Influences of Plant Extract Supplementation on Performance and Blood Characteristics in Weaned Pigs*

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ABSTRACT : One hundred and twenty crossbred pigs [(Duroc×Yorkshire)×Landrace] were used to determine the effects of plant extract (PE) supplementation on performance and blood characteristics in weaned pigs fed a corn-dried whey-SBM based diet. Treatments were 1) NC (antibiotic free basal diet), 2) PC (NC diet+100 ppm apramycin and 100 ppm oxytetracycline), 3) PE 0.1 (NC diet+0.1% plant extract), 4) PE 0.2 (NC diet+0.2% plant extract) and 5) PE+AB (PC diet+0.1% plant extract). Through the entire experimental period, ADG of pigs fed PC (300 vs. 281 g/d), PE 0.2 (310 vs. 281 g/d) and PE+AB (306 vs. 281 g/d) diets was higher than that of pigs fed NC diet ($p<0.05$). However, no differences were found among the treatments for ADFI and gain/feed. At day 2 after the onset of the experiment, fecal consistency score of pigs fed PC, PE 0.1, PE 0.2 and PE+AB diets was lower than that of pigs fed NC diet. There were no significant differences in red blood cell, white blood cell, lymphocytes, neutrophils and monocytes concentrations of blood among the treatments. In conclusion, PE can be used to replace antibiotics in diets for weaned pigs without negative affects on performance. Optimal PE levels seemed to be 0.2% and the results obtained point out to a synergic effect of the combination of PE and antibiotic on performance in weaned pigs. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 3 : 374-378)***

Key Words : Plant Extracts, Growth, Blood Characteristics, Pigs

INTRODUCTION

The plant extracts (PIGWIN) used in this study were the mixture of a citrus fruit and chestnut tree extract. The implicated bioactive components present in citrus fruits included vitamin C, beta-carotene, flavonoids, limonoids, folic acid, and dietary fiber (Jansen, 2002). A high intake of citrus fruits may reduce the risk of degenerative diseases (Jansen, 2002). Kim et al. (2000) conducted to determine the inhibitory effect of some traditional herbal medicines on the infectivity of rotavirus. They demonstrated that the fruit of citrus aurantium had the most potent inhibitory activity on rotavirus infection. The active components of the fruit of citrus aurantium were neohesperidin and hesperidin. In this experiment, their 50% inhibitory concentrations were 25 and 10 micro M, respectively.

Chestnut extract is the third most important vegetable tannin used for leather production. The extract is prepared by hot water extraction of the bark and timber, followed by spray-dring of the solution. The extract contains approximately 75 percent active tanning substances. The primary component is castalagin, along with small amounts of vescalagin, castalin, and vescalin. A castalagin-based pharmaceutical product is currently in use for prevention and treatment of diarrhea in pigs and cattle caused by changes in diet (Krisper et al., 1992). The beneficial effect is due to prevention of water losses through mucous membranes.

The aim of this study was to investigate the effect of plant extract (citrus fruit and chestnut tree extract mixture) on performance and blood characteristics in weaned pigs fed a corn-dried whey-SBM based diet.

MATERIALS AND METHODS

Animals and diets

One hundred and twenty crossbred [(Duroc×Yorkshire)×Landrace] pigs (6.48±0.53 kg average initial body weight and 23 d average age) were used to determine the effects of plant extract (PE) supplementation on performance and blood characteristics in weaned pigs at the Swine Research Facility, Dankook University, Cheonan, Korea. This experiment was conducted using a randomized complete block design and pigs were assigned by body weight and sex. There were six pigs per pen and four pens per treatment.

Dietary treatments included 1) NC (antibiotic free basal diet), 2) PC (NC diet+100 ppm apramycine and 100 ppm oxytetracycline), 3) PE 0.1 (NC diet+0.1% plant extract, PIGWIN, DAEHO Co. Ltd., Seoul, Korea), 4) PE 0.2 (NC diet+0.2% plant extracts) and 5) PE+AB (PC diet+0.1% plant extracts). Experimental diets were formulated to contain 3,335kcal/kg of ME, 22.00% of CP, 1.45% of lysine, 0.41% of methionine, 0.85% of Ca and 0.70% of P for the weaned pigs (Table 1).

Performance and fecal consistency score measurements

Pigs were allowed to consume feed and water *ad libitum* from a two-hole self-feeder and nipple waterer. Average daily gain (ADG) and average daily feed intake (ADFI)

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Table 1. Basal diet composition (as-fed basis)[1]

Ingredients	%
Extruded corn	43.79
Extruded soybean meal (CP 44%)	19.12
Dried whey	10.00
Fish meal	5.00
Oat	5.00
Soy flour	5.00
Glucose	4.00
Spray-dried plasma protein	3.00
Soybean oil	2.09
Acidifier	1.00
Monocalcium phosphate	0.68
Yeast culture	0.60
Vitamin premix[2]	0.20
Trace mineral premix[3]	0.15
L-lysine-HCl	0.19
DL-methionine	0.03
Choline chloride	0.10
Antioxidant (Ethoxyquin 25%)	0.05

[1] Diets were formulated to contain 3,335 kcal ME/kg, 20.00% crude protein, 1.45% lysine, 0.85% calcium and 0.70% phosphorus.

[2] Provided per kg of complete diet: 20,000 IU of vitamin A; 4,000 IU of vitamin D3; 80 IU of vitamin E; 16 mg of vitamin K_3; 4 mg of thiamin; 20 mg of riboflavin; 6 mg of pyridoxine; 0.08 mg of vitamin B_{12}; 120 mg of niacin; 50 mg of Ca-pantothenate; 2 mg of folic acid and 0.08 mg of biotin.

[3] Provided per kg of complete 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.

were measured on d 10 and 20 and gain/feed ratio was also calculated.

Fecal consistency scoring was based on the following index used by Sherman et al. (1983): 0, normal (feces firm and well formed); 1, soft consistency (feces soft and formed); 2, mild diarrhea (fluid feces, usually yellowish); and 3, severe diarrhea (feces watery and projectile).

Determination of blood constituents

The concentrations of red blood cell (RBC), white blood cell (WBC), lymphocytes, neutrophils and monocytes in the blood were measured to investigate the effect of plant extract supplementation in weaned pigs. Blood samples were collected via jugular vein into K_2 vacuum tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ, USA) from ten pigs in each treatment on the final day of the feeding trial. The concentration of RBC, WBC, lymphocytes, neutrophil and monocytes in the blood were measured using the automatic blood analyzer (ADVIA 120, Bayer, USA).

Statistical analyses

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

RESULTS

The growth, feed intake and feed efficiency of pigs fed the experimental diets are presented in Table 2. For d 0 to 10, there were no significant differences in ADG, ADFI and gain/feed. For d 10 to 20, ADG of pigs fed PE0.2 (365 vs. 323 g/d) and PE+AB (350 vs. 323 g/d) diets was faster than that of pigs fed NC diet ($p<0.05$). However, no differences were found among the treatments for ADFI and gain/feed. Through the entire experimental period, ADG of pigs fed PC (300 vs. 281 g/d), PE 0.2 (310 vs. 281 g/d) and PE+AB (306 vs. 281 g/d) diets was higher than that of pigs fed NC diet ($p<0.05$). However, no differences were found among the treatments for ADFI and gain/feed.

Comparison of fecal consistency score of weaned pigs after PE supplementation is presented in Table 3. At day 2 after the onset of the experiment, FC score of pigs fed PC, PE 0.1, PE 0.2 and PE+AB diets were lower than that of pigs fed NC diet.

The RBC, WBC, lymphocyte, neutrophil and monocyte concentrations of pigs fed the experimental diets are presented in Table 4. However, there was no significant difference among the treatments.

Table 2. Effects of plant extracts supplementation on growth performance in weaned pigs[1]

Item	NC[2]	PC[2]	PE 0.1[2]	PE 0.2[2]	PE+AB[2]	SE[3]
0-10 days						
Average daily gain, g	238	256	245	253	262	8
Average daily feed intake, g	417	420	386	393	404	20
Gain/feed	0.57	0.61	0.64	0.64	0.65	0.03
10-20 days						
Average daily gain, g	323^{b}	343^{ab}	342^{ab}	365^{a}	350^{a}	7
Average daily feed intake, g	527	541	543	553	529	17
Gain/feed	0.61	0.63	0.63	0.66	0.66	0.02
0-20 days						
Average daily gain, g	281^{b}	300^{a}	294^{ab}	310^{a}	306^{a}	7
Average daily feed intake, g	472	481	465	473	467	17
Gain/feed	0.59	0.62	0.63	0.66	0.66	0.03

[1] One hundred twenty pigs with an average initial body weight of 6.48±0.53 kg.

[2] Abbreviated NC, antibiotic free diet; PC, NC diet+100 ppm of apramycin and 100 ppm of oxytetracycline; PE 0.1, NC diet+0.1% of plant extracts; PE 0.2, NC diet+0.2% of plant extracts; PE+AB, PC diet+0.1% of plant extracts. [3] Pooled standard error.

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

Table 3. Comparison of fecal consistency score of weaned pigs after plant extracts supplementation[1]

Item	No. of pigs	No. of pigs with diarrhea on		
		Day 2	Day 4	Day 8
NC[2]	24	12 (1.8)[3]	8 (0.8)	2 (0.4)
PC[2]	24	5 (1.0)	5 (0.8)	0 (0.4)
PE 0.1[2]	24	6 (1.1)	4 (0.6)	1 (0.2)
PE 0.2[2]	24	5 (1.0)	2 (0.2)	0 (0.2)
PE+AB[2]	24	6 (0.9)	2 (0.3)	0 (0.2)

[1] One hundred twenty pigs with an average initial body weight of 6.48±0.53 kg.
[2] Abbreviated NC, antibiotic free diet; PC, NC diet−100 ppm of apramycin and 100 ppm of oxytetracycline; PE 0.1, NC diet−0.1% of plant extracts; PE 0.2, NC diet−0.2% of plant extracts; PE+AB, PC diet−0.1% of plant extracts.
[3] FC score is the mean fecal consistency score: 0, normal; 1, soft feces; 2, mild diarrhea; 3, severe diarrhea. Values in brackets represent mean fecal consistency score.

DISCUSSION

Antimicrobials have been used for more than 50 years to enhance performance and to prevent disease in livestock feeding environments (Gustafson and Bowen, 1997). However, studies 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). Recently, the livestock industry has been literally flooded by alternative production enhancing products with claims similar to antibiotics (Kamel, 2000).

Natural herb products estimated that there were 250,000 to 500,000 species of plants on Earth (Borris, 1996). Only 1 to 10% of these were used as foodstuff (or feedstuff) by both humans and livestock (Cowan, 1999). It is possible that even more were used for livestock medicinal purposes. Useful antimicrobial phytochemicals can be divided into several categories, described in Table 5. The plant extract (PIGWIN) used in this study was a citrus fruit and chestnut tree extract mixture, the bioactive compounds of the mixtures were flavonoids and tannin, respectively. Flavonoid compounds exhibit inhibitory effects against multiple virus. Previous studies have documented the effectiveness of flavonoids against human immunodeficiency virus (Critchfield et al., 1996). Kaul et al. (1985) and Barnard et al. (1993) reported that flavone derivatives were inhibitory to respiratory syncytial virus. Tannins, the bioactive compounds in chestnut tree extract, may be formed by condensations of flavan derivatives

Table 4. Effects of plant extracts supplementation on WBC, RBC, lymphocyte, neutrophil and monocyte concentrations of blood in weaned pigs[1]

Item	NC[2]	PC[2]	PE 0.1[2]	PE 0.2[2]	PE+AB[2]	SE[3]
WBC, $\times 10^3$/mm^3	22.39	24.90	22.04	23.84	23.84	2.36
RBC, $\times 10^6$/mm^3	4.58	4.53	4.84	4.47	4.68	0.30
Lymphocyte, %	39.67	42.60	43.50	46.00	44.40	4.35
Neutrophil, %	46.00	48.60	49.00	46.50	47.25	5.34
Monocyte, %	3.00	3.33	4.17	4.20	4.33	0.77

[1] One hundred twenty pigs with an average initial body weight of 6.48±0.53 kg.
[2] Abbreviated NC, antibiotic free diet; PC, NC diet−100 ppm of apramycin and 100 ppm of oxytetracycline; PE 0.1, NC diet−0.1% of plant extracts; PE 0.2, NC diet−0.2% of plant extracts; PE−AB, PC diet−0.1% of plant extracts. [3] Pooled standard error.

Table 5. Major classes of antimicrobial compounds from plants

Class	Subclass	Example	Mechanism	Reference
Phenolics	Simple phenols	Catechol	Substrate deprivation	Peres et al., 1997
		Epicatechin	Membrane disruption	Toda et al., 1992
	Phenolic acids	Cinnamic acid		Fernandez et al., 1996
	Quinones	Hypericin	Bind to adhesins, complex with cell wall, inactivate enzymes	Duke, 1985
	Flavonoids	Chrysin	Bind to adhesins	Perrett et al., 1995
	Flavones		Complex with cell wall	
		Abyssinone	Inactivate enzymes	Ali-Shtayeh et al., 1997
	Flavonols	Totarol		Kubo et al., 1993
	Tannins	Ellagitannin	Bind to proteins	
			Bind to adhesins	Scalbert, 1991
			Enzyme inhibition	Haslam, 1996
Terpenoids, essential oils		Capsaicin	Membrane disruption	Cichewicz and Thorpe, 1996
Alkaloids		Berberine	Intercalate into cell wall and/or DNA	Atta-ur-Rahman and Choudhary, 1995
Lectins and polypeptides		Mannose-specific agglutinin	Block viral fusion or adsorption	Meyer et al., 1997

Cowan (1999).

which have been transported to woody tissues of plants (Cowan, 1999). Alternatively, tannin may be formed by polymerization of quinone units (Geissman, 1963). This group of compounds has received a great deal of attention in recent years, since it was suggested that the consumption of tannin-containing beverages, especially green teas and red wines, can cure or prevent a variety of ills (Serafini et al., 1994). Scalbert (1991) reviewed antimicrobial properties of tannin. He listed 33 studies which had documented the inhibitory activities of tannin. According to these studies, tannins can be toxic to filamentous fungi, yeasts and bacteria. Jones et al. (1994) showed that condensed tannins have been determined to bind cell walls of intestinal bacteria and prevent growth. Also, O'Donovan and Brooker (2001) suggested that both *Streptococcus gallovticus* and *Streptococcus bovis* were inhibited by the presence of tannins in the medium. Perhaps because of the antimicrobial effects of flavonoids and tannins, our study results indicate that antibiotic can be replaced with PE without influencing performance of weaned pigs. At day 2 after the onset of the experiment, fecal consistency score of PE groups (PE 0.1, PE 0.2 and PE+AB treatments) were similar to PC treatment.

Many researchers have conducted to determine the effects of PE (containing herb and botanicals) supplementation and replacing antibiotic with PE in pigs. Beneficial effects of herb or botanicals in farm animals may arise from activation of feed intake and secretion of digestive enzymes and immune stimulation properties (Wenk, 2003). Also, initial screening of potential antibacterial and antifungal compounds from plants may be with pure substances (Afolayan and Meyer, 1997) or crude extracts (Rojas et al., 1992; Freiburghaus et al., 1996; Silva et al., 1996). Our data are in agreement with those of Holden and McKean (2002) who reported that pigs fed additions of 2 or 3% botanicals had ADG and feed/gain similar to antibiotic controls and improved over the treatment without antibiotic controls. Ilsley et al. (2002) demonstrated that sow feed intake and backfat thickness loss were unaffected by PE. However, this showed greater efficiency in feed utilization for milk production. Jamroz and Kamel (2002) conducted a study to determine the effect of PE (a blend of capsicum, cinnamaldehyde and carvacrol) supplementation on performance in broilers. They showed that broilers fed PE diets were significantly better in daily gain weight and feed conversion. Mavromatis and Kyriakis (1998) carried out a study to determine the effects of PE (Origanum essential oil) as a growth promoter in weaned and growing-finishing pigs. Mortality during the overall experiment period, pigs fed PE diet was lower than that of pigs fed control. Feed intake and gain/feed of PE groups were significantly improved, in comparison to the control. Also, Kyriakis et al. (1998) suggested that ADG was faster for the PE groups than for the control. In conclusion, they argued that PE (Origanum essential oil) seemed to be effective on the control of post weaning diarrhea syndrome.

In conclusion, PE can be used to replace antibiotic in diets for weaned pigs without negative affects on growth performance. Optimal PE levels seemed to be 0.2% and the results obtained point out to a synergic effect of the combination of PE and antibiotic on growth performance in weaned pigs.

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