

## Evaluation Effects of Spray-dried Egg Protein Containing Specific Egg Yolk Antibodies as a Substitute for Spray-dried Plasma Protein or Antibiotics in Weaned Pigs\*

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**ABSTRACT :** In Exp. 1, a total of 36 pigs ( $6.55 \pm 0.10$  kg average initial body weight and 21 d average age) were used in a 14 d growth study to determine the effects of replacing spray-dried plasma protein (SDPP) with spray-dried egg protein containing specific egg yolk antibody (SDEP) on growth performance and nutrient digestibility in weaned pigs. The pigs were blocked by weight and assigned to treatments based on sex. There were three pigs per pen and four pens per treatment. Dietary treatments were 0, 3, or 6% SDEP and contained 6, 3, or 0% SDPP, respectively. Through the entire experimental period, average daily gain (ADG), average daily feed intake (ADFI), and gain/feed tended to decrease as the concentration of SDEP increased in the diets. However, there were no significant differences among the treatments ( $p > 0.05$ ). As the addition of SDEP in the diets increased, apparent digestibilities of dry matter (DM) and nitrogen (N) were decreased without significant ( $p > 0.05$ ). For Exp. 2, 36 pigs ( $2.63 \pm 0.04$  kg average initial body weight and 10 d average age) were used in a 14 d growth study to determine the effects of antibiotic replacement with SDEP on growth performance and nutrient digestibility in early-weaned pigs. The pigs were blocked by weight and assigned to treatments based on sex. There were three pigs per pen and four pens per treatment. Dietary treatments included 1) ANTIBIOTIC (corn-dried whey-soybean meal based diet+0.08% antibiotics, 4 mg of tiamuline hydrogen fumarate; 10 mg of sulfadimidine per kg of complete diet), 2) SDEP0.1 (corn-dried whey-SBM based diet+0.1% SDEP), and 3) SDEP0.2 (corn-dried whey-SBM based diet+0.2% SDEP). ADG and gain/feed of pigs fed the SDEP0.2 diet were higher than for pigs fed the ANTIBIOTIC diet without significant ( $p > 0.05$ ). Pigs fed the diet with SDEP0.2 tended to have increased apparent digestibilities of DM and N compared to pigs fed the ANTIBIOTIC diet without significant ( $p > 0.05$ ). In conclusion, the dietary SDEP seemed to be partial replacing the SDPP portion of high nutrient dense diet for weaned pigs. Also, dietary SDEP seemed to be approximately 0.2% or more when the pigs fed the antibiotic-free diet for early-weaned pigs. (*Asian-Aust. J. Anim. Sci.* 2004. Vol 17, No. 8 : 1139-1144)

**Key Words :** Egg Yolk Antibody, SDPP, Antibiotic, Growth, Pigs

### INTRODUCTION

Since the introduction of complex starter diets for early-weaned pigs, several methods of incorporating various protein sources to improve pig performance and decrease diet cost have been investigated. SDPP is an effective protein source for use in the Phase I (d 0 to 14 postweaning) diet for the early-weaned pig (Kim et al., 2001). Also, immunoglobulins present in SDPP are through to provide antimicrobial protection, influence intestinal immune status and prevent mucosal damage by enteric pathogens in early-weaned pigs (Jiang et al., 2000). However, pigs weaned at an early age and reared in isolation (segregated early weaning in off-site facilities) were less responsive to dietary plasma protein than pigs reared in a conventional system. In addition, the plasma protein supply is limited and very expensive. Therefore, finding a protein source to produce similar growth performance at a lower cost would greatly

benefit in the swine industry.

Previous research has shown that spray-dried egg protein reduced feed intake when added at high levels ( $>6.0\%$ ) (Owen et al., 1993). Also, Nessmith et al. (1996) evaluated various protein sources as replacements for spray-dried animal plasma. They reported that pigs fed increasing levels of spray-dried egg protein had decreased average daily feed intake. However, Nessmith et al. (1996) demonstrated that up to 50% of spray-dried plasma protein (SDPP) can be replaced with spray-dried egg protein (6.0% of the diet) without influencing performance of starter pigs.

Increasingly, bacterial resistance to antibiotics has caused concern among health specialists and consumer groups (Kunin, 1993) and one focus of these concerns is the use of drugs in the livestock industry. Several investigations have focused on the emergence of drug-resistant bacteria (Langlois et al., 1984), persistence of resistant bacteria (Langlois et al., 1988), and effects on human medicine (Kunin, 1993). Control of intestinal resistant bacteria has long been a goal of both livestock producer and microbiologist. The most common method of repressing undesirable bacteria has been the use of antibacterial agents. However, recent interest has focused on nonantibiotic feed additions.

\* This work was supported by grant No. 98-0402-10-01-3 from the basic research program of the Korea Science & Engineering Foundation.

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Received July 31, 2003; Accepted April 8, 2004

**Table 1.** Chemical composition of spray-dried egg protein containing specific egg yolk antibodies<sup>1</sup>

Item, %	SDEP	SDPP
Crude protein	41.85	78.00
Ether extract	3.60	2.00
Calcium	0.20	0.15
Phosphorus	0.80	1.71
Amino acids		
Arginine	2.58	4.55
Histidine	1.46	2.55
Isoleucine	2.58	2.71
Leucine	4.00	7.61
Lysine	3.28	6.84
Methionine	1.69	0.75
Phenylalanine	3.65	4.42
Threonine	2.05	4.72
Valine	1.30	4.94

<sup>1</sup>Analyzed values and values obtained from the manufacturer are expressed on an as-fed basis.

In passive immunization experiments, antibodies raised against *Escherichia coli* fimbrial antigens were administered orally to piglets and helped control the disease (Yokoyama et al., 1992). Adhesion studies with specific enterotoxigenic *Escherichia coli* (ETEC) receptors isolated from the mucus of piglets demonstrated that chicken antibodies could prevent the binding of the ETEC to the receptors, supporting the observation that antibodies can block the effects of *Escherichia coli*. These results demonstrated that small amounts of chicken egg yolk antibodies are highly effective at protecting piglets against the pathogenic effects of ETEC (Marquardt, 2000). Chicken egg yolk has recently attracted considerable attention as an inexpensive source of antibodies (Losch et al., 1986), and the application of egg yolk immunoglobulin to antibody-containing diets has been considered (Shimizu et al., 1988).

Our aim of the present study was to determine the effects of dietary spray-dried egg protein containing specific egg yolk antibodies (SDEP) as a substitute for SDPP or antibiotic on starter pig performance.

## MATERIALS AND METHODS

Supplemental animal proteins sources were dried using a spray-drying technique. Diets were formulated to exceed nutrient requirements established by the NRC (1998) for 3 to 5 kg pig using values provided by the NRC (1998) for feedstuffs. Diet was formulated using nutrient analyses of SDEP provided by the manufacturer (Table 1).

### Experiment 1

Thirty six [(Duroc×Yorkshire)×Landrace] pigs (6.55 ±0.10 kg average initial body weight and 21 d average age) were used in a 14 d growth study to determine the effects of replacing SDPP with SDEP on growth performance and

**Table 2.** Diet composition for Exp. 1 (as-fed basis)

Ingredients, %	SDEP <sup>1</sup> , %		
	0	3	6
Corn	38.74	37.42	36.11
Soybean meal (CP 44%)	15.15	17.87	20.57
Spray-dried plasma protein	6.00	3.00	-
Spray-dried egg protein	-	3.00	6.00
Soybean flour	10.00	10.00	10.00
Dried whey	20.00	20.00	20.00
Monocalcium phosphate	1.35	1.42	1.49
Soybean oil	6.69	5.34	3.99
Limestone	1.17	1.05	0.93
Antibiotic <sup>2</sup>	0.10	0.10	0.10
Vitamin premix <sup>3</sup>	0.12	0.12	0.12
Trace mineral premix <sup>4</sup>	0.10	0.10	0.10
Chromic oxide <sup>5</sup>	0.20	0.20	0.20
Salt	0.20	0.20	0.20
L-lysine-HCl	0.07	0.11	0.16
DL-methionine	0.11	0.07	0.03
Chemical composition <sup>6</sup>			
ME, kcal/kg	3,320	3,320	3,320
Crude protein, %	22.00	22.00	22.00
Lysine, %	1.50	1.50	1.50
Methionine, %	0.42	0.42	0.42
Calcium, %	0.90	0.90	0.90
Phosphorus, %	0.80	0.80	0.80

<sup>1</sup>SDEP: spray-dried egg protein containing specific egg yolk antibody.

<sup>2</sup>Provided by 50 mg carbadox per kg of complete diet.

<sup>3</sup>Provided per kg diet: 20,000 IU of vitamin A; 4,000 IU of vitamin D<sub>3</sub>; 80 IU of vitamin E; 16 mg of vitamin K<sub>3</sub>; 4 mg of thiamine; 20 mg of riboflavin; 6 mg of pyridoxine; 0.08 mg of vitamin B<sub>12</sub>; 120 mg of niacin; 50 mg of Ca-pantothenate; 2 mg of folic acid and 0.08 mg of biotin.

<sup>4</sup>Provided per kg diet: 140 mg of Cu; 179 mg of Zn; 12.5 mg of Mn; 0.5 mg of I; 0.25 mg of Co and 0.4 mg of Se.

<sup>5</sup>Used as an indigestible marker. <sup>6</sup>Calculated values.

nutrient digestibility in weaned pigs at the Swine Research Facility, Dankook University, Korea. The pigs were blocked by weight and assigned to treatments based on sex. There were three pigs per pen and four pens (two barrows and gilts pens) per treatment.

Dietary treatments were 0, 3 or 6% SDEP and contained 6, 3 or 0% SDPP, respectively. The basal diet (Table 2) was formulated to contain 3,320 kcal/kg of ME, 22.00% of CP, 1.50% of lysine, 0.42% of methionine, 0.90% of Ca and 0.80% of P for the weaned pigs. Chromic oxide was added (0.2% in the diet) as an indigestible marker to allow digestibility determinations. SDEP was produced by eggs obtained from chickens immunized with purified fimbrial antigen from ETEC 987P and K88 (*Escherichia coli* Reference Centre, Pennsylvania State University, USA). The titer of anti-987P and K88 fimbria antibodies were 75,000 and 180,000, respectively.

Pigs were allowed to consume feed and water on an *ad libitum* basis from a two-hole self-feeder and a nipple waterer. The pigs and feeder were weighed on d 7 and 14 to allow calculation of average daily gain (ADG), average daily feed intake (ADFI) and gain/feed. Digestibility was

**Table 3.** Diet composition for Exp. 2 (as-fed basis)

Ingredients, %	SDEP <sup>1</sup> , %		
	0	0.5	1.0
Corn grain	30.55	30.88	31.10
Dried whey	25.00	25.00	25.00
Soybean flour	10.00	10.00	10.00
Soybean meal (CP 44%)	18.80	18.47	18.10
Spray-dried plasma protein	5.00	5.00	5.00
SDEP <sup>1</sup>	-	0.10	0.20
Soybean oil	5.94	5.95	6.00
Fish meal	2.00	2.00	2.00
Monocalcium phosphate	0.97	0.97	0.97
Limestone	0.93	0.92	0.92
Antibiotic <sup>2</sup>	0.08	-	-
Vitamin premix <sup>3</sup>	0.12	0.12	0.12
Trace mineral premix <sup>4</sup>	0.10	0.10	0.10
Salt	0.20	0.20	0.20
L-lysine-HCl	0.01	-	-
DL-methionine	0.10	0.09	0.09
Chromic oxide <sup>5</sup>	0.20	0.20	0.20
Chemical composition <sup>6</sup>			
ME, kcal/kg	3,320	3,320	3,320
Crude protein, %	24.00	24.00	24.00
Lysine, %	1.60	1.60	1.60
Methionine, %	0.45	0.45	0.45
Calcium, %	0.90	0.90	0.90
Phosphorus, %	0.80	0.80	0.80

<sup>1</sup> Abbreviated SDEP, spray-dried egg protein containing specific egg yolk antibodies.

<sup>2</sup> Provided per kg of complete diet: 4 mg of tiamuline hydrogen fumarate; 10 mg of sulfadimidine.

<sup>3</sup> Provided per kg diet: 20,000 IU of vitamin A; 4,000 IU of vitamin D<sub>3</sub>; 80 IU of vitamin E; 16 mg of vitamin K<sub>3</sub>; 4 mg of thiamine; 20 mg of riboflavin; 6 mg of pyridoxine; 0.08 mg of vitamin B<sub>12</sub>; 120 mg of niacin; 50 mg of Ca-pantothenate; 2 mg of folic acid and 0.08 mg of biotin.

<sup>4</sup> Provided per kg diet: 140 mg of Cu; 179 mg of Zn; 12.5 mg of Mn; 0.5 mg of I; 0.25 mg of Co and 0.4 mg of Se.

<sup>5</sup> Used as an indigestible marker. <sup>6</sup> Calculated values.

determined with 4 d of adjustment to the experimental diets, 2 d of fecal collection. Feed and feces were analyzed for DM and N concentrations (AOAC, 1995). Chromium was determined by UV absorption spectrophotometry (Shimadzu, UV-1201, Japan, Williams et al., 1962) and apparent digestibilities of DM and N were calculated using the indirect-ratio method.

All data were analyzed as a randomized complete block design using the GLM procedure of SAS (1996) with pen as the experimental unit. Polynomial regression (Petersen, 1985) was used to determine linear and quadratic effects of SDEP supplementation.

### Experiment 2

Thirty six pigs [(Duroc×Yorkshire)×Landrace] (2.63 ±0.04 kg average initial body weight and 10 d average age) were used in a 14 d growth study to determine the effects of replacing antibiotic with SDEP on growth performance and

digestibility in early-weaned pigs at the Swine Research Facility, Dankook University, Korea. The pigs were blocked by weight and assigned to treatments based on sex. There were three pigs per pen and four pens (two barrows and gilts pens) per treatment.

Dietary treatments included 1) ANTIBIOTIC (corn-dried whey-SBM based diet+0.08% antibiotic, 4 mg of tiamuline hydrogen fumarate; 10 mg of sulfadimidine per kg of complete diet), 2) SDEP0.1 (corn-dried whey-SBM based diet+0.1% SDEP) and 3) SDEP0.2 (corn-dried whey-SBM based diet+0.2% SDEP). The basal diet (Table 3) was formulated to contain 3,320 kcal/kg of ME, 24.00% of CP, 1.60% of lysine, 0.45% of methionine, 0.90% of Ca and 0.80% of P for the early-weaned pigs. Chromic oxide was added (0.2% in the diet) as an indigestible marker to allow digestibility determinations. Preparation of SDEP was as described for Exp. 1.

Pigs were allowed to consume feed and water on an *ad libitum* basis from a two-hole self-feeder and nipple water. The pigs and feeder were weighed on d 14 to allow calculation of ADG, ADFI and gain/feed. Digestibility was determined with 4 d of adjustment to the experimental diets, 2 d of fecal collection. Feed and feces were analyzed for DM and N concentrations (AOAC, 1995). Chromium was determined by UV absorption spectrophotometry (Shimadzu, UV-1201, Japan, Williams et al., 1962) and apparent digestibilities of DM and N were calculated using the indirect-ratio method.

Statistical analyses were carried out to compare the means by Duncan's multiple range test (Duncan, 1955) using GLM procedure of SAS (1996).

## RESULTS

### Experiment 1

The effects of replacing SDPP with SDEP on growth performance and nutrient digestibility of weaned pigs are presented in Table 4. For d 0 to 7, there were not significant differences in ADG, ADFI, and gain/feed ( $p>0.05$ ). For d 7 to 14, as the addition of SDEP increased in the diets, ADG (Linear effect,  $p=0.01$ ; Quadratic effect,  $p=0.01$ ), ADFI (Linear effect,  $p=0.01$ ), and gain/feed (Quadratic effect,  $p=0.03$ ) were decreased. Through entire experimental period, ADG, ADFI and gain/feed tended to decrease as the concentration of SDEP in the diets was increased. However, there were no significant differences among the treatments ( $p>0.05$ ). There were no significant differences in DM and N digestibilities ( $p>0.05$ ) either. The present study showed that up to 50% of SDPP can be replaced with SDEP (3.0% of the diet) without influencing performance of starter pigs.

### Experiment 2

Growth performance and nutrient digestibility of pigs

**Table 4.** Effects of spray-dried egg protein containing specific egg yolk antibody as substitute for spray-dried plasma protein on growth performance and nutrient digestibility in weaned pigs (Exp. 1)<sup>1</sup>

Item	SDEP <sup>2</sup> , %			SE <sup>3</sup>	Probability (P=)	
	0	3	6		Linear	Quadratic
0-7 days						
Average daily gain, g	245	251	201	25	0.35	0.46
Average daily feed intake, g	424	397	373	15	0.14	0.94
Gain/feed	0.58	0.63	0.54	0.06	0.75	0.52
7-14 days						
Average daily gain, g	223	230	166	11	0.01	0.01
Average daily feed intake, g	524	460	359	14	0.01	0.39
Gain/feed	0.43	0.50	0.46	0.01	0.11	0.03
0-14 days						
Average daily gain, g	234	241	184	18	0.16	0.25
Average daily feed intake, g	474	429	366	24	0.06	0.58
Gain/feed	0.49	0.56	0.50	0.03	0.67	0.25
Nutrient digestibility, %						
Dry matter	78.36	83.47	78.86	5.17	0.95	0.52
Nitrogen	72.91	82.30	73.38	7.14	0.97	0.41

<sup>1</sup>Thirty six pigs with an average initial body weight of 6.55±0.10 kg.

<sup>2</sup>SDEP: spray-dried egg protein containing specific egg yolk antibody. <sup>3</sup>Pooled standard error.

**Table 5.** Effects of spray-dried egg protein containing specific egg yolk antibodies as antibiotic replacement on growth performance and nutrient digestibility in early-weaned pigs (Exp. 2)<sup>1</sup>

Item	Antibiotic <sup>2</sup>	SDEP0.1 <sup>2</sup>	SDEP0.2 <sup>2</sup>	SE <sup>3</sup>
Growth performance				
Average daily gain, g	142	109	176	29
Average daily feed intake, g	297	263	261	41
Gain/feed	0.48	0.41	0.67	0.06
Nutrient digestibility				
Dry matter, %	88.40	85.24	88.47	0.25
Nitrogen, %	83.82	81.94	85.86	1.28

<sup>1</sup>Thirty six pigs with an average initial body weight of 2.63±0.04 kg.

<sup>2</sup>Abbreviated Antibiotic, 0.08 % antibiotic, 4 mg of tiamuline hydrogen fumarate; 10 mg of sulfadimidine per kg of complete diet; SDEP0.1, added 0.1% spray-dried egg protein containing specific egg yolk antibodies; SDEP0.2, 0.2% spray-dried egg protein containing specific egg yolk antibodies.

<sup>3</sup>Pooled standard error.

fed the experimental diet were presented in Table 5. ADG of pigs fed the SDEP0.2 diet grew 24% faster (176 vs. 142 g/d) than pigs fed the diet containing antibiotics, however, there was no statistical difference. ADFI of pigs fed the ANTIBIOTIC diet was higher than pigs fed SDEP0.1 and SDEP0.2 diets, however, there was no significant difference. Pigs fed SDEP0.2 diet were 41% more efficient (0.67 vs. 0.48) than pigs fed ANTIBIOTIC diet, however, there was no significant difference. Pigs fed the diet with SDEP0.2 tended to have increased apparent digestibilities of DM and N compared with pigs fed the ANTIBIOTIC diet without significant differences. In conclusion, the SDEP supplementation seemed to be approximately 0.2% or more when the pigs fed in the antibiotic-free diet for early-weaned pigs.

## DISCUSSION

### Experiment 1

Several studies have suggested the use of other, less

expensive protein sources, such as egg protein as protein sources which can potentially be used to replace plasma protein. Our data are in agreement with those of Owen et al. (1993) who examined the influence of SDEP as a protein substitute for either soybean meal or SDPP on starter pig performance. Hong et al. (2002) estimated that metabolic study to determine the effects of replacing SDPP with SDEP on apparent amino acids digestibility in weaned pigs. They reported that there were no significant differences among the treatments. Also, Hong et al. (2002) conducted to determine the effects on growth performance and nutrient digestibility in early-weaned pigs. In Hong et al. (2002) trails, experimental pigs were fed diets containing 0, 3, 6% SDEP with 7.5% SDPP. They demonstrated that SDEP can be used to add up to 3% in diet for weaned pigs without negative affects on growth performance and nutrient digestibility. Our study and Hong et al. (2002) results showed that ADG of weaned pigs fed 6% SDEP diet decreased. This result due to ovomucoid (100 g/kg egg protein). Kato and Matsuda (1997) reported that ovomucoid

in egg protein was trypsin inhibitor, thus weaned pigs with negative affects on growth performance. Further research is needed to test effects of ovomucoid on growth performance.

Nessmith et al. (1995) evaluated the effects of replacing SDPP with SDEP on starter pig performance. They suggested that SDPP could be replaced with SDEP (6.0% of the diet) without influencing performance of starter pigs. Nessmith et al. (1996), on the other hand, observed a decrease in the performance of pigs fed a diet containing SDEP compared with those fed a diet containing fish meal or extruded soy protein concentrate. Also, Chung et al. (1997) reported that a combination of egg protein and spray-dried porcine blood could not effectively replace plasma protein in phase I (day 0 to 10 postweaning) diets of nursery pigs reared in isolated off-site facilities.

## Experiment 2

Weaning is stressful for pigs because of the adjustment from a liquid to a dry diet. This transition may alter the digestive tract's microbes, resulting in less desirable microflora that cause poor performance and diarrhea (van de Ligt et al., 2002). Diarrhea is one of the most common diseases of young pigs. One of the most common causes of diarrhea is infection with ETEC which is normally kept under control in the young pigs by passive immunity imparted by antibodies present in the milk. Early weaning has resulted in the removal of this protection and thereby has greatly increased the incidence of the disease. In addition, the increased incidence of antibiotic resistance in microorganisms and the pressure by regulatory agents to ban or gradually reduce the use of antibiotic in feeds are also problems (Marquardt, 2000). Consequently, new concepts have been developed aiming to promote animal health and to secure growth performance, feed efficiency, and product quality as well. Several naturally occurring compounds have been shown to affect the composition and activity of the microflora in the gastrointestinal tract of pigs such as diet acidification (Tsiloyiannis et al., 2001), mannan-oligosaccharides (Ko et al., 2000), herbs (Wenk, 2003), minerals (Hill et al., 2001), direct-fed microbial (Xuan et al., 2001) and lactoferricin (Hong et al., 2003). Recently, livestock industry has been interested in egg yolk antibody as nonantibiotic feed additives. The concept of egg yolk antibody could prevent the binding of the ETEC to the receptors (isolated from the mucus of piglets) that antibodies can block the effects of *Escherichia coli*.

Previous studies with weaned pigs have demonstrated that specific antibodies against K88, K99 and 987P fimbrial adhesions of ETEC provided complete protection against fatal enteric colibacillosis (Yokoyama et al., 1992). Adhesion studies with specific ETEC receptors isolated from the mucus of piglets demonstrated that chicken antibodies could prevent the binding of the ETEC to the

receptors, supporting the observation that antibodies can block the pathogenic effects of ETEC. These results demonstrated that small amounts of chicken egg yolk antibodies are highly effective at protecting piglets against the pathogenic effects of ETEC (Marquardt, 2000). Wiedmann et al. (1991) argued that whole egg lyophilisate of immunized hens was as successful as infected with ETEC. They represented good alternative to the commonly used antibiotic therapy. Our data indicated that SDEP supplementation could replace antibiotics for protecting diarrhea in early-weaned pigs. Hong et al. (2001) conducted that to examine SDEP as a substitute for antibiotic in the diets of early-weaned pigs. They argued that SDEP can be used to replace antibiotic in diets for segregated early-weaned pigs without negative effect on growth performance, nutrient digestibility and fecal consistency score.

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