Journal of Animal and Feed Sciences, 13, 2004, 625–634

Effects of probiotics and selenium combination on the immune and blood cholesterol concentration of pigs*

I.-T. Yu[1,3], C.-C. Ju[2], J. Lin[1], H.-L. Wu[1] and H.-T. Yen[1]

[1]Division of Applied Biology, Animal Research Institute Taiwan
P.O. Box 23, Chunan 35099, Miaoli, Taiwan
[2]Council of Agriculture, Taipei, Taiwan

(Received 12 May 2004; revised version 12 July 2004; accepted 25 October 2004)

ABSTRACT

Ninety-six weanling piglets (four weeks old) were randomly assigned into four treatments as follows: 1. control group, 2. probiotics group, 3. probiotics combined with 0.3 ppm organic selenium and 4. carbadox group. Collected data was analysed by using the GLM program of SAS (1990), and each of the two groups was compared using Duncan's test, while the GLM analysis was significant.

The experimental results revealed no influence on pig growth performance by the addition of probiotics alone or with the selenium. The immunoglobulin–G concentration of the probiotics with the 0.3 ppm selenium group was the highest among the four groups, and significantly ($P<0.05$) higher than in the control group. The mortality of the piglets (all survived) and the very-low-density lipoprotein cholesterol (VLDL) concentration of the probiotics group was the lowest ($P<0.05$) among the four groups for the probiotic and with selenium groups when compared to the control and carbadox groups.

KEY WORDS: probiotics, organic selenium, growth, immune, pig

INTRODUCTION

The widespread use of antibiotics in animals to control disease and promote growth has long caused consumer concern due to bacterial resistance and allergenic effects in humans (Williams and Heymann, 1998). Although the use of antimicrobials for growth promotion in livestock diets is still permitted in the United States, the European Union (EU) has decided to ban all growth-promoting antibiotics used in

* Supported by the Council of Agriculture of the Republic of China, Contract No. 92 AS-3.2.1-AD-U1
[3] Corresponding author: e-mail: ity@mail.atit.org.tw

animal feed, driving animal nutritionists and producers to devise natural alternatives for commercial pig farms to reduce the risk of higher mortality and poor growth performances following the ban on the use of antibiotics in feed.

Probiotics generally refers to a live culture of microorganisms, such as lactic acid bacteria (LAB), that exerts a beneficial effect on the host by improving the indigenous microbial balance. The most widely used probiotic LAB are lactobacilli and bifidobacteria that can survive in the intestine. Extensive studies on the beneficial effects on human health of these species have been reported (Perdigon et al., 1990; Benno et al., 1996). It has been confirmed that a culture of *Lactobacillus acidophilus* actively taking up cholesterol from laboratory media and it has beneficially influenced serum cholesterol levels (De Rodas et al., 1996). Besides, the use of *Lactobacillus* and *Bifidobacterium* sp. have been found functions include inhibiting pathogenic bacteria, antitumour and anticholesterolaemic activity, improving digestion, and stimulating the immune system (Piard and Desmazeaud, 1991; Adachi, 1992 ;Wu et al., 2001; Lin et al., 2002). Supplementing LAB to piglets also found promotes body weight gain, increases feed conversion, enhances the colonization of beneficial bacteria, and reduces levels of harmful intestinal bacteria. Our previous experiment found that *Lactobacillus acidophilus*, *L. pentose* and *Bacillus subtilis* mixture could modulate intestinal microbes, stimulate immune response, and reduce serum cholesterol (Lin et al., 2002). However, some other studies have failed to find any improvement in growth performance (Harper et al., 1983).

Additionally, selenium is recognized as an essential mineral for animals. Selenium has been added to farm animal diet in inorganic form as sodium selenite. However, because of its poorer bioavailability and the fact that it is an oxidant of inorganic selenium, sodium selenium could be replaced by organic selenium as a mineral supplement. Selenium deficiency is well known to reduce both cellular and humoral immune function in humans and laboratory animals (Combs and Combs, 1986), in animal reproduction performance (Keating and Caffrey, 1989) as well as in failure of antioxidant membrane protection (Combs and Combs, 1986). The use of selenium in domestic animal diet has been confirmed to improve immune response in pigs (Lessard et al., 1991; Wuryastuti et al., 1993), decrease total cholesterol and triglyceride level (Kang et al., 2000), and decrease drip loss in broilers (Naylor et al., 2000). Due to both probiotics and selenium being immune stimulators, probiotics (such as *L. acidophilus*) can also concentrate selenium in cells, which is assumed to help the combination of probiotics and selenium to enhance animal immune responses. Additionally, researchers recently discovered an unexpected result, namely that selenium may act on lower low-density cholesterol (LDL) and raise high density cholesterol (HDL). This study therefore examines the combination of probiotics and selenium on pig immune responses, growth performances and blood cholesterol concentration.

MATERIAL AND METHODS

Animals and diet treatments

Ninety-six four-week old weaned pigs were randomly assigned to four treatments, with four pigs per pen and six pens per treatment. The four treatments (TRT) were as follows: 1. TRT1 (control feed, maize-soyabean based diet, without additives), 2. TRT2: TRT1 added with 0.3% probiotics, a mixture consisting *Lactobacillus acidophilus*, *Lactobacillus pentose* and *Bacillus subtilis*, with the final concentration of each bacterial count being 10^9 CFU/g,

TABLE 1

Ingredients and diet formulation of experimental diets

Items	Treatments (TRT)[a]			
	1	2	3	4
Ingredients, %				
maize, dent yellow	55	55	55	55
soyabean meal, solvent, 44%	16	16	16	16
whey, dried	14	14	14	14
fishmeal, anchovy, 65%	5	5	5	5
fermented soyabean meal, 49%	7	7	7	7
limestone, 38%	0.8	0.8	0.8	0.8
phosphate, monobasic	1.02	1.02	1.02	1.02
salt	0.37	0.37	0.37	0.37
L-lysine-Hcl	0.01	0.01	0.01	0.01
vitamin premix[b]	0.1	0.1	0.1	0.1
mineral premix[c]	0.1	0.1	0.1	0.1
zinc oxide	0.2	0.2	0.2	0.2
probiotics	-	0.3	0.3	-
Carbadox	-	-	-	0.055
organic selenium	-	-	0.03	-
Nutrient composition (calculated value)				
crude protein,%	21	21	21	21
lysine,%	1.05	1.05	1.05	1.05
Ca,%	0.95	0.95	0.95	0.95
P,%	0.75	0.75	0.75	0.75
digestible energy, kcal/kg	3550	3550	3550	3550

[a] TRT 1:Control (C) TRT 2: (C) added with 0.3% probiotics
TRT 3: TRT 2 added with 0.3 ppm selenium TRT 4: (C) added with 55 ppm carbadox

[b] each kg of vitamin pre-mix contained, mg: retinol 1800; cholecalciferol 20; g: α- tocoperol 20; riboflavin 4; cyanocobalamin 0.02; pantothenic acid 12; niacin 40; folic acid 0.4; biotin 0.1; choline chloride 50

[c] each kg of trace mineral pre-mix contained, g: Cu 4.5; Fe 70; Mn 15; Zn 80; I 0.3

3. TRT3: TRT2 added with 0.3 ppm organic selenium, and 4. TRT4: TRT1 added with 55 ppm carbadox. Table 1 lists the ingredients and nutrient composition of the experimental diets. The probiotics mixture (spray-dried powder) of 0.3% was mixed with other ingredients (Table 1) in dry-mesh form before feeding. Feed was admimistered in dry-mesh form, and was completely consumed within five days after prepared. Before completely consumed, feeds were stored in room temperature in a cool, shady and dry place, and the survival rate of bacterial in feed after five days of storage in room temperature is still higher than 90% (unpublished data). Feeds and water were administered *ad libitum*, and pig body weight and feed intake were measured every two weeks to assess growth performance, including average daily gain (ADG), feed intake (FI) and feed conversion ratio (FCR). This trial ended when pig body weight reached 35 kg.

Blood withdrawal and immune response assay

Piglets were intramuscularly injected with 20 μg/kg liveweight of lipopolysaccharides (LPS, serotype 055:B5, Sigma Chemical, St Louis, MO) one week before the end of the trial. LPS was injected intramuscular (im) in the neck behind the ears of pig to simulate the situation of piglets suffering *E. coli* attack. A blood sample (8 ml) was obtained from the superior vena cava of all piglets before LPS injection, and at 1 h, 2 h and 6 days following injection. After coagulation for 1 h at room temperature, blood clots were centrifuged (2500 g for 20 min at 4°C) and serum was removed and preserved at -20°C for subsequent measurement of serum immunoglobulin-G (IgG) and tumor necrosis factor-α (TNF-α) concentrations. Total serum IgG concentrations were detected using an ELISA kit of porcine IgG (ICN Pharmaceuticals Inc., Ohio, USA). An ELISA porcine TNF-α kit (Endogen, Cambridge, MA) was used to assess total serum TNF-α. Serum samples were assayed in duplicate at either 1:1 or 1:10 dilution. The assay was sensitive to 10 pg/ml of TNF-α and had an intra-assay CV of 10.8%.

Blood cholesterol concentration analysis

Serum cholesterol content, including total cholesterol (TC), high-density lipoprotein cholesterol (HDL) and triglycerides (TRIG), was determined using enzymatic methods from commercially available kits (VITROS Cholesterol Kit, Ortho-Clinical Diagnostics, Johnson and Johnson Company, USA) that are suited to routine analysis, and the very-low-density lipoprotein cholesterol (VLDL) content, as obtained by TRIG divided by 5, and low-density lipoprotein cholesterol (LDL), were obtained by TC subtracts HDL and VLDL concentrations.

Blood cell characteristic assay

Blood cells, including white blood cell (WBC), red blood cell (RBC), platelet (PLT) and haemoglobin (HGB) concentration, are determined using Hematologic Analyser 7290 (Roche Diagonostic System Co., USA).

Statistical analysis

The least square means and their corresponding standard errors are obtained using the LSMEANS method (SAS, 1996). Moreover, the effects of dietary treatments on ADG, FI, FCR and on TNF-α, IgG concentrations, as well as on TC, HDL, LDL, VLDL and TRIC concentrations, are analysed using the General Linear Models and compared using the Duncan's new multiple range test procedure.

RESULTS AND DISCUSSION

Table 2 lists the growth performances and immune responses of piglets given probiotics alone, or given probiotics combined with 0.3 ppm selenium as well as carbadox alone. Different probiotics, including *Lactobacillus* spp., *Bacillus* spp., *Streptococcus* spp., the yeast *Saccharomyces cerevisiae*, and combinations of these organisms have been widely used in commercial farm animals. However, probiotics supplementation to piglets to improve growth performance has shown variable results, and the precise mode of action through which probiotics exert their positive influence remains uncertain (Turner et al., 2001). No difference in growth performance was observed for pigs fed diets with added *Lactobacilli* (Harper et al., 1983) or *Bacilli* (Kornegay and Risley, 1996). However, improved growth performance and reduced incidence of *E. coli* in faeces was noted when *Lactobacilli* or *Bacillus* spp. (Succi et al., 1995) was added to the diet. In this study, growth performance is not improved when the diet is supplemented with probiotics and 0.3 ppm selenium. Meanwhile, the FI of pigs fed diet supplemented with carbadox (TRT4) is significantly ($P<0.05$) lower than for those fed diet supplemented with TRT1 and TRT2, leading to a trend of improving the FCR for carbadox treatment. Carbadox is an antimicrobial and has been used to prevent dysentery and decrease disease as well as to improve growth performances of pigs for many years. The failure of carbadox to stimulate growth performance in this study was unexpected. However, in some situation, such as in clean or hygienic place, the beneficial effect of antimicrobials may be minor (Cromwell, 2001). The nursery building were cleaned with high pressure water and disinfected, so the pens were clean

TABLE 2

Growth performances and immune responses of piglets after treatment

Parameters	Treatments (TRT)[a]					
	1	2	3	4	SE	significance
Growth performance						
daily gain, kg	0.42	0.40	0.41	0.38	0.01	NS
feed intake, kg/d	0.73[a]	0.75[a]	0.66[ab]	0.62[b]	0.06	*
feed/gain ratio	1.78	1.88	1.69	1.66	0.02	NS
Immune responses						
immunoglobulin-G, mg/ml						
pre-LPS/Sal	22.2	23.5	23.8	21.7	0.79	NS
1 h post LPS/Sal	24.5	23.8	23.7	25.0	0.62	NS
2 h post LPS/Sal	18.8	20.5	21.5	17.6	1.02	NS
6 d post LPS/Sal	24.1[b]	28.1[ab]	28.9[a]	28.4[ab]	0.76	*
Tumor Necrosis Factor-α, pg/ml						
pre-LPS/Sal	59.4	62.8	54.6	58.7	6.2	NS
1 h post LPS/Sal[b]	4076	5040	3778	3969	302	NS
2 h post LPS/Sal[b]	471	600	572	607	56	NS
6 d post LPS/Sal[b]	42	63	51	54	4	NS
Survival rate, %	83	100	88	92	-	-

[a] TRT1: control (C) TRT2: (C) added with 0.3% probiotics
TRT3: TRT2 added with 0.3 ppm selenium TRT4: (C) added with 55 ppm carbadox
NS: $P>0.05$ *: $P<0.05$

[b] LPS/Sal: lipopolysaccharide powder (LPS) was dissolved into 0.9% of salt solution (normal salime, Sal) before injection to make a final solution of LPS at the concentration of 200 μg/ml

enough at the beginning of the study, which may have been a contributing factor. The similar result also appeared in the study of White et al. (2002).

Immunoglobulin - G (IgG) concentration is higher for TRT2, TRT3 and TRT4 than for TRT1 on the sixth day following LPS injection, and is significantly higher for TRT3 than for TRT1. As mentioned above, both probiotics and selenium stimulate immune responses. This work also found this result. Moreover, when combine probiotics with 0.3 ppm Se, the stimulation strength on immune tended to be enhanced (TRT3 compared with TRT2). TRT3 also tended to be higher than TRT4 (carbadox treatment), this observation result revealed the additional benefit of increasing serum IgG concentration when 0.3 ppm Se combined with probiotics was used in piglet diet.

TNF-α, a potent cytokine, was first identified as a serum protein that caused tumor necrosis in mice. The response of TNF-α concentration appears not always to accord with IgG concentration. When bacterial endotoxin prevails, macrophages excrete TNF-α, which controls different leukocyte activity, and regulates and optimizes the immune and inflammatory responses (Webel et al., 1997). TNF-α also regulates the acute phase response, induces the prosecution of other immunoregulatory cytokines, and activates T cells, B cells, NK cells, and neutrophils (Wells et al., 1999). In the current study, LPS injection sharply raised ($P<0.05$) TNF-α concentrations of all treatment groups to a level similar at 1h post injection. No significant difference in TNF-α concentration was noted among the four treatments, although the concentration of TRT 2 (probiotics group) tended to be higher than that of TRT 1 (control group). The survival rate of the piglets in the whole study period is higher for TRT 2 (100%) than for the other three groups (83, 88 and 92% for TRT 1, 3 and 4, respectively), which seems to agree with the TNF-α and IgG concentration for TRT 2, but survival rate of piglets does not respond to TRT 3, which TNF-α concentration is tended but slightly lower than TRT 1.

Excessive cholesterol levels are associated with cardiovascular problems leading to coronary failure. High cholesterol content in pork disadvantaging consumers. Probiotics supplementation influences the concentration of some blood metabolites and the reduction of serum cholesterol and triglyceride (Noh et al., 1997). The proven *in vitro* cholesterol assimilation of *Lacbacilli* strains probably causes this *in vivo* observed lowering effect (Gilliland et al., 1985), and this assimilation of cholesterol and deconjugation of bile salt reduced serum cholesterol by affecting the enterohepatic cycle (De Rodas et al., 1996). Result of serum analysis in this study found that the addition of probiotics tended to reduce TC, LDL, TRIG and increase HDL, but only VLDL was significantly ($P<0.05$) reduced by using probiotics. This result agreed with the findings of some *in vitro* (Gilliland et al., 1985; Brashears et al., 1998; Usman, 1999), or *in vivo* studies (De Rodas et al., 1996; Noh et al., 1997).

The beneficial influence of probiotics on serum cholesterol levels considered cholesterol incorporated into or attached to bacteria in the intestine is likely to be unavailable for absorption into the blood, and the ability to incorporate cholesterol into or attach it to bacteria has been equated with the ability to remove cholesterol from media (Kimoto et al., 2002).

In this study, selenium in combination with probiotics did not display any additive effect on lowering serum cholesterol concentration, although this tended ($P>0.05$) to reduce TC, VLDL, TRIG and increase HDL concentrations. Moreover, an *in vivo* study showed that selenium supplementation decreases total cholesterol and triglyceride levels in humans (Yilmaz et al., 1997); however, no similar results have been observed in pigs *in vivo*. This result seems to need further study to confirm.

TABLE 3

Serum cholesterol and characteristics assay

Parameters	Treatment (TRT)[a]					
	1	2	3	4	SE	significance
Serum cholesterol, mg/dl[b]						
TC	55.4	47.2	50.5	51.7	3.71	NS
LDL	47.9	44.9	48.4	41.6	3.71	NS
VLDL	5.47[a]	4.89[b]	5.07[ab]	5.80[a]	0.14	*
HDL	10.5	18.9	16.3	10.2	1.67	NS
TRIG	27.8	27.3	26.3	26.7	0.69	NS
Blood characteristics[c]						
WBC, × 10^3/μl	20.8	19.8	18.7	20.2	0.64	NS
RBC, × 10^6/μl	5.26[b]	5.29[b]	5.75[ab]	5.84[a]	0.08	*
PLT, × 10^3/μl	329	308	363	327	18.22	NS
HGB, × g/dl	9.00	9.10	9.05	9.65	0.13	NS

[a] TRT1: control (C) TRT2: (C) added with 0.3% probiotics TRT3: TRT2 added with 0.3 ppm selenium TRT4: (C) added with 55 ppm carbadox

[b] TC: total cholesterol LDL: low-density lipoprotein cholesterol
VLDL: very-low-density lipoprotein cholesterol
HDL: high-density lipoprotein cholesterol TRIG: triglycerides

[c] WBC: white blood cell RBC: Red blood cell PLT: Platelet
HGB: haemoglobin
NS: P>0.05 *: P<0.05

The function of RBC is known to be to carry oxygen from the lungs to the body tissue and organs, and to carry carbon dioxide back to the lungs where it is excreted. Excessively low density of RBC will cause anaemia and threaten health. Meanwhile, higher density of RBC in a normal range should benefit health. Blood cell characteristic analysis reveals that probiotics supplementation did not increase erythrocyte (RBC) concentration, but if combined with selenium, erythrocyte concentration tended to be enhanced. Notably, the RBC concentration is markedly higher (P<0.05) for carbadox treatment (TRT4) than for TRT 1. Although many data have demonstrated that the addition of carbadox can improve pig growth performance and reduce diarrhoea, no data has yet emerged demonstrating the increase in RBC concentration following carbadox addition. Whether this finding can explain any beneficial effect on pigs following the dietary addition of carbadox needs further investigation.

CONCLUSIONS

Probiotics inclusion in piglet diet demonstrated decreased (P<0.05) bad serum cholesterol (VLDL) concentration and tended (P>0.05) to reduce other cholesterols (LDL and TC) and increase HDL and serum IgG concentration. Moreover, the survival rate (100%) for the probiotics group is the highest among the four groups, but no effect was observed on growth performance and blood characteristics. The addition of 0.3 ppm selenium with probiotics in piglet diet exhibited an additive effect on increasing serum IgG concentration ($P<0.05$) six days following LPS injection, and tended ($P>0.05$) to decrease serum TC and VLDL concentration and increase HDL concentration.

ACKNOWLEDGEMENTS

BION TECH INC. is appreciated for their providing partial testing material freely.

REFERENCES

Adachi S., 1992. Lactic acid bacteria and the control of tumours. In: B.J.B. Wood (Editor). The Lactic Acid Bacteria in Health and Disease. Elsevier Applied Science, London, pp. 233-262

Benno Y., He F., Hosoda M., Hashimoto H., Kojima T., Yamazaki K., Iino H., Mykkanen H., Salminen S., 1996. Effects of Lactobacillus GG yogurt on human intestinal microecology in Japanese subjects. Nutr. Today, Suppl. 31, 9S-11S

Brashears M.M., Gilliland S.E., Buck L.M., 1998. Bile salt deconjugation and cholesterol removal from media by *Lactobacillus casei*. J. Dairy Sci. 81, 2103-2110

Combs G.F., Combs S.B., 1986. The Role of Selenium in Nutrition. Academic Press, New York

Crommwell T.L., 2001. Antimicrobial and promivrobial agents. In: A.J. Lewis, L.L. Southern (Editors). Swine Nutrition. CRC Press, Boca Raton, FL

De Rodas B.Z., Gilliland S.E., Maxwell C.V., 1996. Hypocholesterolemic action of *Lactobacillus acidophilus* ATCC 43121 and calcium in swine with hypercholesterolemia induced by diet. J. Dairy Sci. 79, 2121-2128

Gilliland S.E., Nelson C.R., Maxwell C., 1985. Assimilation of cholesterol by *Lactobacillus acidophilus*. Appl. Environ. Microbiol. 49, 377-381

Harper A.F., Kornegay E.T., Bryant K.L., Thomas H. R., 1983. Efficacy of virginiamycin and a commercially-available *lactobacillus* probiotic in swine diets. Anim. Feed Sci. Tech. 8, 69-76

Kang B.P., Bansal M.P., Mehta U., 2000. Hyperlipidermia and type 15'-monodeiodinase activity: regulation by selenium supplementation in rabbits. Biol. Tr. Elem. Res. 77, 231-239

Keating K.I., Caffrey P.B., 1989. Selenium deficiency induced by zinc deprivation in a crus. Proc. Nat. Acad. Sci. USA 86, 6436-6440

Kimoto H., Ohmomo S., Okamto T., 2002. Cholesterol removal from media by Lactococci. J. Dairy Sci. 85, 3182-3188

Kornegay E.T., Risley C.R., 1996. Nutrient digestibilities of a corn-soybean meal diet as influenced by Bacillus products fed to finishing swine. J. Anim. Sci. 74, 799-805

Lessard M., Yang W.C., Elliott G.S., Rebar A.H., Van Vleet J.F., Deslauriers N., Brisson G.J., Schultz R.D., 1991. Cellular immune responses in pigs fed a vitamin E and selenium-deficient diet. J. Anim. Sci. 69, 1575-1582

Lin J., Lin E.C., Yu I.T., Liu H.T., Yang I.S., Huang C.H., 2002. Effect of probiotic supplementation on growth performance, serum cholesterol and triglyceride, immune responde and fecal bacteria in early weaned piglets. Agr. Assn. China 91, 3 (4) 325-336

Naylor A.J., Choct M., Jacques K.A., 2000. Effects of selenium source and level on performance and meat quality in male broilers. Poultry Sci. 79, Suppl. 1, 117 (Abstr.)

Noh D.O., Kim S.H., Gilliland S.E., 1997. Incorporation of cholesterol into the cellular membrane of *Lactobacillus acidophilus* ATCC 43121. J. Dairy Sci. 80, 3107-3113

Perdigon G., Alvarez S., de Macias M.E.N., Roux M.E., de Ruiz Holgado A.P., 1990. The oral administration of lactic acid bacteria increase the mucosal intestinal immunity in response to enteropathogens. J. Food Protect. 53, 404-410

Piard J.C., Desmazeaud M., 1991. Inhibiting factors produced by lactic acid bacteria. I. Oxygen metabolites and catabolsom end-products. Lait 71, 525-541

SAS Institute, 1996. SAS User's Guide: Statistics. SAS Institute, Cary, NC

Succi G., Sandrucci A., Tamburini A., Adami A., Cavazzoni V., 1995. Effects of using a new strain of *Bacillus coagulans* as a probiotic on the performance of piglets. Riv. Suinicol. 36, 59-66

Turner J.L., Dritz S.S., Minton J.E., 2001. Alternatives to conventional antimicrobials in swine diets. Prof. Anim. Scientist. 17, 217-226

Usman A.H., 1999. Bile tolerance, taurocholate deconjugation, and binding of cholesterol by *Lactobacillus gasseri* strains. J. Dairy Sci. 82, 243-248

Webel D.M., Finck B.N., Barker D.H., Johnson R.W., 1997. Time course of increased serum cytokines, cortisol, and urea nitrogen in pigs following intraperitoneal injection of lipopolysaccharides. J. Anim. Sci. 75,1514-1520

Wells S.M., Kew S., Yaqoob P., Wallace F.A., Calder P.C., 1999. Dietary glutamine enhances cytokine production by murine macrophages. Nutrition 15, 881-884

White L.A., Newman M.C., Cromwell G.L., Lindemann M.D., 2002. Brewers dried yeast as a source of mannan oligosaccharides for weanling pigs. J. Anim. Sci. 80, 2619-2628

Williams R.J., Heymann D.L., 1998. Containment of antibiotic resistance. Science 279, 1153

Wu J.F., Hsu J.B., Cheng C.S., Hsyu J.N., 2001. Microbial supplements in pig diets 1. Growth benefit and cost consideration in the replacement of antibiotics in diets for growing-finishings pigs. Agr. Assn. China 90, 2 (1), 16-23

Wuryastuti H.H., Stowe D., Bull R.W., Miller E.R., 1993. Effects of vitamin E and selenium on immune responses of peripheral blood, colostrum, and milk leukocytes of sows. J. Anim. Sci. 71, 2464-2472

Yilmaz O., Celik S., Cay M., 1997. Protective role of intraperitioneally administered vitamin E and selenium on the levels of total lipid, total cholesterol, and fatty acid composition of muscle and liver tissues in rats. J. Cell. Biochem. 64, 233-241

STRESZCZENIE

Wpływ kombinacji probiotyków i selenu na odporność i stężenie choresterolu w krwi prosiąt

Dziewięćdziesiąt sześć odsadzonych prosiąt, w wieku 4 tygodni, podzielono na 4 grupy: 1. kontrolna, 2. z dodatkiem probiotyków, 3. z dodatkiem kombinacji probiotyków z 0,3 ppm selenu organicznego i 4. z dodatkiem carbadoxu. Uzyskane dane poddano analizie statystycznej z zastosowaniem programu GLM, SAS (1990), i każdą z dwóch grup porównywano stosując test Duncana, wówczas gdy wyniki analizy GLM były istotne.

Nie stwierdzono wpływu dodatku samego probiotyku lub w kombinacji z selenem na wzrost prosiąt. Stężenie immunoglobiny G w grupie 3 (probiotyk + Se) było najwyższe i istotnie większe niż w grupie kontrolnej. Stężenie choresterolu VLDL było najniższe w grupie 2 ($P<0,005$) i różniło się istotnie w porównaniu z grupą kontrolną oraz z dodatkiem carbadoxu (grupa 4).