxine; 0.07 mg biotin; 0.4 mg folic acid; 10 μg vitamin B12; and 350 mg choline.

evaluating the energy value of main feed ingredients for pigs through the use of supplemental LPL.

2. Material and methods

The experiments were conducted at the Kangwon National University farm facility and approved by the Institutional Animal Care and Use Committee of Kangwon National University, Chuncheon, Republic of Korea. The lysophospholipid (Lipidol) was obtained from soybean lecithin with the exclusive proprietary technology (EASY BIO System Inc., Seoul, South Korea).

2.1. Experimental design and procedure

In Exp. 1, Eight barrows with an initial body weight (BW) of 22.3 ± 2.4 kg were used alternatively in 6 periods to determine DE and ME content of 4 feed sources (Corn, SBM, DDGS, and animal fat) and 2 LPL concentrations (totally 8 treatments) in 6 periods and each experimental period lasted 13 d (7 days adaptation period to experimental diets followed by a 6-d total collection of feces and urine).

The pigs were individually housed in metabolism cages that measured 1.2 × 1 m and equipped with a feeder, fully slatted floors, and urinary trays, which allowed separate collection of urine and fecal materials from each pig. The temperature of the rooms housing the pigs was maintained at 21 °C, and the lights were kept on 24 h a day. The experimental diets were specially formulated as shown in Table 1. The corn diet contained 96.48% corn as the sole source of energy. The other additional diets were formulated by mixing corn with SBM (30%), DDGS (50%) and animal fat (10%). Vitamins and minerals were added to all diets according to requirement estimates (NRC, 2012). Feed was provided at daily amounts of 2.5 times the estimated maintenance requirement for energy (2.5 × 197 kcal of ME/kg of $BW^{0.60}$; NRC, 2012). The daily feed allowance was divided into 2 equal meals and provided to pigs at 0900 and 1700 h.

In Exp. 2, A total of 200 growing pigs (Yorkshire × Landrace × Duroc) with an initial BW of 32.2 ± 1.2 kg were randomly allotted to 4 treatments in a 2 × 2 factorial arrangement with 2 concentrations of fat and 2 concentrations of LPL (0% and 0.1%). There were 5 pens in each treatment, with 10 pigs per pen. Each 1.5- by 5-m pen had a 2-hole dry self-feeder and a nipple water to allow ad libitum access to feed and water. The experimental diets were fed for 42 d in 2 phases: phase 1 (d 0–21) and phase 2 (d 22–42). For a feeding trial, pigs were housed in partially slatted, concrete floor pens.

The ME values of ingredients (Corn, SBM, DDGS, and animal fat) in this feeding trial were calculated with or without dietary LPL (Exp. 1). As calculated in equation I, the predicted ME for low fat diet (3298 kcal/kg of ME; Exp. 2) supplemented with LPL was predicted to be 52 kcal higher than energy values evaluated for non-LPL-supplemented diets based on NRC (2012). The diets were formulated to meet or exceed the requirement of NRC (2012), and experimental diet formula and chemical compositions are presented in Table 2.

$$DL = [C \times (ME_{2C} - ME_{1C})] + [S \times (ME_{2S} - ME_{1S})] + [D \times (ME_{2D} - ME_{1D})] + [A \times (ME_{2A} - ME_{1A})], \quad (1)$$

where DL = The predicted energy difference between LPL and without LPL in diet, C = Corn ratio in the diet, S = Soybean ratio in the diet, D = DDGS ratio in the diet A = Animal fat ratio in the diet, ME_1 = Predicted ME in Exp. 1 without LPL, ME_2 = Predicted ME in Exp. 1 with LPL.

2.2. Sampling and measurements

In Exp. 1, the initial 7 d of the experiment were considered an adaptation period to the diet. On d 8, a marker (0.5% chromic oxide) was mixed into the morning meal. Fecal samples were collected as the marker appeared in the feces. On d 13, a second marker (0.5% ferric oxide) was included in the morning meal. Fecal collection was quantitatively continued until the second marker appeared in the feces (Adeola, 2001). Urine collection started at 0900 h on d 8 and ceased at 0900 h on d 13. Urine was collected in a urine bucket over 50 mL of 6 *N* HCl. The total quantities of feces and 20% of the collected urine were stored at −20 °C immediately after collection. The DE and ME of each experimental ingredient were calculated using the difference method with the chromium oxide (Cr; 0.25%) concentration of feed, digesta, and feces (Adeola, 2001). Fecal samples were dried in an air-forced