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## 学位論文全文に代わる要約 Extended Summary in Lieu of Dissertation

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Name

学位論文題目 : Study on the development of natural substances to improve pig growth performance  
Title of Dissertation due to activated digestive and immune systems  
(活性化された消化器系および免疫系による豚の成長を改善させるための天然物質の開発に関する研究)

学位論文要約 :  
Dissertation Summary

Population of the world were increase pork production is an important industry because most people are in favor of consuming pork. Demand of meat production were increase followed for population This causes the continuous promotion of both manufacturing and productivity. The number of both major and minor agriculturists who are interested in swine farming is increasing

However, at the present time, the pork production industry is confronting major problems such as diarrhea found in piglets and weaner pigs. The most important point during the pig breeding is diarrhea of piglets due to the stress and changes of feeding method by the isolation with the mother pig at weaning Additionally, disease infection found until the grower pig period is also important problems. The way to solve these problems, the management to keep piglets healthfully duo to activating instinctive homeostatic functions is important. On the other hand, the immune system is fundamental system to keep healthy body, and the intestine is also the most important organ for improving animal growth.

Thus author tried to improve the supplementation to activate these immune and digestive system in addition to mineral in basal diets. Besides, to effectively produce pigs the breed improvement has been carried out. However, suitable diets for crossbred pigs are not improved. At the beginning, new mineral supplementation was developed for piglets. As final results, the following 6 kinds of natural feed additive were obtained as effective supplementation for improved growth performance due to elevated immune and intestinal function.

Development of *Bacillus subtilis* MP and Effective Utilization on Productivity and Microorganisms in Feces of Suckling Piglets. The effects of newly developed *Bacillus subtilis* MP9 and MP10 from fermented soybean on the productive performance and number of microorganisms in feces, 80 suckling piglets (Large White x Landrace x Duroc) were randomly divided into four groups. From 3-day-old, piglets were consecutively hand-fed 10 ml/pig/day of phosphate-buffered saline (control group), *Bacillus subtilis* MP9 ( $10^{11}$  CFU/ml.) (MP9 group), and *Bacillus subtilis* MP10 ( $10^{11}$  CFU/ml.) (MP10 group) until 10-day-old for 7 days. Another group of 3-day-old piglets were consecutively hand-fed 1 g of an antibiotic (Chlortetracycline)/pig/day until 6 -day-old for 3 days (antibiotic group).

Body weight was recorded at 3, 7, 14, 21, and 28 days of age. Diarrhea incidence was observed from 3 to 21 days of age. A diarrhea score was calculated using a scale from 0 to 1 (0 = no diarrhea, 1 = diarrhea). At 7 and 11 days of age, fresh feces were collected to be analyzed for *Escherichia coli*, *Salmonella* spp, *Lactobacillus* spp, and *Bacillus subtilis* MP (total of MP9 and MP10).

Compared with the control, the average daily weight gain from 1 to 28 days of age was increased in the MP9 and MP10 groups ( $P < 0.05$ ), not increased in the antibiotic group, and better in MP groups than the antibiotics group. Mean diarrhea score and numbers of piglets with diarrhea were better in the MP9 and MP10 groups than in the control. Periods of diarrhea were shorter in all the experimental groups except the control ( $P < 0.05$ ); the MP9 and MP10 groups tended to have shorter periods than the antibiotic group. *Escherichia coli* and *Salmonella* spp. were suppressed, and *Lactobacillus* spp. and *Bacillus subtilis* MP were increased at 11 days of age in the MP9 and MP10 groups ( $P < 0.05$ ). However, *Escherichia coli* was not suppressed, and *Bacillus subtilis* MP was not

increased in the antibiotics group.

The present data suggest that *Bacillus subtilis* MP9 and *Bacillus subtilis* MP10 have a growth promoting activity, due to their suppressing diarrhea during the new-born to weaning period in piglets by competing with pathogenic gut flora, and by stimulating effective microorganisms. The *Bacillus subtilis* MP9 and MP10 are promising alternatives to antibiotics for use as a feed supplement in piglet diets.

Histological alterations of intestinal villi and epithelial cells after feeding dietary sugar cane extract in piglets. The effects of sugar cane extract (SCE) on the piglet intestinal histology were observed. Twelve castrated male piglets weaned at the age of 26 days were allotted to three groups fed diets containing 0, 0.05 or 0.10% SCE. At the end of feeding experiment, each intestinal segment was taken for light or scanning electron microscopy. Feed intake, body weight gain and feed efficiency did not show a difference among groups. Most of the values for villus height, villus area, cell area and cell mitosis numbers were not different among groups, except for that the villus area of the 0.10% SCE group and the cell area of both SCE groups increased significantly at the jejunum compared to the control ( $P < 0.05$ ). For cell mitosis numbers, the 0.10% SCE group was higher than the 0.05% SCE group at the jejunum. Compared with the majority of flat cells of each intestinal segment in the control, the SCE groups had protuberated cells. In the 0.05% SCE group, deeper cells at the sites of recently exfoliated cells in the duodenum, cell clusters aggregated by protuberated cells in the jejunum and much more protuberant cells in the ileum were observed. These histological intestinal alterations suggest that SCE could raise the functions of intestinal villi and epithelial cells, especially at the 0.05%.

Effect of turmeric (*Curcuma longa* Linnaeus) on growth performance, nutrient digestibility,

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hematological values, and intestinal histology in nursery pigs. The effects of dietary turmeric on growth performance, nutrient digestibility, hematological and biochemical values, and intestinal histology in nursery pigs. A total of 48 nursery pigs were divided into groups receiving 0.00%, 0.05%, 0.10%, and 0.20 %turmeric in the feed, with four replicates. Experiment 1: visceral organs and light microscopic parameters (eg, intestinal villus height) were measured at 30 kg body weight (BW). Epithelial cell morphology on the villus apical surface was observed using a scanning electron microscope. Experiment 2 blood was collected at 40 and 80 kg BW for hematology, triglyceride, and cholesterol assays. Growth performance was compared at 90 kg BW. Growth performance and weight of carcass and visceral organs did not differ between turmeric and control groups, but nutrient digestibility was higher in the 0.10% group ( $P < .05$ ). Duodenal weight was lower in all treated groups than in the controls, and ileal weight was lower in the 0.10% and 0.20% groups ( $P < .05$ ). At 80 kg BW, hematocrit was lower in 0.10% group ( $P < .05$ ). White blood cell counts were higher in the 0.10% and 0.20% groups, and triglycerides in all treated groups ( $P < .05$ ). Cell mitosis numbers were higher in the jejunum and ileum of the 0.10% and 0.20% groups ( $P < .05$ ). Protuberant mucosal epithelial cells and cell clusters were observed in treated groups. Under the conditions of this study, dietary turmeric promotes nutrient digestibility, enhances hematological values, and stimulates intestinal mucosal morphology.

Effects of dietary supplement of *Centella asiatica* on serum interleukin-10 and interferon gamma of growing pigs. This study evaluates the effects of *Centella asiatica* L. Urban (*C. asiatica*) supplemented in conventional diets on serum levels of interleukin- 10(IL-10) and interferon-gamma (IFN- $\gamma$ ) of growing pigs. Sixteen 8-week old crossbred pigs were divided into four groups of four pigs. Each group was fed *ad libitum* with conventional diets supplemented with either 0% (control), 0.5%, 1%, or 2% pulverized *C. asiatica*. Pigs were bled twice at 12 and 20 weeks of

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age which corresponded to one and three months of experimental feeding, respectively. The results showed that, after one month of *C. asiatica* feeding, pigs of all experimental groups demonstrated comparable levels of serum IL-10 to control pigs, but pigs fed with 1% and 2% *C. asiatica* demonstrated significantly reduced serum IFN- $\gamma$  levels. At three months of experimental feeding, pigs fed with 1% and 2% *C. asiatica* showed significantly reduced serum IL-10 and reduced, but not significantly, serum IFN- $\gamma$  levels. These results indicate that *C. asiatica* has the potential to suppress both anti-inflammatory and pro-inflammatory cytokines. Further study is needed to determine whether these effects of *C. asiatica* have clinical importance in anti-inflammatory treatment.

Effects of dietary *Centella asiatica* (L.) Urban on growth performance, nutrient digestibility, blood composition in piglets vaccinated with *Mycoplasma hyopneumoniae*. *Centella asiatica* (L.) is a kind of herb consist of active ingredients such as asiaticosides, madecassoside, asiatic acid and asiaticoside, which action to wound healing and skin lesions by stimulate connective tissue development, inhibit bacteria growth, and support strengthening the immune system. The analysis of dried *Centella asiatica* (L.) which cultivated in Chiangmai that used in this experiment consist of madecassoside and asiaticoside 1.64 and 1.12 % DM respectively. The experiment of using *Centella asiatica* (L.) supplemented in growing piglet diets at 0.0, 0.5, 1.0 and 2.0 % showed that digestibility of nutrients decreased ( $P < 0.05$ ) when supplemented over 1.0 % in diet. Growth performance increased and back fat thickness decreased when supplemented *Centella asiatica* (L.) in diets, but not significant ( $P > 0.05$ ), this effects may cause of *Centella asiatica* (L.) can inhibit bacteria and supported healthily. Supplemented *Centella asiatica* (L.) in diets were not effect to feed cost per kilogram body weight gain. For red blood cell concentration, haematocrit value are increased in *Centella asiatica* (L.) supplemented groups but significant ( $P < 0.05$ ) from the control was only 2.0 %

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supplemented group. Supplemented *Centella asiatica* (L.) in diets strengthened the immune system by increase ( $P < 0.05$ ) number of various white blood cell and specific antibody for Mycoplasma disease in blood. Cholesterol decrease when supplemented *Centella asiatica* (L.) in diet, caused by an anti-oxidant in *Centella asiatica* (L.), but no effect on Triglyceride in blood. Concluded that *Centella asiatica* (L.) is induce pig healthiness.

Assessment of mixed minerals by observing intestinal epithelial cell alterations in piglets. The experiment was conducted to assess the effect of dietary Mixed Minerals (MM) on intestinal epithelial cell morphology, villus height and area, and growth performance in piglets. Thirty two-month-old hybrid piglets (15 kg BW) (Large White x Landrace x Duroc), consisting of 15 castrated males and 15 females, were allocated into three experimental groups with five replicates of one castrated male and one female per replicate. The basal diet was supplemented with MM at 0 (control), 0.05, and 0.1% for 30 days. Compared with dome-shaped epithelial cells on the intestinal villus apical surface, further protuberated dome-shaped cells were observed in the 0.05% MM group, and cell clusters comprised of dome-shaped cells appeared in the 0.1% MM group. However, the villus height and villus area as well as growth performance were not affected, except that the feed intake and average daily feed intake of the 0.1% MM group increased compared with those of the 0.05% MM group ( $P < 0.05$ ); as well, body weight gain of the 0.1% MM group was 4% greater than the control. These results suggest that MM can stimulate functions of epithelial cells with increasing levels of MM, but that they have no power to improve body weight gain resulting from increased villus activity, and that MM have no function to affect growth performance but might affect other biochemical functions, such as immunity processes in the body.

These results in series of the present feeding experiments suggest that each

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supplementation might activate the functions of immune and digestive systems, enhancing piglet healthy growth performance. This would contribute to pig industry by production for safety pig meats.

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