Effects of Yucca Extract and (or) Far Infrared Emitted Materials Supplementation on the Growth Performance, Serum Characteristics and Ammonia Production of Growing and Finishing Pigs

J. W. Hong, I. H. Kim*, T. H. Moon[1], O. S. Kwon, S. H. Lee and Y. G. Kim[2],
Department of Animal Resource & Science, Dankook University, Cheonan 330-714, Korea

ABSTRACT : For the Exp. 1, a total of fifty four crossbred [(Duroc×Yorkshire)×Landrace] pigs (77.67±1.42 kg average initial BW) were used in a 41-d growth assay to determine the effects of yucca extract supplementation on growth performance, nutrient digestibility and serum characteristics of finishing pigs. Dietary treatments included 1) Control (basal diet), 2) YE60 (basal diet+60 ppm yucca extract), 3) YE120 (basal diet+120 ppm yucca extract). Average daily gain was not improved by yucca extract supplementation during the whole experimental perid (d 0 to 41). Pigs fed control diet showed the best average daily gain. Pigs fed control and YE120 diets tended to increase average daily feed intake compared with pigs fed YE60 diet (quadratic effect, $p<0.0001$). Gain/feed with control treatment was significantly better than the YE groups (linear effect, $p<0.071$). However, there was no significant difference among levels of yucca extract ($p>0.10$). Apparent digestibility of dry matter in pigs fed yucca extract were greater than for pigs fed control diets (linear effect, $p<0.017$). Pigs fed YE120 tended to have higher digestibility of nitrogen than pigs fed the control diets (linear effect, $p<0.019$). There were no significant differences in Total-, HDL- and LDL-cholesterol concentrations of serum, and the blood urea nitrogen (BUN) concentrations in serum was not influenced by the yucca extract supplementation ($p>0.10$). For the Exp. 2, fifteen [(Duroc×Yorkshire)×Landrace] pigs (25.00±0.50 kg average initial BW) were used in a 30-d metabolism experiment to determine the effects of yucca extract supplementation on fecal ammonia gas production. Treatments were : 1) Control (basal diet); 2) YE (basal diet+150 ppm yucca extract); 3) BD (basal diet+100 ppm Bio-Dr; yucca extract+far infrared emitted materials). Fecal ammonia gas production differences between d 0 and d 30 were significantly reduced ($p<0.05$) by feeding BD compared to control and YE. Also, when pigs were fed the diet with YE tended to be decreased ammonia gas production compared to pigs fed the control diet without significant differences ($p>0.05$). There were no differences for DM and N digestibility among pigs fed the treatment diets. In conclusion, yucca and (or) far infrared radiological materials can be used to make environment-friendly diets for growing-finishing pigs without negative effects on growth performance and nutrient digestibility. *(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 9 : 1299-1303)*

Key Words : Yucca Extract, Growth Performance, Cholesterol, BUN, Ammonia Gas

INTRODUCTION

The yucca schidigera extract is a natural plant product derived from the yucca schidigera plant which is native to Southern California and Mexico. Yucca extracts and preparations of the desert plant yucca schidigera, family liiaceae, have a variety of beneficial effects when included in the diet of domestic animals. Yucca extract has insoluble dietary fibers and contains high cellulose. A commercial product made from the plant extract has been used to reduce ammonia and enhance biodegradation of animal waste for over 30 years. Ammonia produced from amino acid degradation in the body is converted to urea in the mammalian liver 20 to 25% of urea is excreted into the gastrointestinal tract and eventually it was hydrolyzed to ammonia by microbial urease (Wrong, 1981). This ammonia has been recognized as a toxin in animals, consequently it caused detrimental affect on growth of animal (Lin and Visek, 1991). Headon and Walsh (1994) demonstrated that 10 ppm ammonia (NH_3) gas in the air can reduce animal performance and 25 ppm NH_3 may induce respiratory and other illness. They also demonstrated that if animal is exposed to 50 ppm NH_3 gas, it caused pneumonia and other respiratory disease as well as poor growth performance of the animal.

The objective of this study was to determine the effect of yucca extract and (or) far infrared emitted materials supplementation on the growth performance, nutrient digestibility, serum cholesterol concentration and ammonia production of feces in growing and finishing pigs fed a corn-soybean meal based diet.

MATERIALS AND METHODS

Experiment 1

Fifty four crossbred [(Duroc×Yorkshire)×Landrace] pigs (77.67±1.42 kg average initial BW) were used in a 41-d growth assay to determine the effects of yucca extract supplementation on growth performance in finishing pigs. This experiment was conducted by randomized complete block (RCB) design and pigs were assigned by body weight

* Corresponding Author: I. H. Kim, Tel: +82-41-550-3652, Fax: +82-41-553-1618, E-mail: inhokim@anseo.dankook.ac.kr.
[1] EASY-BIO SYSTEM, Inc., Korea.
[2] Cheiljedang Feedmill, Korea.
Received March 15, 2001; Accepted May 10, 2001

and sex. There were six pigs per pen and three pens per treatment.

Dietary treatments included 1) Control (basal diet), 2) YE60 (basal diet+60 ppm Yucca extract, EASY-BIO SYSTEM, Inc., Cheonan, Korea), 3) YE120 (basal diet+120 ppm Yucca extract). Experimental diet was formulated to contain 3,400 kcal/kg of ME, 16.20% of CP and 1.00% of lysine for the finishing pigs (table 1). The diet was formulated to meet or exceed the nutrient requirements recommended by NRC (1998). Chromic oxide (Cr_2O_3) was added (0.2% in the diet) as an indigestible marker to allow digestibility determinations.

Pigs were allowed to consume feed and water *ad libitum* from a five-holes self-feeder and cup waterer. Average daily gain and average daily feed intake were measured on d 21 and 41 and gain/feed ratio was also calculated.

Feed and feces were analyzed for DM and N concentrations (AOAC, 1994). Chromium was determined by UV absorption spectrophotometry (Shimadzu, UV-1201, Japan) and apparent digestibilities of DM and N were calculated using the indirect method.

The concentrations of blood urea nitrogen (BUN), Total-, HDL- and LDL-cholesterol in the serum were measured to investigate the effect of yucca extract supplementation on nitrogen and cholesterol metabolism. Blood samples were collected via jugular vein into vacuum tubes from eight pigs in each treatment at the termination of the feeding trial. Blood samples were centrifuged at 2,000×g for 30 min and serum samples were taken and stored at -20°C until analyses for BUN, Total-, HDL- and LDL-cholesterol. Blood urea nitrogen determination was made using Urea Kit (Boehringer Mannheim, Germany), Total- and HDL-cholesterol concentrations were determined by T. chol Kit (Boehringer Mannheim, Germany) and HDL-C Kit (Boehringer Mannheim, Germany), respectively. The concentration of LDL-cholesterol was determined by calculated using the following equation (Barker et al., 1984); total cholesterol concentration - HDL cholesterol concentration - (triglyceride/5) = LDL cholesterol concentration.

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

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

Ingredient, %	Exp. 1	Exp. 2
Corn	54.30	64.38
Soybean meal (CP 48%)	18.71	28.09
Wheat	11.00	-
Animal fat	3.92	3.00
Molasses	2.50	2.00
Tricalcium phosphate	1.22	1.86
Canola meal	4.00	-
Rice bran, polished	3.00	-
Tocopherol (10%)	0.05	-
Limestone	0.47	0.12
Vitamin/trace mineral premix[a]	0.20	0.20
Salt	0.25	0.20
L-lysine	0.23	-
Choline (25%)	0.05	-
Rye	0.05	-
Antioxidant (Ethoxyquin 25%)	0.05	0.05
Antibiotic[b]	-	0.10
Chemical composition[c]		
ME, kcal/kg	3,400	3,380
Crude protein, %	16.20	19.00
Lysine, %	1.00	1.00
Calcium, %	0.70	0.80
Phosphorus, %	0.60	0.70

[a] Provided the following per kg of the complete diet : 11,025 IU of vitamin A; 1,103 IU of vitamin D_3; 44 IU of vitamin E; 4.4 mg of vitamin K; 8.3 mg of riboflavin; 50 mg of niacin; 29 mg of d-pantothenic; 166 mg of choline; 33 μg of vitamin B_{12}; 12 mg of Mn; 165 mg of Fe; 165 mg of Zn; 16 mg of Cu; 0.3 mg of I; 0.3 mg Se.

[b] Provided 50 mg of Carbadox per kg of complete diet.

[c] Calculated values.

Experiment 2

Fifteen crossbred [(Duroc×Yorkshire)×Landrace] pigs (25.00±0.50 kg average initial BW) were used in a 30-d experiment. Pigs were housed in individual stainless steel metabolism cages with slotted floors and designed to separate urine and feces.

Dietary treatments included 1) Control (basal diet), 2) YE (basal diet+150 ppm yucca extract), 3) BD (basal diet+100 ppm Bio-Dr, EASY-BIO SYSTEM, Inc., Cheonan, Korea). Bio-Dr used in this study was a mixture of yucca extract and far infrared emitted materials. Experimental diet was formulated to contain 3,380 kcal/kg of ME, 19.00% of CP and 1.00% of lysine for the growing pigs (table 1). The diet was formulated to meet or exceed the nutrient requirements recommended by NRC (1998). Chromic oxide (Cr_2O_3) was added (0.2% in the diet) as an indigestible marker to allow digestibility determinations.

Pigs were allowed to consume feed and water *ad libitum* from self-feeder and nipple waterer.

The fecal samples (100 g) for ammonia gas measurement were collected twice daily in plastic container at d 0 and d 30. The feces were incubated at 38°C for 48 h. At the end of the 48 h incubation, ammonia gas concentrations were determined by ammonia gas detector (TG-2400KA, Bionics Instrument, Japan).

Feed and feces were analyzed for DM and N concentrations (AOAC, 1994). Chromium was determined by UV absorption spectrophotometry (Shimadzu, UV-1201, Japan) 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 general linear model procedure of SAS (1996).

RESULTS AND DISCUSSION

Experiment 1

Growth performance of pigs fed experimental diet is presented in table 2. For d 0 to 21, average daily gain was not significantly different among treatments ($p>0.10$). However, average daily feed intake (linear effect, $p<0.002$; quadratic effect, $p<0.022$) increased as the concentration of YE in the diets was increased. Gain/feed ratio for pigs fed control was greater (quadratic effect, $p<0.065$) than that of pigs fed yucca extract.

For d 21 to 41, pigs fed control diet grew faster than pigs fed yucca extract. However, there was no significant difference in average daily gain among treatments ($p>0.10$). Average daily feed intake with YE groups was significantly less than control group (linear effect, $p<0.001$; quadratic effect, $p<0.001$). The lowest gain/feed ratio was observed in pigs fed YE120 treatment.

Overall (d 0 to 41), average daily gain was not improved by yucca extract supplementation. Pigs fed control diet showed the best average daily gain. Pigs fed control and YE120 diets tended to increase average daily feed intake compared with pigs fed YE60 diet (quadratic effect, $p<0.001$). Gain/feed ratio with control treatment was significantly better than the YE groups (linear effect, $p<0.071$). However, there was no significant difference among levels of yucca extract ($p>0.10$).

Our data are in partial agreement with those of Brumm et al. (1985), who indicated that the addition of dietary sarsaponin (0.2%) to the growing-finishing pig diets did not affect average daily gain, average daily feed intake and feed conversion. Also, Yen and Pond (1993) showed that yucca extract (125 ppm) additions had no effects on average daily gain, average daily feed intake and gain/feed. Gipp et al. (1988) reported that yucca extract supplementation to diets without an antibiotic did not have any effect on the growth performance, feed consumption and feed conversion ratio.

To the contrary, Foster (1983) reported that pigs fed sarsaponin gained faster and more efficiently compared to the control in growing pigs. These results are in agreement with those of Bae et al. (1999), who showed that average daily gain of pigs fed the yucca extract (125 ppm) diet was significantly improved. Also, Mader and Brumn (1987) and Min et al. (2001) demonstrated that average daily gain of pigs fed yucca extract diet was significantly improved in pigs.

The effects of yucca extract supplementation on fecal nutrient digestibility of finishing pigs are summarized in table 3. Apparent digestibility of DM in pigs fed yucca extract were greater than for pigs fed control diets (linear effect, $p<0.017$). Pigs fed YE120 tended to had higher digestibility of nitrogen than pigs fed the control diets (linear effect, $p<0.019$). However, Bae et al. (1999) reported that digestibilities of DM and N were not affected by the yucca extract supplementation.

As shown in table 4, there were no significant

Table 2. Effects of yucca extract on growth performance in finishing pigs (Exp. 1)[a]

Item	Control	YE60[b]	YE120[b]	SE[c]	Contrast	
					Linear	Quadratic
0-21 days						
Average daily gain, kg	0.770	0.709	0.810	0.099	NS[d]	NS
Average daily feed intake, kg	3.002	3.024	3.304	0.289	0.002	0.022
Gain/feed	0.257	0.234	0.245	0.055	NS	0.065
21-41 days						
Average daily gain, kg	0.925	0.742	0.809	0.069	NS	NS
Average daily feed intake, kg	4.017	3.306	3.696	0.186	0.001	0.001
Gain/feed	0.230	0.224	0.219	0.023	0.029	NS
0-41 days						
Average daily gain, kg	0.848	0.726	0.810	0.044	NS	0.085
Average daily feed intake, kg	3.510	3.165	3.500	0.102	NS	0.001
Gain/feed	0.242	0.229	0.231	0.032	0.071	NS

[a] Fifty four pigs with an average initial weight of 77.67±1.42 kg (SD).
[b] Abbreviated YE60, added yucca extract 60 ppm; YE120, added yucca extract 120 ppm, respectively.
[c] Pooled standard error.
[d] NS : Not significant ($p>0.10$).

Table 3. Effects of yucca extract on nutrient digestibility in finishing pigs (Exp. 1)[a]

Item	Control	YE60[b]	YE120[b]	SE[c]	Contrast	
					Linear	Quadratic
Dry matter, %	81.89	83.21	83.51	0.15	0.017	NS[d]
Nitrogen, %	80.87	82.38	82.77	0.19	0.019	NS

[a] Fifty four pigs with an average initial weight of 77.67±1.42 kg (SD).
[b] Abbreviated YE60, added yucca extract 60 ppm; YE120, added yucca extract 120 ppm, respectively.
[c] Pooled standard error. [d] NS : Not significant ($p>0.10$).

Table 4. Effects of yucca extract on cholesterol and blood urea nitrogen concentrations of serum in finishing pigs (Exp. 1)[a]

Item	Control	YE60[b]	YE120[b]	SE[c]	Contrast	
					Linear	Quadratic
Total cholesterol, mg/dl	89.25	86.00	92.13	4.17	NS[d]	NS
HDL-cholesterol, mg/dl	45.00	44.75	45.71	3.53	NS	NS
LDL-cholesterol, mg/dl	35.95	32.60	40.38	4.74	NS	NS
Blood urea nitrogen, mg/dl	19.43	18.73	19.71	0.90	NS	NS

[a] Blood samples were taken from eight pigs per treatment.
[b] Abbreviated YE60, added yucca extract 60 ppm; YE120, added yucca extract 120 ppm, respectively.
[c] Pooled standard error. [d] NS : Not significant ($p>0.10$).

differences in Total-, HDL- and LDL cholesterol concentrations of serum, and also the blood urea nitrogen concentrations in serum was not influenced by the yucca extract supplementation ($p>0.10$).

Numerous animal and human studies confirmed the pronounced hypocholesterolemic effects of soluble dietary fiber. Also, recent interest has focused on human health, particularly cardiovascular diseases, because of public concern over cholesterol in meat and meat product. Several hypotheses have been proposed to explain the hypocholesterolemic effect of dietary fiber, including binding of bile acids by fiber, interference of lipid absorption and reduced hepatic cholesterol synthesis by propionate. However, Because the yucca extract has insoluble fiber, our results showed that Total-, HDL- and LDL cholesterol concentrations in serum were not influenced by the yucca extract supplementation in finishing pigs.

Experiment 2

Ammonia gas production of pigs fed experimental diet is presented in table 5. The differences of fecal ammonia gas production between d 0 and d 30 were significantly reduced by feeding BD diet compared to control and YE diets. Because Bio-Dr used in the present study was a mixture of yucca extract and far infrared radiological materials, our data indicated that there was synergy effect for reducing fecal ammonia gas production. Kwon (1999) reported that fecal *Lactobacillus sp.* concentrations were significantly increased by far infrared emitted materials to the growing pig diets. Many intestinal bacteria produce urease, however, most *Lactobacillus* strains have been known to produce little urease or other ammonia-generating enzymes (Phear and Ruebner, 1956; Macbeth et al., 1965; Agostini et al., 1972).

Table 5. Effects of yucca extract on ammonia gas production in growing pigs (Exp. 2)[a]

Item	Control	YE[b]	BD[b]	SE[c]
Ammonia gas production				
D 0, ppm	44.00[e]	37.00[e]	64.50[d]	4.30
D 30, ppm	58.13[d]	37.00[e]	34.88[e]	4.93
Difference, ppm	14.13[e]	0.00[e]	-29.63[d]	5.03

[a] Fifteen pigs with an average initial weight of 25.00±0.50 kg (SD).
[b] Abbreviated YE, added yucca extract 150 ppm; BD, added yucca extract+far infrared radiological materials 100 ppm, respectively.
[c] Pooled standard error, [d,e] Means in the same row with different superscripts differ ($p<0.05$).

Pigs fed the diet with YE tended to have decreased fecal ammonia gas production compared to pigs fed the control diet without significant differences ($p>0.05$). Also, Jeon et al. (1996) reported that ammonia concentration in feces was significantly reduced by yucca extract (0.02%) addition. It was hypothesized that one mechanism of action of yucca extract in improving performance of swine might be the reduction of ammonia concentration in the atmosphere of the swine house. Min et al. (2001) demonstrated that NH_3-N content in manure tended to be increased by the increased dietary protein levels and with yucca extract supplementation. Also, Yeo and Kim (1997) showed that yucca extract supplementation to diet did affect on intestinal urease activity in broiler, although net ammonia production shows tendency to be decreased. Rowland et al. (1976) reported that yucca extract may be of significant benefit in reducing ammonia levels in feces. Sutton et al. (1992) also

Table 6. Effects of yucca extract on nutrient digestibility in growing pigs (Exp. 2)[a]

Item	Control	YE[b]	BD[b]	SE[c]
Dry matter, %	87.54	87.91	88.71	0.40
Nitrogen, %	85.36	85.40	85.66	0.71

[a] Fifteen pigs with an average initial weight of 25.00±0.50 kg (SD).
[b] Abbreviated YE, added yucca extract 150 ppm; BD, added yucca extract+far infrared radiological materials 100 ppm, respectively.
[c] Pooled standard error.

found that ammonia emission was significantly suppressed by 55.5% in manure sarsaponin extract.

Proximate nutrients digestibility of pigs fed experimental diets are presented in table 6. Pigs fed YE and BD diets did not find improvements in digestibility of DM and N compared to control diet.

ACKNOWLEDGMENTS

The authors thank EASY-BIO SYSTEM, Inc. for financial support for these experiments.

REFERENCES

Agostini, L., P. F. Down, J. Murison and O. M. Wrong. 1972. Fecal ammonia and pH during lactulose administration in man; Comparison with other cathartics. Gut 13:859-866.

AOAC. 1994. Official methods of analysis (16th Ed.). Association of official analytical chemists. Arlington, VA.

Bae, K. H., T. G. Ko, J. H. Kim, W. T. Cho, Y. K. Han and In K. Han. 1999. Use of metabolically active substances to substitute for antibiotics in finishing pigs. Korean J. Anim. Sci. 41:23-30.

Barker, H. J., J. R. Lindsey and S. H. Weisbroth. 1984. The laboratory rats. Academic Press. Inc. New York. pp. 123-127.

Brumm, M. C., E. R. Peo and T. L. Mader. 1985. Effect of dietary sarsaponin and chlortetracycline on pig performance. J. Anim. Sci. 61(Suppl. 1):312(Abstr.).

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Foster, J. R. 1983. Sarsaponin for growing-finishing swine alone and in combination with an antibiotic at different pig densities. J. Anim. Sci. 57(Suppl. 1):245(Abstr.).

Gipp, W. F., C. W. Newman, D. O. Elliott and N. J. Roth. 1988. Influence of dietary yucca schidigera extract and antibiotic on starter pig performance. J. Anim. Sci. 66(Suppl. 1):330(Abstr.).

Headon, D. R. and G. Walsh. 1994. Biological control of pollutants. Principle of pig science (Ed. D. J. A. Cole, J. Wiseman and M. A. Varley), Nottingham University Press. pp 375-384.

Jeon, B. S., J. H. Kwang, Y. H. Yoo, J. O. Cha and H. S. Park. 1996. Effects of feeding enzymes, probiotics or yucca powder on pig growth and odor-generating substances in feces. Korean. J. Anim. Sci. 38:52-58.

Kwon, K. K. 1999. Effects of biologically activity substances on meat quality and immunity in pig diets. M. S. Thesis. Dankook Univ., Korea.

Lin, H. C. and W. J. Visek. 1991. Colon mucosal cell damage by ammonia in rats. J. Nutr. 121:887-893.

Macbeth, W. A., E. H. Kass and W. V. McDermott. 1965. Treatment of hepatic encephalopathy by alteration of intestinal flora with *Lactobacillus acidophilus*. Lancet. 1:399-403.

Mader, T. L. and M. C. Brumn. 1987. Effect of feeding sarsaponin in cattle and swine diets. J. Anim. Sci. 65(Suppl. 1):9(Abstr.).

Min, T. S., J. D. Kim, J. H. Lee, Y. Hyun, K. S. Sohn and In K. Han. 2001. Effects of yucca extracts and protein levels on growth performance, nutrient utilization and carcass characteristics in finishing pigs. Asian-Aust. J. Anim. Sci. 14:525-534.

NRC. 1998. Nutrient requirement of pigs. National Research Council. Academy Press.

Peterson, R. G. 1985. Design and analysis of experiments. Marcel dekkor, New York.

Phear, E. A. and B. Ruebner. 1956. The in vitro production of ammonia and amines by intestinal bacteria in relation to nitrogen toxicity as a factor in hepatic coma. Br. J. Exp. Pathol. 37:253-262.

Rowland, L. O., J. E. Plyler and J. W. Bradlry. 1976. Yucca schidigera extract effect on egg production and house ammonia levels. Poult. Sci. 55:2086-2090.

SAS. 1996. SAS user guide. release 6.12 edition. SAS Inst Inc Cary NC. USA.

Sutton, A. L., S. R. Goodall, J. A. Patterson, A. G. Mathew, D. T. Kelly and K. A. Meyerholtz. 1992. Effects of odor control compounds on urease activity in swine manure. J. Anim. Sci. 70(Suppl. 1):160(Abstr.).

Wrong, O. M. 1981. Nitrogen compounds. In : The Large Intestine: Its Role in Mammalian Nitrogen and Homeostasis (Ed. O. M. Wrong, C. J. Edmonds and V. S. Chadwick). p. 133. John Wiley and Sons. New Yolk.

Yen, J. T. and W. G. Pond. 1993. Effects of carbadox, copper, or yucca shidigera extract on growth performance and visceral weight of young pigs. J. Anim. Sci. 7:2140-2146.

Yeo, J. M. and K. I. Kim. 1997. Effects of feeding diets containing an antibiotic, a probiotic, or yucca extract on growth and intestinal urease activity in broiler chicks. Poult. Sci. 76:381-385.