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ANIMAL

Effect of sodium stearoyl-2-lactylate (PROSOL®) supplementation on growth performance and nutrient digestibility in growing pigs

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Abstract

The aim of this study is to evaluate the effects of supplementation of low-energy diets with PROSOL® (sodium stearoyl-2-lactylate) as an emulsifier on the growth performance and nutrient digestibility of growing pigs. A total of 120 crossbred ([Landrace × Yorkshire] × Duroc) growing pigs with an average initial body weight of 23.80 ± 4.87 kg were used in a 56-day feeding trial and were sorted into three dietary treatments. Each treatment utilized eight replications with five pigs per pen. The dietary treatments were as follows: PC (high, net energy diet [NE] = 2,488 $kcal \cdot kg^{-1}$ [weeks 1 to 4] and NE = 2,477 $kcal \cdot kg^{-1}$ [weeks 5 to 8]); NC (low, NE = 2,472 $kcal \cdot kg^{-1}$ [weeks 1 to 4] and NE = 2,468 $kcal \cdot kg^{-1}$ [weeks 5 to 8]); NC1 (NC + 0.05% PROSOL® emulsifier). Growth performance outcomes were measured at the initial point and at weeks 4 and 8 while nutrient digestibility parameters were measured at weeks 4 and 8. From weeks 1 - 8, body weight and the average daily gain of the NC1 group pigs showed significant increases ($p < 0.05$) compared to those of the PC and NC treatment groups. At the end of the trail, pigs fed a diet containing low net energy with 0.05% of the emulsifier showed reduced feed conversion ratio (FCR) levels. However, the average daily feed intake and nutrient digestibility of dry matter and nitrogen remained unaffected throughout the experiment. In summary, the addition of a low-net-energy diet with 0.05% sodium stearoyl-2-lactylate as an emulsifier enhanced the body weight and daily gain with no adverse effects on nutrient digestibility in growing pigs.

Key words: growing pig, growth performance, stearoyl-2-lactylate

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Introduction

Lipids are essential components for a variety of body functions in animals. Plant based lipids are generally used in the form of oils, whereas animal lipids are used in the form of concentrated fats (Zhao et al., 2015). Recently, fats and oils become considerable energy sources in swine diets due to their high energy value and energy density. The energy obtain from fats and oils is higher than that of carbohydrate and protein source (Pettigrew and Moser, 1991). Among all nutrients, lipids contribute the highest caloric energy to animals (Kerr and Shurson, 2013). Such dietary energy level become the most important consideration in terms of cost-effective feed formulation (Velayudhan et al., 2015). Yun et al. (2019) stated that lower energy density in the diet of pigs could help to formulate cost effective feed. The amount of energy that an animal receive from dietary fat is mostly depends on digestibility of fat (Rovers, 2014). However, fat droplets are not easily subjected to enzymatic digestion thus remaining a problem within the digestive tract. Generally fat and water do not mix well. At that time, bile salts act as a natural emulsifier in mixing process (Yun et al., 2019). Previously, several researchers (Soares and Lopez-Bote, 2002) reported that the addition of an emulsifier to the diet such as phospholipids, lecithin, and lysolecithin can significantly reduce the size of fat globules and improve the total available surface for enzymatic digestion.

Sodium stearoyl-2-lactylate is applied as emulsifier, whipping agent, and conditioning agent to a wide range of advanced food processing technologies (Gomez et al., 2004). It is a mixture of sodium salts of stearoyl lactylic acid and minor proportions of other salts of related acids, formed by the esterification of commercial stearic acid with lactic acid, and neutralized to sodium salts. Previous studies reported that addition of an emulsifier to the diet of chickens improved fat digestibility (An et al., 2020). Additionally, Hoque and Kim (2020) reported that addition of exogenous emulsifier had reduced the feed efficacy of growing pigs. Whereas, Liu et al. (2020) and Polin (1980) stated that the inclusion of fat in animal diet increase the daily gain and feed efficiency. Though, these studies showed positive effects with fat and emulsifier supplement, yet to the best of our knowledge studies dealt with emulsifier in different levels of energy diet of monogastric animal is still rare. Thus, we conduct this study to find how Sodium stearoyl-2-lactylate supplement with different level of energy diet affect the growth performance and nutrient digestibility of growing pigs.

Materials and Methods

The experimental protocols (DK-1-1935) describing the animal management and care were revised and permitted by the Animal Care and Use Committee of Dankook University. The PROSOL® (sodium stearoyl-2-lactylate [SSL] emulsifier) employed in this study was obtained from Daehan Feed Co., Ltd. (Incheon, Korea). It was formed by esterification of commercial stearic acid with lactic acid followed by neutralization with sodium salts. The SSL consisted of 33% stearic acid, 15% lactic acid, and 2% sodium.

A total of 120 crossbred ([Landrace × Yorkshire] × Duroc) growing pigs with an average initial body weight of 23.80 ± 4.87 kg were used in 56 days feeding trial and they were sorted into 3 dietary treatments. Each treatment has 8 replications with 5 (3-male, 2-female) pigs pen. The dietary treatments were as follows: PC (high, net energy diet [NE] = 2,488 $kcal \cdot kg^{-1}$ [weeks 1 to 4] and NE = 2,477 $kcal \cdot kg^{-1}$ [weeks 5 to 8]); NC (low, NE = 2,472 $kcal \cdot kg^{-1}$ [weeks 1 to 4] and NE = 2,468 $kcal \cdot kg^{-1}$ [weeks 5 to 8]); NC1 (NC + 0.05% PROSOL® emulsifier). The basal diets were formulated to meet or exceed the recommendation of NRC (2012). The dietary ingredients and the chemical compositions are presented in Table 1. All pigs were housed in a slatted plastic floor and the room temperature was maintained at 28℃. Each pen was equipped with one sided self-feeder and a nipple waterer that allow the pigs ad libitum access to feed and water throughout the trial.

The body weight (BW) of growing pigs were measured individually at the beginning of the trial, after a 2-week interval, and at the end of the trial. Average weight gain (ADG) was calculated by the difference between initial and final BW, and feed efficiency (FCR) was calculated by dividing the BW/total feed intake (FI). To determine the nutrient digestibility of dry matter and nitrogen, seven days prior to fecal collection (week 2 and 4) 0.5% of chromium oxide (Cr_2O_3) as an indigestible marker was added to pigs' diet. At the end of week 4 and 8 fresh fecal samples were collected from at least 2 $pigs \cdot pen^{-1}$ (1 barrow and 1 gilt) by rectal palpation. The collected samples were taken to laboratory and dried in a hot air dryer at 60℃

for 72 hours, then pulverized well analysis. Then samples were milled and sieved using a 1 mm screen sieve. Following to the guidelines of AOAC (2002) dry matter (DM) and nitrogen (N) were analyzed. The chromium absorption in feed and fecal samples were identified using UV-1201 spectrophotometry (Shimadzu, Kyoto, Japan). The protein content (N) in feed and fecal sample was analyzed using Tecator^{TM} Kjeltec8400 analyzer (Höganäs, Scania, Sweden). The digestibility was calculated using: ATTD = [1 - {(Nf × Cd)/(Nd × Cf)}], where Nf = nutrient concentration in feces (g·kg^{-1} DM), Nd = nutrient concentration in diets (g·kg^{-1} DM), Cf = chromium concentration in feces (g·kg^{-1} DM), and Cd = chromium concentration in diets (g·kg^{-1} DM).

Table 1. Ingredient and composition of basal diet (as fed basis) for growing pig.

Item	Starter		Grower	
	PC	NC	PC	NC
Corn	64.98	57.35	69.40	61.64
Rice	3.00	3.00	3.00	3.00
SBM (soy bean meal)	15.26	25.46	9.66	17.66
DDGS, corn, USA	5.00	4.00	6.00	6.00
Palm kernel meal	2.00		3.00	2.00
Tallow	3.20	4.30	3.00	4.10
Molasses, cane	2.80	2.50	2.80	2.50
Limestone	1.20	1.15	1.12	1.14
MDCP	0.62	0.59	0.50	0.52
Salt	0.41	0.35	0.40	0.35
Methionine 98%, DL-form	0.15	0.13	0.07	0.08
Lysine 50%	0.67	0.59	0.51	0.50
Threonine 98.5%	0.16	0.11	0.11	0.08
Tryptophane 20%	0.23	0.15	0.17	0.17
Vitamin/mineral mixture [y, z]	0.20	0.20	0.18	0.18
Vitamin E, 10%	0.02	0.02	0.01	0.01
$CuSO_4$	0.03	0.03		
Phytase	0.07	0.07	0.07	0.07
Chemical composition				
Digestible energy (kcal·kg^{-1})	3,560	3,530	3,550	3,520
Net energy (kcal·kg^{-1})	2,488	2,472	2,477	2,468
C. protein (%)	17.61	16.36	15.25	14.46
C. fat (%)	6.75	6.83	6.79	6.77
C. Ash (%)	5.04	5.09	4.77	4.70
C. fiber (%)	2.46	2.74	2.64	2.79
SID lysine (%)	1.070	1.015	0.855	0.807
Calcium (%)	0.76	0.77	0.72	0.71
Phosphorus (%)	0.40	0.41	0.38	0.38
Moist (fermented feed for cattle)	12.71	12.73	12.72	12.83
DCP : CAL	14.72	13.49	12.44	11.65

DDGS, distillers dried grains with soluble; MDCP, mono-dicalcium phosphate; C., crude; SID, standardized ileal digestible; DCP, dicalcium phosphate; CAL, calcium.

[y] Starter diets, provided during weeks 1 to 4, whereas grower diets, provided during weeks 5 to 8. Provided per kg diet: Fe, 115 mg as ferrous sulfate; Cu, 70 mg as copper sulfate; Mn, 20 mg as manganese oxide; Zn, 60 mg as zinc oxide; I, 0.5 mg as potassium iodide; and Se, 0.3 mg as sodium selenite.

[z] Provided per kilograms of diet: Vitamin A, 13,000 IU; vitamin D3, 1,700 IU; vitamin E, 60 IU; vitamin K_3, 5 mg; vitamin B_1, 4.2 mg; vitamin B_2, 19 mg; vitamin B_6, 6.7 mg; vitamin B_{12}, 0.05 mg; biotin, 0.34 mg; folic acid, 2.1 mg; niacin, 55 mg; D-calcium pantothenate, 45 mg.

Statistical analysis

All data were processed by Duncan's multiple range test using the General Linear Model procedure of SAS (2013) to test the significance between the means.

Results and Discussion

Energy plays an important role in animal nutrition. Such energy provision to animals through diets where mainly utilized for maintenance and production (Velayudhan et al., 2015). Previously, Yun et al. (2019) stated that poor feed intake and deprived fat digestibility may adversely affect the growth performance of older pigs. Thus, to enhance the growth and nutrient utilization of growing pigs PROSOL emulsifier was added to energy reduced diet in the present study (Table 2). From weeks 1 - 8, NC1 group pigs has better growth and daily gain ($p < 0.05$) was supported by Zhao et al. (2015) who found the same result in weaning pigs. Also, Wang et al. (2016) reported that low-energy diet with 0.05% SSL supplement partially improved growth performance of broilers. Pigs fed low net energy diet supplement with 0.05% emulsifier reduced the FCR was constant with Gheisar et al. (2015) who observed the same result in broilers fed low energy diet with emulsifier. Previously, Azman and Ciftci (2004) and Cho et al. (2012) reported that chicks fed low energy diet had consumed more feed. Also, Gheisar et al. (2015) stated that sodium stearoyl-2-lactylate emulsifier increased feed intake in broilers and this statement was not consistent with our result in which pigs fed low energy diet with sodium stearoyl-2-lactylate emulsifier showed no difference on the average daily feed intake. The first reason for variance in the results might be due to the animal models and the second possible reason for no changes in the feed intake might be due to the lack of nutrient digestibility. The effect of PROSOL as an emulsifier on the nutrient digestibility of growing pig is shown in Table 3. Previously, Jones

Table 2. Effect of PROSOL as an emulsifier on the growth performance of growing pigs.

Item	PC	NC	NC1	SEM
Body weight (kg)				
Initial	23.80	23.79	23.79	0.01
Week 4	43.71	43.43	43.96	0.18
Week 8	66.22ab	65.61b	66.90a	0.37
Week 4				
ADG (g)	711	702	721	7
ADFI (g)	1,646	1,639	1,668	12
FCR	2.317	2.337	2.315	0.009
Week 8				
ADG (g)	804	792	819	16
ADFI (g)	2,080	2,076	2,100	24
FCR	2.589	2.623	2.565	0.021
Overall				
ADG (g)	757ab	747b	770a	7
ADFI (g)	1,863	1,858	1,884	9
FCR	2.460ab	2.488a	2.447b	0.010

PC (high, net energy [NE] = 2,488 kcal·kg^{-1} [weeks 1 to 4] and NE = 2,477 kcal·kg^{-1} [weeks 5 to 8]); NC (low, NE = 2,472 kcal·kg^{-1} [weeks 1 to 4] and NE = 2,468 kcal·kg^{-1} [weeks 5 to 8]); NC1 (NC + 0.05% PROSOL® emulsifier).

SEM, standard means of error.

a, b: Means in the same row with different superscripts differ ($p < 0.05$).

et al. (1992) reported that inclusion of exogenous emulsifier to the diet of weaning pig has improved the nutrient digestibly. Similarly, Gheisar et al. (2015) stated that broilers fed diet contain low energy level with lysolecithin or sodium stearoyl-2-lactylate significantly enhanced the digestibility of nitrogen. However, in this study pigs fed 0.05% of sodium stearoyl-2-lactylate emulsifier has failed to affect the nutrient digestibility of growing pigs. Studies investigating the effects of dietary sodium stearoyl-2-lactylate on nutrient digestibility of growing pigs reveals a better digestion is still limited thus sufficient comparisons could not made.

Table 3. Effect of PROSOL as an emulsifier on the nutrient digestibility of growing pig.

Item (%)	PC	NC	NC1	SEM
Week 4				
Dry matter	78.16	77.91	79.04	1.12
Nitrogen	76.72	76.47	77.45	1.12
Week 8				
Dry matter	76.77	76.37	77.48	0.70
Nitrogen	75.11	74.52	75.76	0.84

PC (high, net energy [NE] = 2,488 kcal·kg^{-1} [weeks 1 to 4] and NE = 2,477 kcal·kg^{-1} [weeks 5 to 8]); NC (low, NE = 2,472 kcal·kg^{-1} [weeks 1 to 4] and NE = 2,468 kcal·kg^{-1} [weeks 5 to 8]); NC1 (NC + 0.05% PROSOL® emulsifier).
SEM, standard means of error.

Conclusion

The addition of low energy diet with 0.05% sodium stearoyl-2-lactylate emulsifier had increased the growth performance of growing pigs without affecting nutrient digestibility. The exact reason for the lack of nutrient digestibility is unknown. Thus, further research is needful with different levels of emulsifier.

Conflict of Interests

No potential conflict of interest relevant to this article was reported.

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