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Influence of sodium stearoyl-2-lactylate emulsifier on growth performance and nutrient digestibility of growing pig

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Abstract

This study investigated the influence of sodium stearoyl-2-lactylate (SSL) emulsifier on the growth performance and nutrient digestibility of growing pigs. For this 56-day long-duration experiment, 80 heads of cross-bred ([Landrace × Yorkshire] × Duroc) pigs with an initial body weight of 23.80 ± 4.87 kg were divided into two (2) treatment groups each fed a different diet: with and without an emulsifier. Each treatment group had 8 replication pens with 5 pigs per pen. Feed treatments were as follows: 1) CON: Basal diet, and 2) SSL: CON + 0.05% SSL. Body weight (BW), average daily gain (ADG), and feed conversion ratio (FCR) were measured for three periods: 0 - 4, 5 - 8, and 0 - 8 weeks. The nutrient digestibility parameters consisting of dry matter (DM) digestibility and nitrogen (N) digestibility were calculated on the 4^{th} and 8^{th} week. Based on the results, the SSL supplementation did not show any significant influence on the growth performance parameters during the 0 to 4 and 5 to 8 week phases. For the overall performance, only the FCR ($p = 0.048$) was significantly different in the emulsifier fed group (SSL) compared to the CON group (T1). DM and N digestibility was also not influenced by the SSL addition in the growing pig diet. Overall, the SSL supplementation showed a limited effect on the growth performance of growing pigs.

Keywords: feed conversion ratio (FCR), growing pig, sodium stearoyl-2-lactylate

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Introduction

In commercial farming, profit depends highly upon supplying balanced and economic feed. Growing pigs need a balanced diet that provides enough energy for their maintenance and production. Energy sources are not less expensive, so energy levels should be in good consideration during feed formulation. Oils and fats are important sources of energy in diet and emulsifiers are used for improving fat digestibility and energy utilization (Yin et al., 2018). But, fat globules are not readily available for enzymatic action. So, we need to emulsify them to decrease the size of fat globules and increase the total available surface area for enzymatic digestion. As emulsifiers, phospholipids, lecithin, and lysolecithin were found effective especially in weaning pigs and broilers (Krogdahl, 1985; Jones et al., 1992; Gheiser et al., 2015; Zhao et al., 2015; Bai et al., 2019). For reason, newly hatched broilers and weaning pigs have an immature digestive system that has restricted bile salts and lipase secretion. Bile salts and lipase are essential for fat digestion. So, exogenous emulsifiers work effectively in broiler and weaning pigs. On the contrary, growing pigs have developed a digestive system that may reduce the necessity of exogenous emulsifiers in the diet. Though Sun et al. (2019) found a significant effect of lecithin in growing pigs, most emulsifiers showed less effective results in the growth performance of growing pigs.

Sodium stearoyl-2-lactylate (E 481 SSL) is an emulsifier that is comprised of sodium salts of stearoyl lactic acid and other salts of related acids in minor proportions. It is formulated by esterification of commercial stearic acid with lactic acid, followed by sodium salt neutralization. SSL also showed a significant effect on broiler growth performance (Gheiser et al., 2015; Ali et al., 2017; Liu et al., 2020). Hardly any study has been conducted on the effect of SSL on growing pigs. Therefore, the objective of our study was to determine the impact of SSL supplementation in growing pig's growth performance and nutrient digestibility.

Materials and Methods

Experimental management, treatment, and care of animal was approved (DK-4-1345) by the Animal Care and Use Committee of Dankook University, South Korea.

Emulsifier source

The tested product was sodium stearoyl-2-lactylate composed of 95% sodium stearoyl-2-lactylate and 5% starch supplied by a local company (Il Shin Wells, Seoul, Korea). It was formulated by esterification of commercially available stearic acid with lactic acid and then neutralized with sodium salts.

Animals, diets and facilities

The sample population was comprised of a total of 80 ([Landrace × Yorkshire] × Duroc) pigs of 23.80 ± 4.87 kg initial body weight. This experiment was conducted for 8 weeks feeding trial divided into two phases, 0 to 4 weeks, and 5 to 8 weeks. Animals were randomly assigned to three treatments according to their body weight and sex (2 gilts + 3 barrows per pen). Each treatment had 8 replication pens. Feeding treatments were 1) T1, control basal diet; T2, T1 + 0.05% sodium stearoyl-2-lactylate emulsifier. All diets (Table 1) were comprised in a way to meet or exceed the nutrient requirement of NRC (2012) for pigs. All pigs were raised in an environment controlled house with a slated plastic floor where each pen was supplied with a self-feeder and nipple waterer to provide *ad libitum* access to feed and water.

Sampling and measurements

At the starting of the experiment, at the end of week 4 and week 8, the body weight of each pig was measured and average daily gain (ADG) was estimated. At the same time, feed intake was recorded on a cumulative basis on pens to calculate average feed intake (FI) and feed conversion ratio (FCR). At the end of the 3rd week and 7th week pigs were fed a diet mixed with chromium oxide (Cr_2O_3, 0.2%) as an indigestible marker to estimate the apparent total tract digestibility (ATTD) of dry matter (DM) and nitrogen (N). In the last two days of each phase, fecal samples were collected by anal massaging from

Table 1. Composition of growing pig diets (as fed-basis).

Items	Amounts (%)
Ingredients	
Corn	61.52
Rice	1.00
SBM	17.59
DDGS, corn, USA	8.00
Plam kernel meal	1.57
Oat	3.60
Molasses, cane	3.00
Limestone	1.36
MDCP (mono di-calcium phosphate)	0.55
Salt	0.35
Methionine, 99%, DL-form	0.12
Lysine 50%	0.72
Threonine, 98.5%	0.14
Tryptophan, 20%	0.23
Vitamin premix[y]	0.10
Mineral premix[z]	0.10
Phytase	0.05
Total	100.00
Calculated composition (%)	
Nutrient	
Moist	13.13
Crude protein	15.78
Crude fat	6.30
Crude fiber	2.54
Crude ash	5.56
ME ($kcal \cdot kg^{-1}$)	3,352
NE ($kcal \cdot kg^{-1}$)	2,413
Ca	0.71
Total P	0.45
Lysine	1.11

SBM, soybean meal; DDGS, dried distillers grains; ME, metabolizable energy; NE, net energy.
[y] 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 D_3, 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.

each pig pooled based on a pen. Fecal samples and feed samples were stored in a -20℃ freezer until analysis. Fecal samples were dried at 70℃ for 72 hours and grounded finely to pass through a 1 mm screening sieve. The DM and N content were analyzed according to (Method 930.15; AOAC, 2005) and (Method 990.03; AOAC, 2005). The chromium content was measured by UV absorption spectrophotometry (Shimadzu UV-1201, Shimadzu, Kyoto, Japan) according to Williams et al. (1962). ATTD was calculated according to the following formula.

$$ATTD\ (\%) = [1 - \{(Nf \times Cd] / (Nd \times Cf)\}] \times 100 \quad (1)$$

where, Nf = nutrient concentration in feces (% DM), Nd = nutrient concentration in diet (% DM), Cd = chromium concentration in diet (% DM), and Cf = chromium concentration in feces (% DM).

Statistical analysis

This experiment was designed for t-test analysis. Each treatment comprised of 8 replication pens with 5 pigs·pen^{-1}. Pigs were allocated in pens according to their body weight and sex. Then pens were divided into treatments randomly. All data were analyzed by t-test using SAS (SAS Institute Inc., Cary, NC, USA). A probability level of $p < 0.05$ was considered statistically significant.

Results

Growth performance

The results of the supplementation of 0.05% SSL in the diet of growing pigs are presented in Table 2. In the 1st phase (0 to 4 wk) SSL supplemented diet did not bring any significant difference ($p > 0.05$) in BW, ADG, and ADFI. But, it reduced ($p = 0.006$) FCR in the emulsifier supplemented group compare to the CON group. In the 2nd phase (4 to 8 wk) BW, ADG, ADFI and FCR did not vary ($p > 0.05$) between CON and SSL groups. Interestingly, in overall measurement emulsifier

Table 2. Effect of emulsifier supplementa tion on growth performance of growing pigs.

Items	CON	SSL	SEM	p-value
Body weight (kg)				
Initial	23.79	23.79	0.81	0.999
Week 4	43.40	43.96	1.16	0.993
Week 8	65.53	66.90	1.39	0.733
Week (0 to 4)				
ADG (g)	702	721	10	0.540
ADFI (g)	1,639	1,668	16	0.461
FCR	2.337a	2.314b	0.012	0.006
Week (4 to 8)				
ADG (g)	792	819	19	0.720
ADFI (g)	2,076	2,100	23	0.739
FCR	2.623	2.565	0.028	0.670
Overall				
ADG (g)	747	770	10	0.252
ADFI (g)	1,858	1,884	12	0.296
FCR	2.488a	2.447b	0.014	0.043

8 replicate pens per treatment, 2 gilt and 5 barrows pen^{-1}.
CON, basal diet; SSL, CON + 0.05% sodium stearoyl-2- lactylate; SEM, standard error of means; ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio.
a, b: Means in the same row with different superscript differ significantly ($p < 0.05$).

Table 3. Effect of emulsifier supplementa tion in nutrient digestibili ty of growing pigs.

Items (%)	CON	SSL	SEM	p-value
Week 4				
Dry matter	77.91	79.04	1.27	0.195
Nitrogen	76.47	77.45	1.32	0.413
Week 8				
Dry matter	76.37	77.48	1.16	0.501
Nitrogen	74.52	75.54	1.41	0.547

8 replicate pens per treatment, 2 gilt and 2 barrows pen^{-1}.
CON, basal diet; SSL, CON + 0.05% sodium stearoyl-2- lactylate; SEM, standard error of means.

supplementation showed improvement in FCR (p = 0.048) compared to the control diet (CON) group, though ADG and ADFI showed no significant difference (p > 0.05).

Nutrient digestibility

The effects of SSL emulsifier supplementation in growing pigs are shown in Table 3. During week 4, 0.05% SSL supplementation did not influence (p > 0.05) the digestibility of N and DM in the SSL group compared to the CON group. Consequently, emulsifier supplementation showed no improvement in N and DM digestibility during week 8.

Discussion

The effect of emulsifiers in animal growth performance showed different effects according to species and their stage of growth. Again each emulsifier variously acted depending on the source of fat or oil. In broiler chicken, Gheiser et al. (2015); Ali et al. (2017) and Liu et al. (2020) found SSL and other emulsifiers effective that change ADG and FCR positively. SSL supplementation also brought significant changes in weaning pigs (Bai et al., 2019). As there is a scarce of reports of SSL emulsifiers on growing pig growth performance, our findings are compared with other emulsifiers used in growing pigs' diet and pigs of different ages.

Santos et al. (2017) and Li et al. (2017) reported that the application of emulsifiers such as lecithin and glycerol polyethylene glycol respectively in growing pigs have shown improvement in FCR. However, Yun et al. (2019) and Yin et al. (2019) used SSL emulsifier on finishing and growing pig respectively. Their reports showed no significant difference in BW, ADG, ADFI, and FCR parameters. The fully developed digestive system in growing-finishing pigs may be responsible for no differences in growth parameters. When in young pigs, the digestive system was less developed emulsifiers showed a significant effect on growth performance (Krogdahl, 1985; Bai et al., 2019). However, in growing animals and finishing animals, the developed digestive system reduced the impact of emulsifiers on growth performance (Yun et al., 2019). There are not enough existing literature explaining the significant change of FCR in our experiment. Long time continuous use of SSL emulsifier may have brought this change in FCR. In different phases, the mean value of ADG and FCR of the SSL group was always better than CON though not significant. This improvement of FCR could not bring significant changes to the ADG and BW.

The digestibility of nutrients like DM and N were not significant, maybe due to the developed digestive system of growing pigs. There are some limitations to this experiment. Fat source and fat digestibility were not considered. Since emulsifier breaks down lipid particles and provides more nutrition to the animal, lipid digestibility should have been considered. Lipid digestibility could have caused the changes in the FCR. It is possible that the increased lipid digestion reduced the FCR of the pig from 0 to 4 wk and the overall period.

Conclusion

In conclusion, dietary supplementation of SSL in the growing pig diet showed a very confined effect on growth performance. Even though only FCR was decreased in SSL supplied group, we still have a chance of further experiment about SSL in growing pig feed considering above mentioned missing factors and using higher doses.

Conflict of Interests

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

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