section were measured. Digesta samples from all intestinal sections were collected into containers by gently squeezing with thumb and fingers for pH measurement using a semisolid glass electrode probe pH meter. Digesta samples were kept frozen and stored at –20 $^{\circ}$C until analysis. After digesta drained and perfused with tap water, the emptied intestines were weighed again. Subsequently, the intestinal sections were longitudinally opened and fixed on foam plate. The tissue was collected in equal area for each sample by pressing a circular metal block (1 cm in diameter) on the tissue, then the tissue weight and tissue weight without fat were determined. The mucosal samples were scraped using glass slide and kept in folded foil paper and stored at –70 $^{\circ}$C until the analysis for DNA and RNA content were performed.

The Calculation of Growth Performance

The feed intake and individual live body weight data collected at the 2nd and 5th week of the experiment were used to calculated the average daily gain (ADG), average feed intake (AFI) and feed/gain (FCR) in each replicate. The formula is shown below.

$$\text{Average daily gain (ADG, kg/day)} = \frac{\text{Final BW} - \text{Initial BW}}{\text{Days}}$$

$$\text{Average feed intake (AFI, kg/day)} = \frac{\text{Feed intake}}{\text{Days}}$$

$$\text{Feed/Gain (FCR)} = \frac{\text{AFI}}{\text{ADG}}$$

Short-chain Fatty Acids (SCFAs) Determination

Caecal short-chain fatty acid concentrations were analyzed using the method modified from Erwin (1961). Frozen intestinal contents were thawed at room temperature. They were weighed and diluted with the equal volume of distilled water (eg 5 g contents diluted with 5 ml water). The solutions were centrifuged at 9,000 rpm for 10 min. The supernatant was removed for the SCFAs determination. Standard SCFAs solution was prepared and there were four SCFAs, 70 mM acetic acid, 30 mM propionic acid, 10 mM butyric acid and 2 mM valeric acid. The internal standard used was isocaproic acid. Distilled water was used as a blank. The volume of 0.4 ml working internal standard solution (containing isocaproic acid; formic acid and 25% metaphosphoric acid) was mixed with 0.7 ml of the supernatant or standard solution. In case of the small volume of some samples, the same proportion of sample: working internal standard solution at 7:4 was applied. The solutions were centrifuged again at 9,000 rpm for 5 min and the supernatant aliquots were removed. The aliquots were analyzed for the concentration of SCFAs using a gas chromatograph equipped with a hydrogen flame ionization detector. The column used for analysis (GL Sciences Inc) was treated with 1% (wt/wt) H_3PO_4 (length 2.1 m, ID 4 mm, OD 7 mm) and packed with 10% FFAP (80-100 mesh). The concentration of individual SCFA was expressed as μ mole/g caecal content.

The Determination of Ribonucleic Acid (RNA) and Deoxyribonucleic Acid (DNA) Contents

Frozen mucosal scrapings were homogenized with 0.2 N perchloric acid (PCA) and all homogenized samples were centrifuged at 500g for 10 minutes. The precipitate of both RNA and DNA fractions were washed with cold 0.2N PCA and recentrifuged. The precipitation was solubilized for RNA in 3.0 ml of 0.3N potassium hydrochloride (KOH) and placed at 37 °C for 90 minutes. Two milliliter of 10%PCA were added into the tube and placed on ice for 10 minutes and centrifuged as described above (Berseth et al, 1983 ; Simmen et al, 1990). The supernatant was separated for the RNA determination using ultraviolet absorption measurement (Flek and Begg, 1954) by two wavelengths (λ) of 260 and 232 nm (wavelengths of maximal and minimal absorption of RNA). The content of pigs intestinal mucosal RNA was calculated from the following formula:

$$C_{RNA} = 3.40\ A_{260nm} - 1.44 A_{232nm}$$

DNA fraction in the intestinal pellet was solubilized in 10% PCA and heated to 70 °C for 20 minutes. The DNA content of the samples was determinded by the Burton procedure as modified by Giles and Myers (1965). Two milliliter of 4% diphenylamine in glacial acetic acid was added to 2 ml of the DNA solution followed by 0.1 ml of aqueous 1.6 mg/ml of acetaldehyde. After incubation at 30 °C overnight, the optical density difference at λ 595-700 nm were read against blank in the without DNA solution.

Transit time Determination

At the end of the experiment, each treatment group (2 pigs/replicate) received the same diet supplemented with 10 g/kg Cr_2O_3 as an indigestible marker. These Cr_2O_3 containing diets were given to pigs once in the afternoon. After Cr_2O_3 diet feeding, fecal color of pigs was observed every 30 minutes by two observers. The transit time was measured by the length of time from the beginning of Cr_2O_3 diet feeding until the green color of Cr_2O_3 in the feces was observed.

Feed Chemical Analytical Procedure

All feed samples were analyzed in duplicate. Dry matter content in diets was determined at 103°C. Nitrogen content was determined by the Kjeldahl method and Crude protein was calculated as Kjeldahl N x 6.25. Crude Fat was determined by Ether extract procedure (AOAC, 1995).

Tissue Weight and Defatted Tissue Weight

Tissues removed from all 5 intestinal sections (area approximately 0.78 cm^2) were weighed again. Then they were dried in an oven at 80 °C until the weight was constant. Next, fat in dried intestine samples was extracted by ether for 48 hours. After all fat was extracted, tissues were put in the oven again. Finally, no-fat-dried weight of intestinal tissue was recorded.

Statistical Analysis.

The data was analyzed by the Analysis of Variance procedure for complete randomized design (CRD) and the different means were compared using Duncan's new multiple range test with the significant level at $P < 0.05$ (Steel and Torrie, 1960).

CHAPTER IV

RESULTS

Growth Performance

The average temperature and relative humidity of the entire experimental period were 26.38 - 32.15 ^{o}C and 59 - 87 %, respectively. At the end of the 2nd week of the experiment, pigs received antibiotic diet had slightly better growth performance than other diets ($P>0.05$). The pigs in the control diet and 3% artichoke diet had higher mortality rate (18.75 ± 23.94 and 6.25 ± 12.50, respectively) than other diets. At the 5th week of the experiment, pig fed on 3% artichoke diet had better FCR and ADG. Finally, for the overall 5 weeks of experiment, the 3% artichoke diet had the best growth performance but it was not significant compared to the other diets. The data are demonstrated in Tables 9 -11. For the transit time, there was no significant difference among all treatment diets (Figure 5).

Physical Changes of the Intestine

All treatment diets did not affect the pH of intestinal content in all intestinal part compared to those in control diet (Table 12). For relative wet intestinal weight with content to body weight and relative emptied intestinal wet weight to body weight, 3% artichoke diet tended to be heavier than those of other diets ($P>0.05$) (Figure 6 and Figure 7). The effect is more prominent in the proximal colon. In addition, there was no significant difference on the length and defatted-dry weight of the intestine (Figure 8 and Table 13).

Table7 Composition of the experimental diet

Ingredient	Composition, Kg
Broken rice	513.10
Palm oil	30.00
Soybean meal (44%)	251.00
Full fat soybean	84.00
Fish meal (61%)	40.00
Whey powder	50.00
Calcium carbonate	9.00
Mono-dicalcium phosphate	11.000
Salt	3.00
DL-Methionine	0.50
L-Lysine	0.05
Threonine	0.08
Premix*	8.27
Total Batch	1000.00

* Premix / Kg feed contained A 12,000 IU,D3 2,400 IU,E 18 mg, K3 3 mg, B1 1.2 mg, B2 3.6 mg, B6 1.8 mg, B12 0.018 mg, Nicotinic acid 24 mg, D-Calcium pantothenate 16 mg, Folic acid 0.6 mg, Biotin 0.1 mg, Choline chloride 300 mg, Mn 42 mg, Zn 120 mg, Fe 100 mg, Cu 1500 mg, I 1.5 mg, Co 0.84 mg and Se 0.2 mg

Table 8 Chemical feed analysis, Fed basis

Nutrients	Artichoke	Control	3%Artichoke	6%Artichoke	FOS	Antibiotic
Moisture, %	3.80	7.20	7.04	7.03	7.12	7.19
Crude protein, %	7.79	20.42	20.58	20.49	20.44	20.51
Crude fat, %	0.27	4.10	4.17	4.39	4.47	4.51
Crude fiber %	3.10	0.99	1.10	1.13	1.20	1.21
Ash %	4.47	6.18	6.10	6.17	6.15	6.22
Calcium %	0.11	0.83	0.85	0.84	0.88	0.82
Phosphorus %	0.2	0.98	0.93	0.93	0.92	0.95

Table 9 Growth performance of pigs at the 0 - 2nd week of the experiment (Mean ± SD)

Parameter	Treatment				
	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Av.starting weight (kg)	6 75±0.79	7.25±1.27	6.99±0.76	7.20±0.99	7.18±1.20
Av.final weight (kg)	10.22±1.21	9.96±1.12	10.08±1.78	9.96±2.07	10 56±1.30
ADG (kg/pig/day)	0.25±0.06	0.24±0.04	0.23±0.08	0.20±0.08	0.24±0.04
Av. Feed intake (kg/pig/day)	0.35±0.05	0.35±0.09	0.33±0.06	0.28±0.10	0.32±0.05
FCR	1.41±0.17	1.47±0 14	1.48±0.36	1.47±0.09	1.36±0.17
Mortality (%)	18.75±23.94	6.25±12.50	0	0	0

Means within a row without superscript does not differ (P>0.05)

Table 10 Growth performance of pigs at the 2nd – 5th week of the experiment (Mean±SD)

Parameter	Treatment				
	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Av.starting weight (kg)	10.23±1.21	9.96±1.12	10.08±1.79	9.96±2.07	10.56±1.30
Av.final weight (kg)	18.73±2.62	20.25±3.79	19.95±1.45	17.86±3.50	20.43±1.65
ADG (kg/pig/day)	0.41±0.07	0.45±0.09	0.44±0.03	0.38±0.08	0.43±0.03
Av. Feed intake (kg/pig/day)	0.73±0.04	0.68±0.17	0.72±0.06	0.62±0.12	0.69±0.01
FCR	1.85±0.31	1.50±0.14	1.65±0.12	1.64±0.06	1.61±0.05
Mortality (%)	0	0	0	0	6.25±12.50

Means within a row without superscript does not differ (P>0.05)

Table 11 Growth performance of pigs at the 0 – 5th week of the experiment (Mean±SD)

	Treatment				
Parameter	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Av.started weight (kg)	6.75±0.79	7.25±1.27	6.99±0.76	7.20±0.99	7.18±1.20
Av.final weight (kg)	18.73±2.62	20.25±3.79	19.95±1.45	17.86±3.50	20.43±1.65
ADG (kg/pig/day)	0.34±0.06	0.37±0.08	0.37±0.03	0.30±0.07	0.38±0.03
Av. Feed intake (kg/pig/day)	0.58±0.04	0.55±0.14	0.57±0.06	0.48±0.11	0.57±0.03
FCR	1.72±0.26	1.47±0.09	1.52±0.10	1.59±0.04	1.50±0.07
Mortality (%)	18.75±23.94	6.25±12.50	0	0	6.25±12.50

Means within a row without superscript does not differ (P>0.05)

Table 12. The effect of treatments on pH of the intestinal content (Mean ± SD)

	Treatment				
Intestinal part	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Jejunum	5.66±0.45	6.33±0.27	5.87±0.63	6.13±0.87	6.22±0.29
Ileum	6.33±0.60	6.71±0.33	5.98±0.59	6.37±0.90	6.50±0.32
Caecum	5.69±0.22	5.68±0.31	5.41±0.21	5.78±0.28	5.69±0.10
Proximal Colon	5.79±0.40	5.98±0.41	6.15±0.47	6.47±0.27	6.14±0.29
Distal Colon	6.36±0.49	6.36±0.40	6.30±0.41	6.23±0.19	6.52±0.17

Means within a row without superscript does not differ (P>0.05)

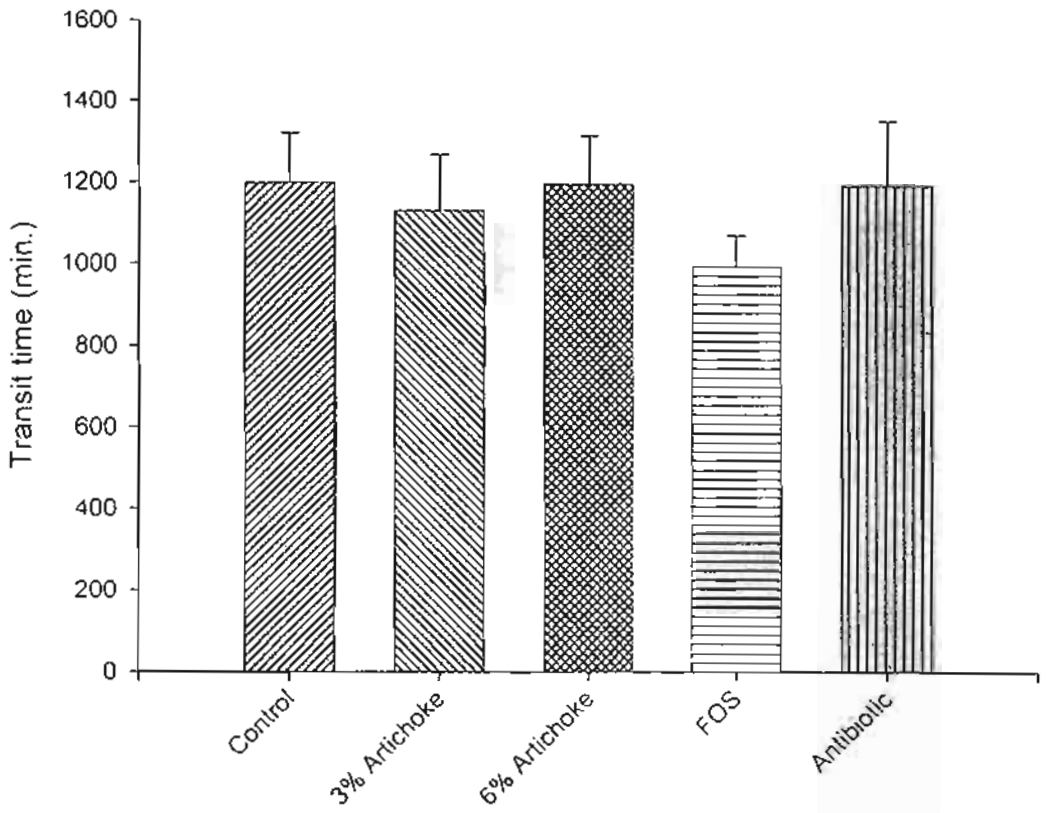

Figure 5 The effect of treatments on transit time at 5 weeks of the experimental period using Cr_2O_3 as an indigestible marker

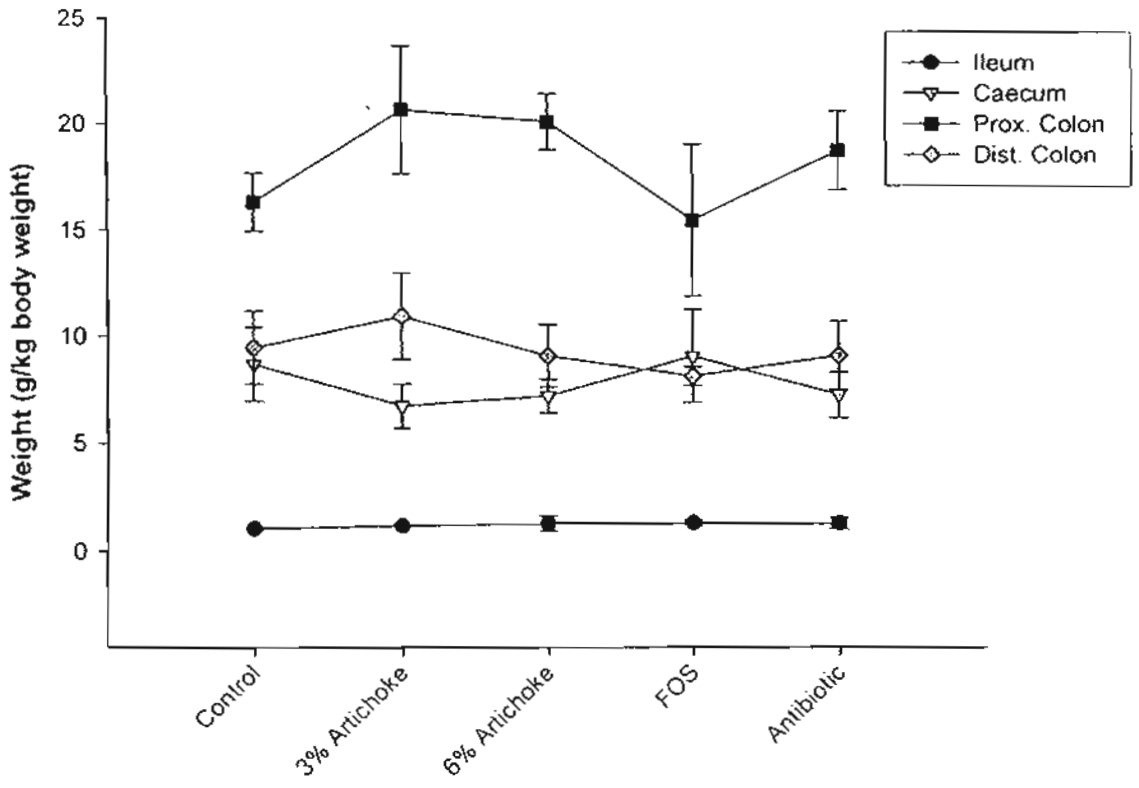

Figure 6. The effect of treatments on relative intestinal wet weight with content to body weight at 5 weeks of the experimental period

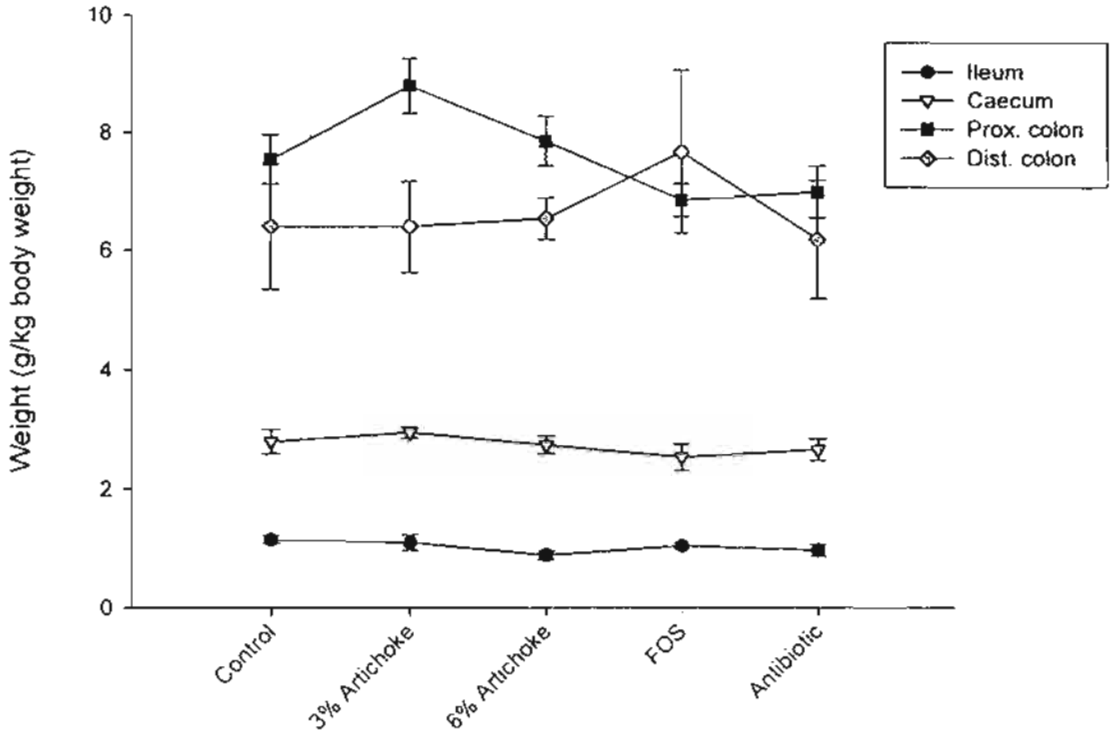

Figure 7. The effect of treatments on relative intestinal emptied wet weight to body weight at 5 weeks of the experimental period

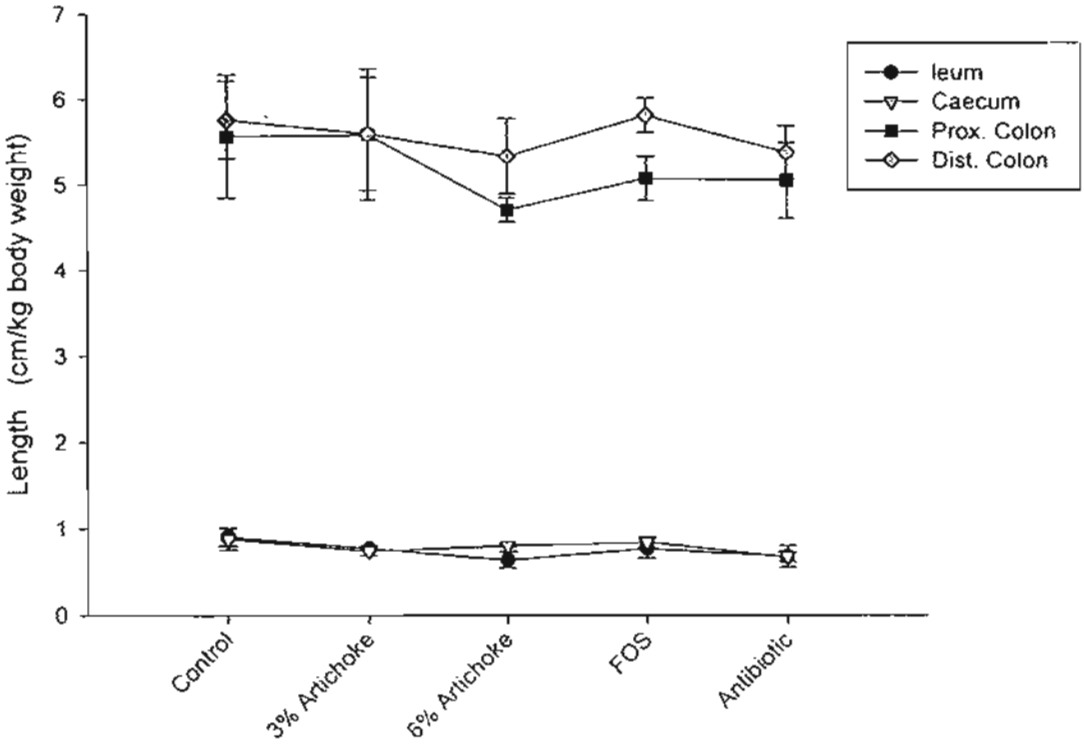

Figure 8 The effect of treatments on the intestinal length at 5 weeks of the experimental period

Table 13 The effect of treatments on defatted-dry weight (g) of intestinal tissue(Mean±SD)

	Treatment				
Intestinal part	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Jejunum	0.023±0.006	0.020±0.006	0.021±0.003	0.022±0.004	0.024±0.004
Ileum	0.030±0.002	0.024±0.006	0.027±0.002	0.021±0.006	0.026±0.006
Caecum	0.020±0.004	0.017±0.003	0.024±0.004	0.016±0.004	0.018±0.007
Proximal Colon	0.017±0.004	0.018±0.006	0.015±0.003	0.019±0.006	0.017±0.006
Distal Colon	0.021±0.002	0.014±0.002	0.019±0.002	0.016±0.005	0.014±0.003

Means within a row without superscript does not differ (P>0.05)

SCFAs Concentration

The jejunal acetate and butyrate concentrations were highest in pigs fed on antibiotic diet while propionate concentration were highest in pig received 3%artichoke diet (Figure 9). For the total SCFAs concentration, pig fed on antibiotic diet had the highest SCFAs concentrations (23.42±12.70 mM) while the FOS diet had the lowest SCFAs concentration (13.82±5.78 mM). In ileum (Figure 10), pig received antibiotic diet had the highest total SCFAs (21.74±4.98 mM), and 3% artichoke diet had the lowest total SCFAs concentrations (12.00±6.96 mM). For individual SCFA, the antibiotic diet showed the highest acetate: the 6% artichoke diet had the highest propionate and butyrate.

In Caecum (Figure 11), there was no significant difference in total SCFAs concentration, however the control diet seem to have the highest acetate and propionate while 6% artichoke diet has the highest butyrate concentration. In proximal and distal colon, the highest total SCFAs concentration was found in 3% and 6% artichoke diet while the others had similar total SCFAs concentration (Figure 12 and Figure 13). The proportional percentage of SCFAs in all diet was shown in Table 14. The detail of SCFAs concentration is shown in appendix.

Table 14 The proportional percentage of SCFAs in each part of intestine (Acetate:Propionate:Butyrate:Valerate)

	Treatment				
Intestinal part	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Jejunum	53:39:8:0	55:41:4:0	53:37:7:0	61:36:3:0	67:22:11:0
Ileum	57:39:3:0	52:44:4:0	57:34:9:0	54:40:5:0	69:23:7:0
Caecum	53:29:16:2	55:30:14:2	50:27:21:3	55:30:14:2	57:30:12:1
Proximal Colon	58:27:13:2	60:26:13:2	56:26:15:2	61:27:11:2	59:26:13:2
Distal Colon	58:26:14:2	61:24:13:2	57:26:15:2	62:26:10:2	59:25:14:2

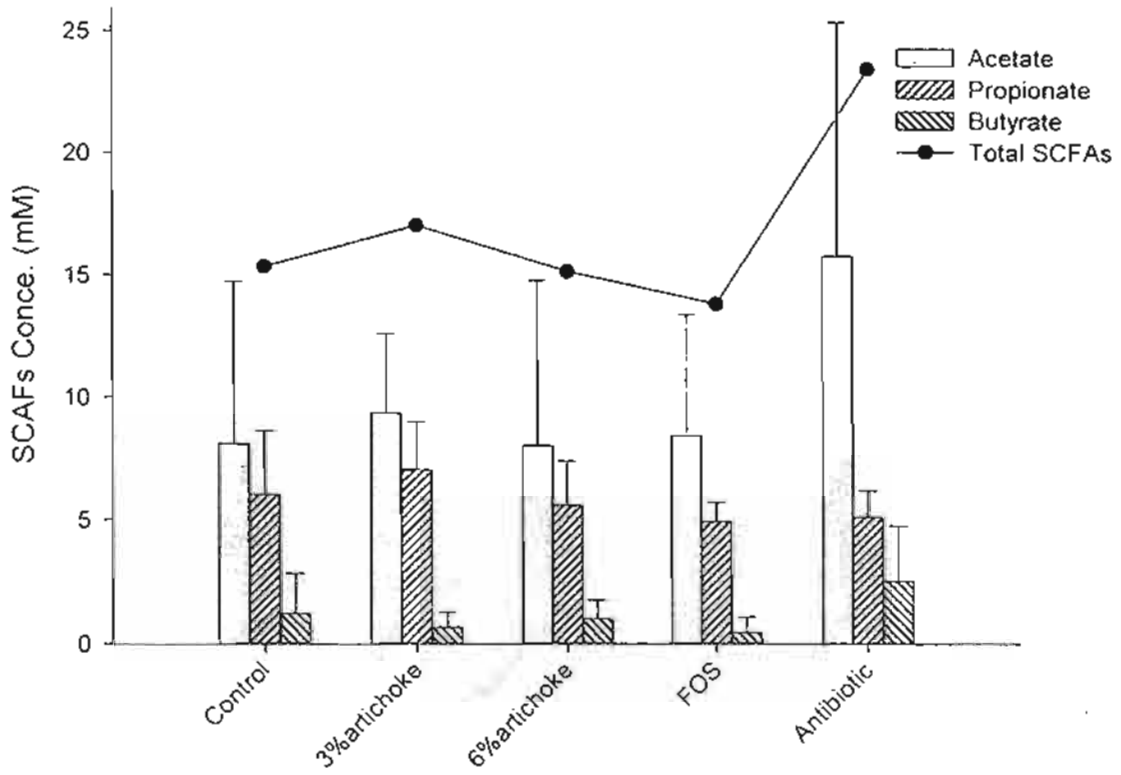

Figure 9 The effect of treatments on SCFAs concentration in the jejunum at 5 weeks of the experimental period

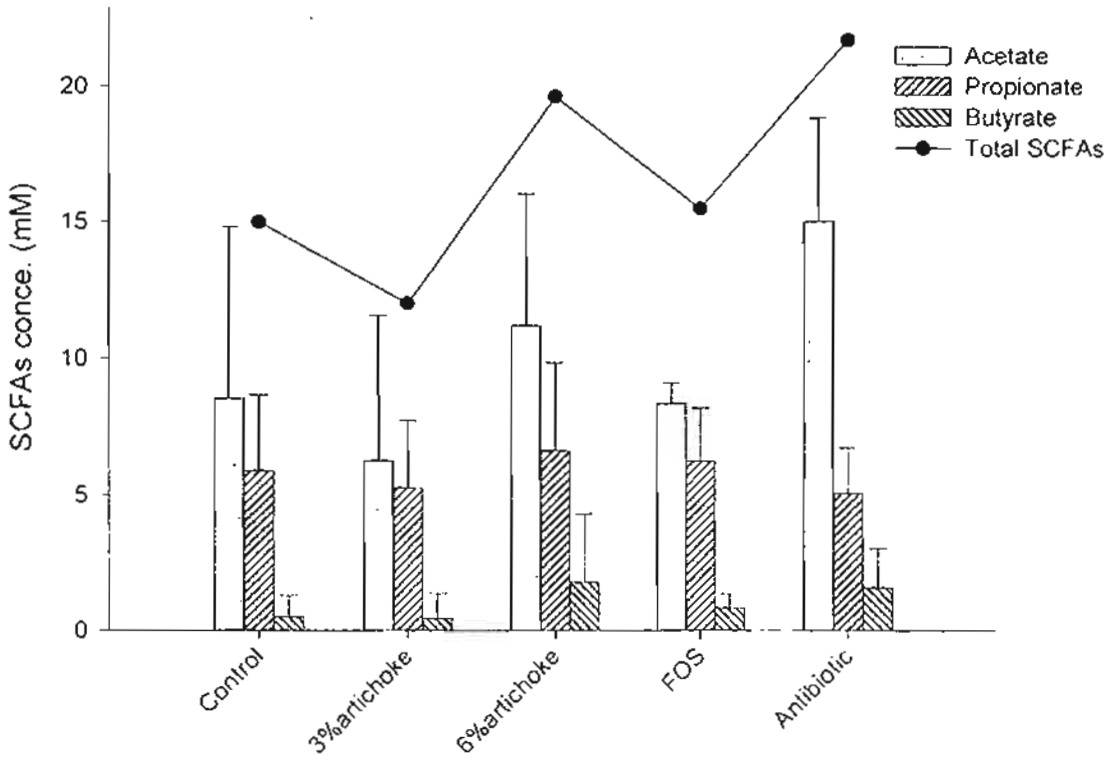

Figure 10 The effect of treatments on SCFAs concentration in the ileum at 5 weeks of the experimental period

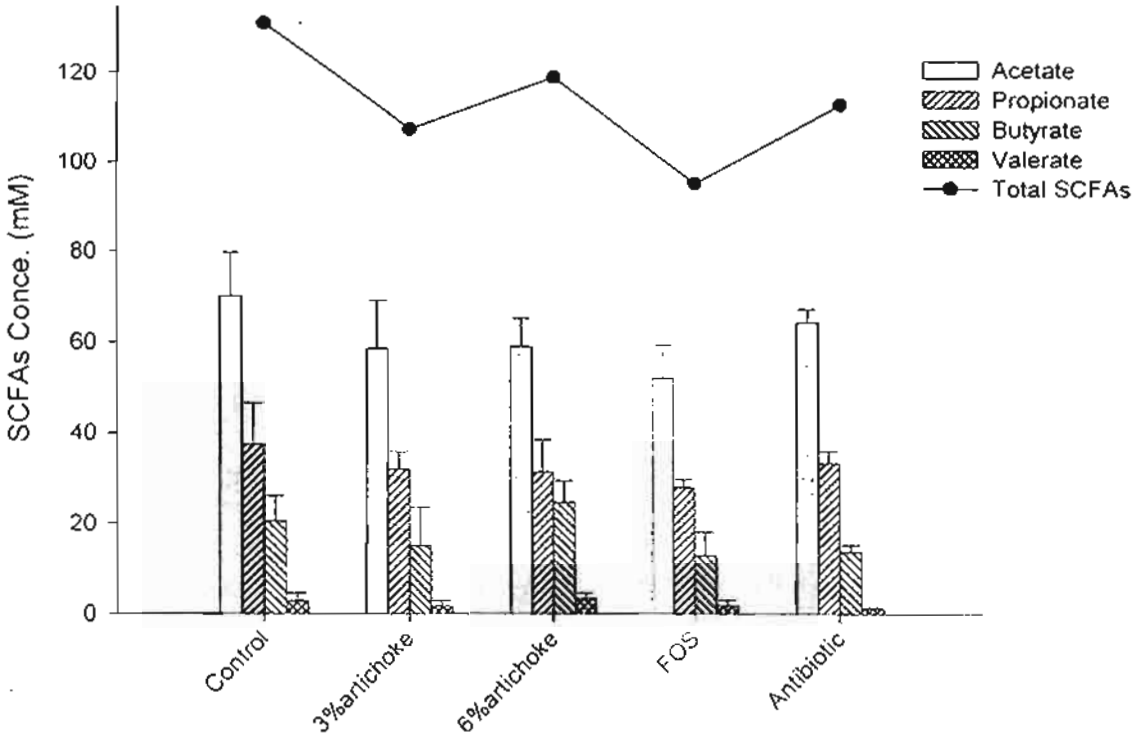

Figure 11 The effect of treatments on SCFAs concentration in the caecum at 5 weeks of the experimental period

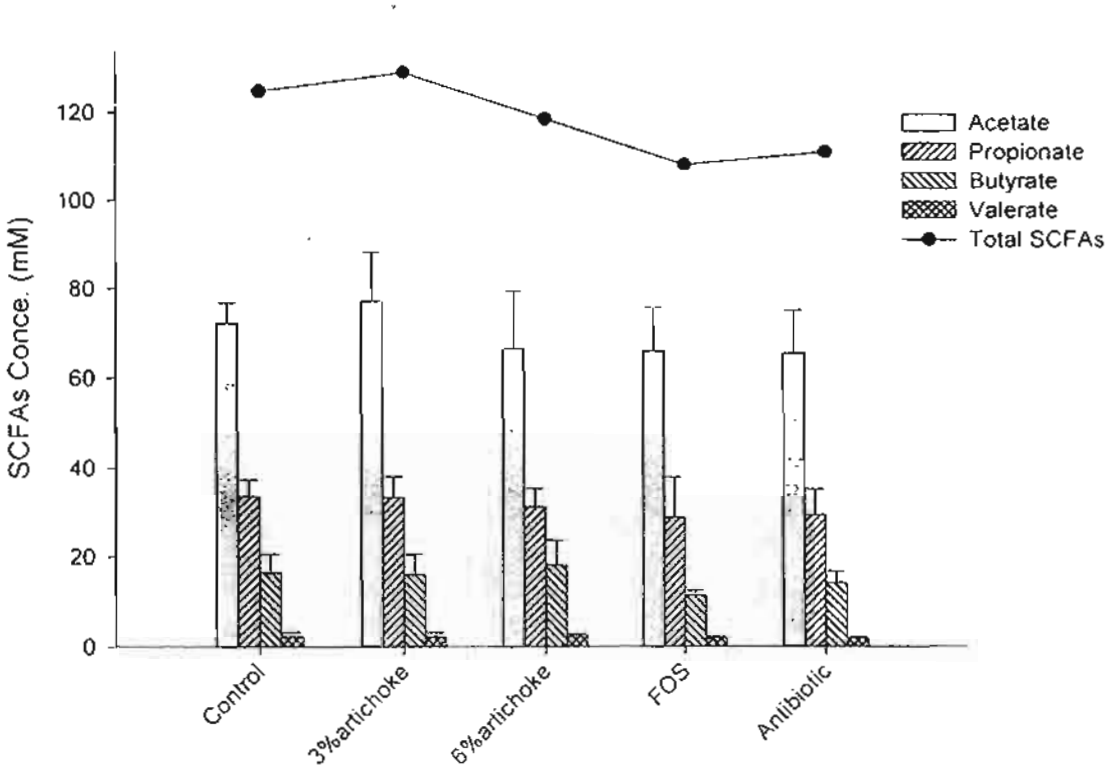

Figure 12 The effect of treatments on SCFAs concentration in the proximal colon at 5 weeks of the experimental period

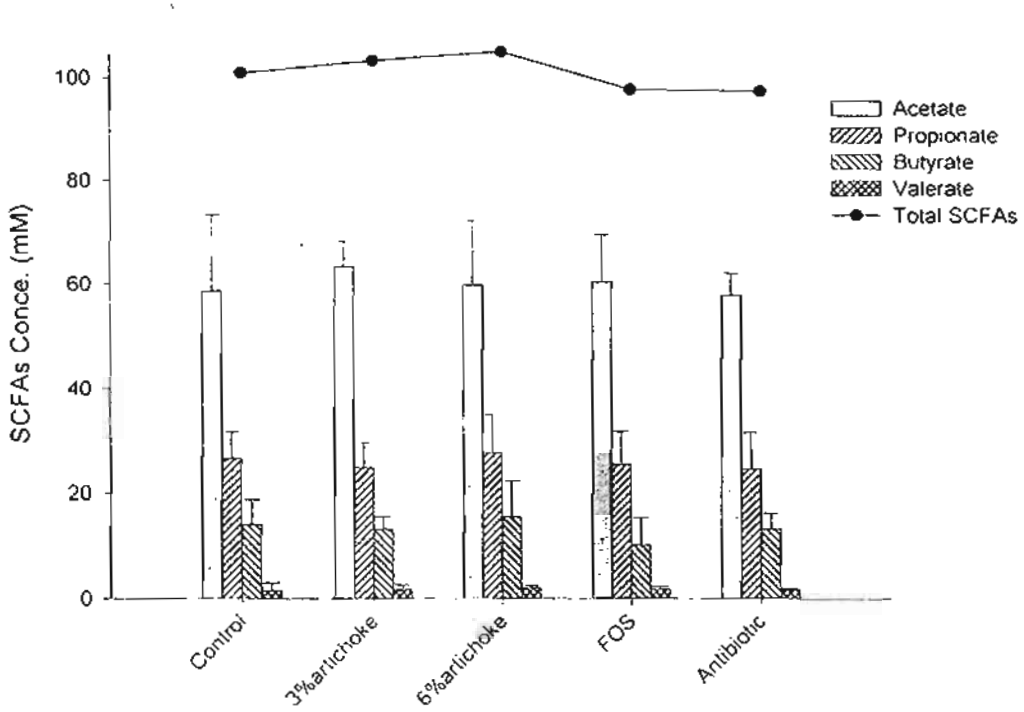

Figure 13 The effect of treatments on SCFAs concentration in the distal colon at 5 weeks of experimental period

DNA and RNA Content of Intestinal Mucosa

There was no significant difference in DNA content of the mucosal scraping from pigs' intestines at 5 weeks of the experimental period. The average DNA content of control, 3% artichoke, 6% artichoke, FOS, and antibiotic diets were 3.36±0.35, 3.02±0.19, 3.14±0.52, 3.07±0.61 and 3.06±0.67 mg/g of tissue wet weight, respectively. For the RNA content measured in the same samples, 6% artichoke diet and antibiotic diet had significantly higher RNA content than those of the control and FOS diets at ileum ($P<0.05$). The average RNA content of control, 3% artichoke, 6% artichoke, FOS, and antibiotic diets were 0.402±0.033, 0.382±0.031, 0.403±0.043, 0.370±0.049 and 0.358±0.050 mg/g tissue wet weight, respectively. The detail is shown in Table 15 and Table 16.

Table 15 The effect of treatments on DNA content at 5 weeks of the experimental period (Mean ± SD)

	Treatment				
Intestinal part	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Jejunum	3.68±0.63	3.41±0.48	3.59±0.73	3.86±0.66	3.31±0.84
Ileum	3.54±0.96	3.45±0.86	4.17±0.81	3.58±0.83	3.76±0.72
Caecum	3.26±0.69	2.68±1.06	2.86±0.36	2.88±0.59	2.17±1.20
Proximal Colon	2.83±1.07	2.48±0.74	2.14±0.74	2.35±0.41	3.22±1.25
Distal Colon	3.50±0.75	3.08±1.04	2.96±0.74	2.66±0.86	2.86±0.77

Means within a row without superscript does not differ (P>0.05)

Table 16 The effect of treatments on RNA content at 5 weeks of the experimental period (Mean ± SD)

	Treatment				
Intestinal part	Control	3% Artichoke	6% Artichoke	FOS	Antibiotic
Jejunum	0.303±0.011	0.368±0.044	0.338±0.023	0.366±0.020	0.304±0.083
Ileum	0.320 ± 0.074^{a}	0.358 ± 0.048^{ab}	0.444 ± 0.036^{b}	0.361 ± 0.062^{a}	0.444 ± 0.026^{b}
Caecum	0.472±0.0047	0.421±0.111	0.477±0.081	0.423±0.043	0.363±0.027
Proximal Colon	0.430±0.07	0.384±0.097	0.367±0.100	0.343±0.119	0.446±0.064
Distal Colon	0.451±0.058	0.378±0.097	0.390±0.051	0.359±0.053	0.358±0.050

a, b Means in the same row with different superscripts differed significantly (P<0.05)

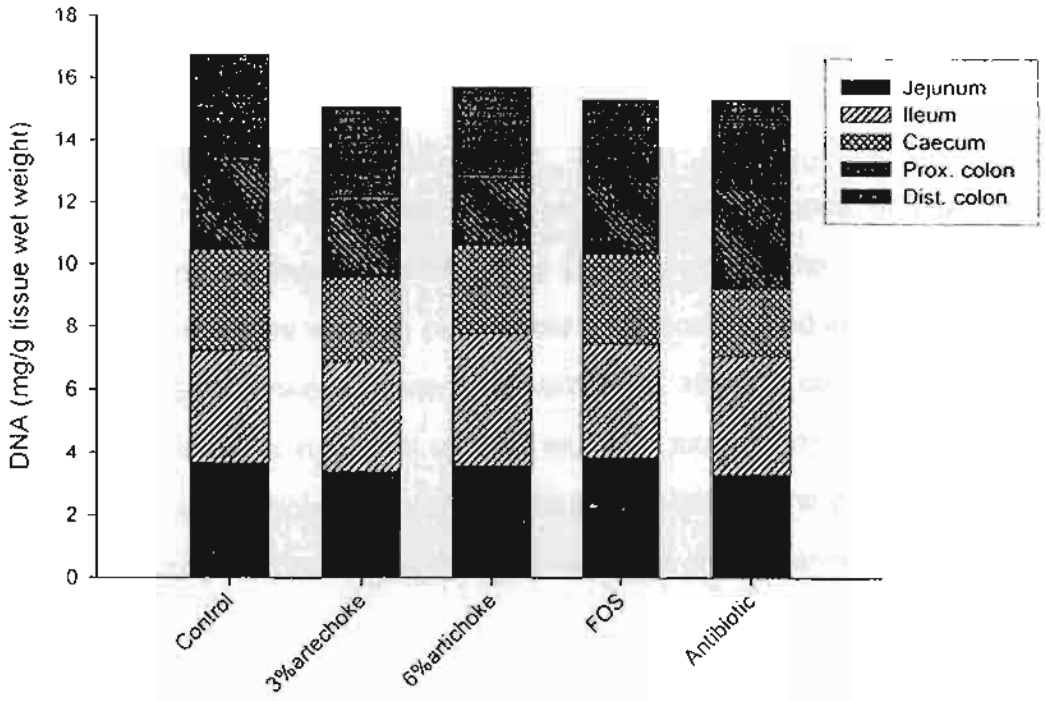

Figure 14 The effect of treatments on DNA content at 5 weeks of the experimental period.

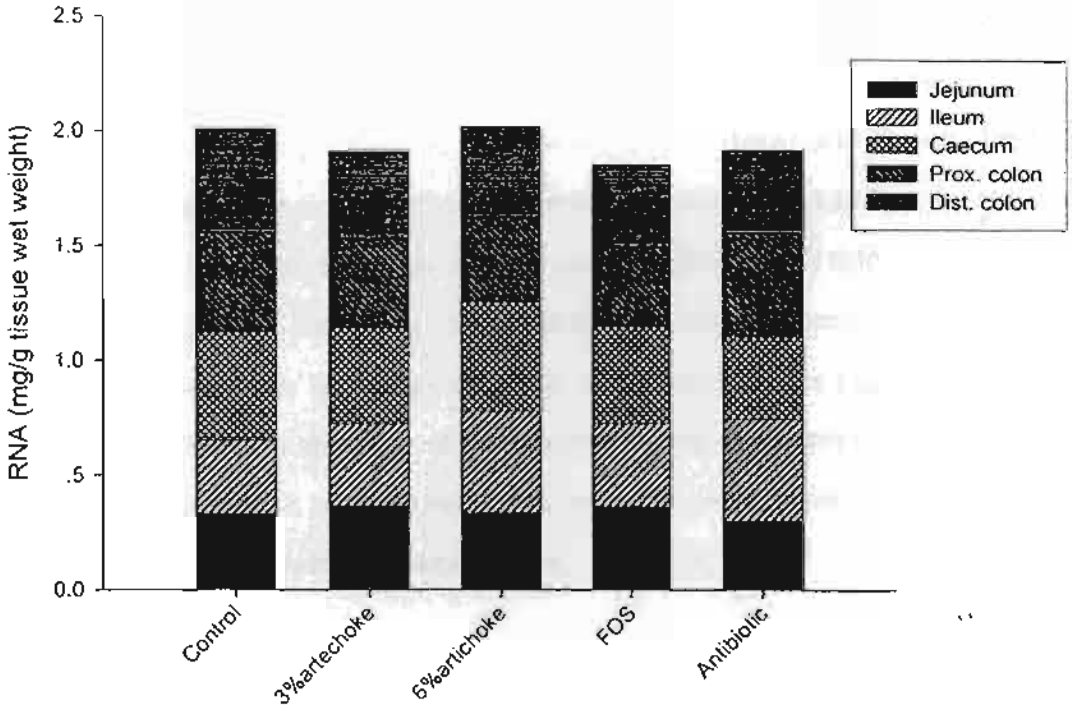

Figure 15. The effect of treatments on RNA content at 5 weeks of the experimental period.

CHAPTER V
DISCUSSION

Growth Performance

There was no significant difference on growth performance of pigs among treatment diets. This finding was similar to a previous report, the inclusion of 1.5% Jerusalem artichoke flour to weaning pig diet did not affect the feed intake, body weight gain, or feed efficiency between groups (Farnworth et al., 1991). In contrast, the inclusion of 6% Jerusalem artichoke in the diet reduced total feed intake of pigs compared with 0, 1% and 3% Jerusalem artichoke diet (Farnworth et al., 1995). In the present study, pigs received 3% artichoke tended to have the most preferable growth performance at 5 weeks of the experiment.

The highest mortality rate was found in the control group without feed additive. All infected pigs showed the sign of anorexia, emaciation and diarrhea. After death, carcasses were sent for necropsy examination at the animal hospital, Faculty of Veterinary Science, Chulalongkorn University. Results from death pigs indicated bacterial infection and septicemia. There are several factors affecting the mortality rate of weaning piglets. The colostral antibodies absorbed into the blood stream of the piglet during the first 24 hours of life are declining rapidly in the weaning period (Miller and Stokes, 1994). The piglet is eventually deprived of protective antibodies from milk. In addition, the stress from many activities affected the pigs in the experiment, for example transportation of experimental pigs from the farm to the experimental unit, new environment, new social hierarchy and new feed. These stress factors could suppress the piglet immune system (Fahey et al., 1990). In the present experiment, piglets under stress had less mortality when feed additive such as Jerusalem artichoke, FOS and antibiotic were used, though, the difference was not statistically significance.

Short-chain Fatty Acids

Bergman (1990) reported that caecum is the site of the highest production of SCFAs in almost all of hindgut-fermenting animal. Breves and Stuck (1995) reported that the total SCFAs concentration were in between 100 and 140 mM in caecum, 80 and 130 mM in proximal colon and 20 and 65 mM in distal colon. In the present experiment, the average SCFAs concentrations in disregard of treatment diet were 113.15±18.56 mM in caecum, 118.31±16.77 mM in proximal colon and 100.88±17.08 mM in distal colon (Appendix). The concentrations were in the range that has been reported except in distal colon that the concentrations were higher. This higher concentration might be due to the difference in the sampling site. The samples of distal colon content in all treatment were collected from the proximal end of distal colon, so this could make the SCFAs concentration higher than that of the previous report.

The proportional percentage of each SCFA was 52-69% for acetate, 22-44% for propionate, 3-21% for butyrate and 0-3% for valerate (Table 14). Fleming et al. (1989) showed proportional percentage of each SCFA, they found that 65% was present as acetate, 25% as propionate and 10% as butyrate in hindgut of pigs. The proportion of propionate and butyrate in the present experiment were higher than that of the previous report. The concentration and molar proportions of individual SCFAs could be varied in response to many dietary factors, such as level and source of neutral detergent fiber (NDF), crude fiber contents and the ratio of enzymatically degradable carbohydrates to crude fiber (Bach et al., 1991).

Interestingly, propionate tended to be in the highest proportion in jejunum, ileum and caecum in 3%artichoke group. For butyrate, 6%artichoke group tended to be in the highest proportion in ileum, caecum, proximal colon and distal colon. Pigs fed on diet with antibiotic had the highest proportion of acetate in jejunum, ileum and caecum, but for FOS group, the highest concentration of acetate was in the colon. For the characteristics of SCFAs proportion, Bergman (1990) and Herdt (1997) reported that the typical proportion of SCFAs depended on the type of diet. Animal that ate greater amount of fiber tended to have the higher proportion of acetate while animal fed greater amount of starch tended to have the higher proportion of propionate (Herdt, 1997). In addition, animal fed greater

have the higher proportion of propionate (Herdt, 1997). In addition, animal fed greater amount of nonstarch polysaccharide (NSP; sugar beet pulp, for example) showed an increase in the proportion of propionate compared with animal fed with high fiber diet (Christine et al., 2000). Therefore pigs fed on 3%artichoke and 6%artichoke diet having the higher level of oligosaccharides should have SCFAs concentration pattern similar to those of the animals fed with high NSP diet. Moreover, a slightly higher fiber content in pigs fed on diet with antibiotic and FOS (Table 2) had the higher acetate proportion compared with other groups. It should be noted that the change in proportion did not affect the absolute amount of total SCFAs.

Physical Changes of the Intestine

According to the result, all treatment diets did not show any effect on the length of intestine and defatted-dry weight of the intestinal tissue. For intestinal weight, the control group, 3%artichoke group and 6%artichoke group tended to have higher wet intestinal weight with content and relative emptied wet intestinal weight than those of the other groups ($P>0.05$) in the proximal colon. These results corresponded with the higher amount of total SCFAs found in these 3 groups, especially in the proximal colon, the major fermentation site. Numerous studies reported that SCFAs were trophic to colonic mucosa. *In vitro* studies showed an increase in colonocyte proliferation rate under SCFA stimulation (Sakata and Engelhardt, 1983; Ichikawa and Sakata, 1998). *In vivo* study by Kissmeyer-Nielsen et al. (1995) showed that SCFAs instilled into atrophic and defunctioned rat colon for 14 days exhibited the higher colonic wet weight compared with those of the placebo group. Sakata (1987) reported that acetate, propionate and n-butyrate have a dose-dependent stimulatory effect on epithelial cell production rates in the jejunum and distal colon. However, the mechanism by which SCFAs were trophic to the intestinal mucosa remained unclear (Mortensen and Nielsen., 1995). Stimulation of the microcirculation in the intestinal wall could, at least in part, explain the trophic effect of SCFAs in the large intestine. Mortensen et al. (1990) reported that the sodium salt of SCFAs, both separately and in mixture, had concentration dependent relaxant effects on colonic resistance arteries *in vitro*. These findings were in agreement with a study of autoperfused

denervated dog colon preparation showing that SCFAs after instillation in the lumen increased colonic blood flow (Kvietys and Granger, 1981). There was also another explanation of SCFAs on having trophic effect on intestine. It could be an increasing of the mucosa metabolism since SCFAs are the preferred oxidative fuel for the colonic mucosa. Roediger (1980) identified luminal n-butyrate as the major respiratory fuel of the colonocytes, accounting for 70% of oxygen consumption. Colonocyte must, therefore, obtain most of their energy from luminal SCFAs produced by colonic fermentation of dietary carbohydrates (Rabassa and Roger, 1992).

DNA and RNA Content of the Mucosa

In the present experiment, DNA content of intestinal mucosa was in the range of 2.14 and 3.86 mg/g tissue wet weight while RNA content is in the range of 0.03 and 0.47 mg/g tissue wet weight Previous report in newborn pigs showed that the average of DNA and RNA content of intestinal mucosa were 4.96 and 2.5 mg/g tissue wet weight, respectively (Simmen et al., 1990). Although hardly comparable between two experiments, in this report, DNA content was slightly lower and RNA content was much lower. The variation could be due to several possible factors, usually, the difference in the age of animal, laboratory facilities and laboratory techniques. The present experiment did not show any changes on DNA and RNA contents among treatment diets. Additionally, the relationship between SCFAs concentrations and DNA or RNA content of mucosa was not found. *In vitro* studies using isolated, viable colonic epithelial cell culture for 24-h in the absence of butyrate did not exhibit reduction in the rate of energy consuming process such as DNA, protein synthesis and the total DNA content (Gibson et al., 1991). In contrast, Kripke et al. (1989) found that continuous infusion of either butyric acid (20-150 mM) or a mixture of SCFAs (acetate, propionate and n-butyrate: 70, 35 and 20 mM, respectively) into the colon increased the mucosal DNA content of the jejunum and proximal colon.

Transit Time

The average transit time of all treatment groups was 1137.71±134.71 minute (approximately 19 hours). This was very close to the study of Steven and Hume (1995) who used Cr-EDTA as a marker. The marker can be detected at the terminal colon of pigs within 16 hours after an oral intake The rate of food passage through the digestive tract may be influenced by several factors such as the amount of energy derived from diet, management and environmental factor, genetic background, excitement, amount of feed intake and pelleting ration for example (Mateos et al., 1980). In the present experiment, control group, 6%artichoke group and antibiotic group had similar transit time (1199.00± 122.51, 1196.00±118.53 and 1191.00±159.34 minutes, respectively). Pigs received diet with 3% artichoke had slightly shorter transit time (1131.50±1363.66 minutes) and the shortest transit time was found in FOS group (994.00±75.51 minutes). The difference between average longest and shortest transit time is about 205 minutes. Although there was no statistically difference which might be due to the small sample size (n = 4 per treatment), it is obviously a long time for nutrient digestion and fermentation in the gastrointestinal tract of pigs. Consequently, this might affect the nutrient digestibility, SCFAs production and growth performance of pigs. The causes of shortest transit time in FOS group may be in part by the increasing of osmotic force from FOS which is the purified soluble fiber (Clausen et al., 1998). Administration of FOS in healthy human subject caused the increasing of fecal, and exhibited the laxative effect (Clausen et al., 1998).

There were several articles on the effect of SCFAs on transit time. Cuche et al. (2000) demonstrated that ileal SCFAs can inhibit gastric motility by humoral pathway involving the release of an inhibiting factor, which is likely to be peptideYY. SCFAs may be one of the mediators involves in the "Ileo-colonic break", i.e. the inhibition of gastric emptying by the presence of nutrients in the distal ileum and proximal colon (Cherbut et al., 1997). In colon, an *in vitro* study using isolated colon demonstrated that infusion of SCFA inhibit the rate of contractions in the proximal, mid and distal regions (Squires et al., 1992). All these researches might explain, in part, that the lowest SCFAs in almost intestinal part of FOS group could be accounted for the shortest transit time.

Conclusion

In present study, using of Jerusalem artichoke as feed additive did not show any significant difference on growth performance, the physical and biological changes of ileum and large intestine in weaning pigs. However, 3% Jerusalem artichoke supplemented in diet tended to improve the growth performance of weaning pigs. The possible reasons might, in part, due to higher SCFAs concentration in their colon. Since there were several reports supported that SCFAs could have a trophic effect to colon and delay the gastrointestinal transit time, so pigs fed 3% artichoke diet tended to have higher colon wet weight and longer transit time. Pigs fed on 1% fructooligosaccharide diet did not promote SCFAs production in the hindgut and by itself caused the shortest gastrointestinal transit time, but it tended to show better growth performance and showed the less mortality rate when compared with those of the control diet. In conclusion, using of prebiotic as feed additive could benefit the weaning pig production in comparison to antibiotic. Further studies on the use of Jerusalem artichoke as prebiotic on the improvement of nutrient digestibility, microbial change and local immune systemic in large intestine of pigs are needed.

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APPENDIX

SCFAs CONCENTRATION

Table 1 The effect of treatments on SCFAs concentration (mM) in Jejunum (Mean ± SD)

	Treatment				
	Control diet	Artichoke 3%	Artichoke 6%	FOS 1%	Antibiotic
Acetate	8.11±6.64	9.36±3.24	8.03±6.75	8.43±4.94	15.77±9.60
Propionate	6.03±2.59	7.05±1.94	5.58±1.83	4.93±0.77	5.12±1.07
Butyrate	1.22±1.63	0.64±0.61	1.00±0.75	0.46±0.61	2.53±2.25
Valerate	0	0	0	0	0
Total	15.35±8.81	17.06±4.19	15.14±9.39	13.82±5.78	23.42±12.70
C2:C3:C4:C5	53:39:8:0	55:41:4:0	53:37:7:0	61:36:3:0	67:22:11:0

Table 2 The effect of treatments on SCFAs concentration (mM) in ileum (Mean ± SD)

	Treatment				
	Control diet	Artichoke 3%	Artichoke 6%	FOS 1%	Antibiotic
Acetate	8.56±6.28	6.27±5.29	11.18±4.84	8.35±0.75	15.02±3.82
Propionate	5.90±2.78	5.27±2.45	6.64±3.20	6.25±1.93	5.09±1.65
Butyrate	0.50±0.80	0.46±0.92	1.79±2.52	0.85±0.52	1.60±1.42
Valerate	0	0	0	0	0
Total	15.00±7.77	12.00±6.96	19.61±6.88	15.49±0.91	21.74±4.98
C2:C3:C4:C5	57:39:3:0	52:44:4:0	57:34:9:0	54:40:5:0	69:23:7:0

Table 3 The effect of treatments on SCFAs concentration (mM) in caecum (Mean±SD)

	Treatment				
	Control diet	Artichoke 3%	Artichoke 6%	FOS 1%	Antibiotic
Acetate	70.11±9.64	58.56±10.51	59.14±6.11	52.29±7.17	64.40±2.88
Propionate	37.52±9.08	32.05±3.79	31.57±6.99	28.19±1.64	33.48±2.60
Butyrate	20.61±5.63	15.08±8.62	24.89±4.66	12.98±5.15	13.76±1.45
Valerate	2.96±1.61	1.73±1.28	3.44±1.13	1.80±1.25	1.23±0.32
Total	131.19±23.17	107.41±22.39	119.05±11.66	95.26±7.10	112.87±2.40
C2:C3:C4:C5	53:29:16:2	55:30:14:2	50:27:21:3	55:30:14:2	57:30:12:1

Table 4 The effect of treatments on SCFAs concentration (mM) in proximal colon (Mean±SD)

	Treatment				
	Control diet	Artichoke 3%	Artichoke 6%	FOS 1%	Antibiotic
Acetate	72.23±4.52	77.12±11.32	66.51±12.80	66.03±9.52	65.45±9.58
Propionate	33.68±3.72	33.49±4.69	31.21±4.23	28.81±9.11	29.38±5.86
Butyrate	16.61±3.98	16.13±4.43	18.15±5.58	11.45±1.15	14.23±2.48
Valerate	2.33±0.93	2.30±0.85	2.70±0.17	1.83±0.40	1.91±0.44
Total	124.84±7.27	129.03±17.26	118.57±18.49	108.11±19.13	110.97±17.37
C2:C3:C4:C5	58:27:13:2	60:26:13:2	56:26:15:2	61:27:11:2	59:26:13:2

Table 5 The effect of treatments on SCFAs concentration (mM) in distal colon (Mean ± SD)

	Treatment				
	Control diet	Artichoke 3%	Artichoke 6%	FOS 1%	Antibiotic
Acetate	58.73±14.72	63.47±4.88	59.79±12.54	60.36±9.15	57.77±4.33
Propionate	26.70±5.07	24.86±4.78	27.71±7.31	25.44±6.29	24.71±6.82
Butyrate	14.04±4.83	13.17±2.36	15.52±6.84	10.09±5.12	13.17±2.91
Valerate	1.57±1.45	1.86±0.76	2.03±0.41	1.74±0.53	1.68±0.24
Total	101.05±23.21	103.36±11.52	105.05±26.02	97.63±15.90	97.34±13.55
C2:C3:C4:C5	58:26:14:2	61:24:13:2	57:26:15:2	62:26:10:2	59:25:14:2

Table 6 The average SCFAs concentration (mM) [from all treatment groups (n=20)] of intestinal content (Mean ± SD)

	Short-chain fatty acid (mM)				
Intestinal part	Acetate	Propionate	Butyrate	Valerate	Total SCFA
Jejunum	9.94±6.59	5.74±1.75	1.17±1.41	0.11±0.48	16.96±8.47
Ileum	9.87±8.75	5.83±2.27	1.04±1.39	0.02±0.05	16.77±11.29
Caecum	60.90±9.24	32.56±5.84	17.46±6.83	2.23±1.36	113.15±18.56
Proximal Colon	69.47±9.99	31.31±5.60	15.31±4.16	2.21±0.65	118.31±16.77
Distal Colon	60.03±9.11	25.88±5.58	13.20±4.55	1.78±0.73	100.88±17.08

BIOGRAPHY

Mister Phiphob Sodsee was born on January 7th, 1976 in Nakornsawan, Thailand. He graduated from Faculty of Veterinary Science, Chulalongkorn University as a Doctor of Veterinary Medicine in 1998. Currently he is working as instructor at Department of Animal Husbandry, Faculty of Veterinary Science, Chulalongkorn University.