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Study on effectiveness of activated charcoal and wood vinegar on prevention of piglet diarrhea

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ABSTRACT

The study was conducted from January 2016 to July 2016 at some pig farms in Can Tho City to determine the effectiveness of activated charcoal and wood vinegar on protecting piglet from diarrhea. The experiment was set in 19 herds of suckling pig (217 piglets) and 21 herds of post weaning pig (226 piglets) with activated charcoal: wood vinegar in 8 g:2 ml/kg feed. The result showed that average ratio of diarrhea in suckling pigs (7.37%) was higher than that in post weaning pigs (1.32%) in experimental group; but these rates were deep descended in comparison with control groups (27.94% and 30.3% respectively). Applying activated charcoal and wood vinegar in feed was effective to prevent diarrhea in suckling pigs and post weaning pigs in both rainy and dry seasons as 2.77%, 4.54% and 3.77%, 5.88% in comparison with control groups 36.36%, 16.67% and 54.54%, 25.45%, respectively. However, such an application was not effective to weight gain of piglets at 60 days old (16.827kg) and in control group (15.327 kg), neither to feed conversion ratio 1.474 and 1.592, respectively. The experimental herds were not used antibiotic when piglet having diarrhea recovered themselves after one day, usefully increasing income of farmers (124%).

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1 INTRODUCTION

Livestock production constitutes a very important component of the agricultural economy of developing countries; especially swine production plays an important role in meat production to human. Swine production in the Mekong Delta is currently common in small size with open pen where herds' health is easily affected by risk factors such as temperature, humidity and diseases (Hong *et al.*, 2006). Among common diseases, piglet diarrhea, especially in suckling and post weaning pigs, causes economic losses to farmers. There are

many causative agents leading to diarrhea in piglets such as microorganisms, host immunity and caring process (Katsuda *et al.*, 2006). *Escherichia coli* appeared to be the most dangerous agents causing diarrhea in piglets (Callesen *et al.*, 2007).

Nowadays, antibiotic abuse for the treatment of diarrhea in piglets leads to antibiotic resistance of *E. coli* strains (Hunter *et al.*, 2010). Antibiotic abuse is not only generating more antibiotic resistant microorganisms, but also influencing consumers' health. Thus, reduction of antibiotic use becomes overall trend in the world and in Vietnam. Currently,

it is necessary to find the bio-products for antibiotic replacement that do not affect human and animal health. Activated charcoals are known in absorption capability to not only harmful bacteria in digestive tract such as *Salmonella* and *E. coli*, but also bacteria toxic secretion in vitro and in vivo experiments a long time ago (Naka *et al.*, 2000). Besides activated charcoal, wood vinegar or organic acidifier compounds were used for supplying young animals in digestive sterilization, increasing protein digestion, and stimulating useful microbe duplication in gastrointestinal tract (Partanen and Mroz, 1999). Moreover, almost industry farms and small-scale farms in the Mekong Delta have been intensified on farms hygiene, disease prevention, and vaccination. However, diseases continuously occur with high frequency while antibiotic treatment has low effectiveness. Therefore, the study was conducted to evaluate the effectiveness of activated charcoal, wood vinegar on prevention of piglet diarrhea caused by *E. coli* and to determine antibiotic alternatives in prevention and treatment of digestive diseases in piglets.

2 MATERIALS AND METHODS

2.1 Materials

Two hundred and seventeen suckling piglets (1-28 days old), 226 post-weaning pigs (28-60 days old) with neonatal weight range of 1.418 – 1.440 kg were selected, which belong to Landrace x Yorkshire x Duroc of second litter sows in swine farms in Can Tho City, suckling piglet was fed at 7 days of age with diet of activated charcoal mixed with wood vinegar. Antibiotics such as enrofloxacin, amoxicillin, colistin, norfloxacin, were injected intramuscularly for diarrhea treatment in 3-5 days. Vitamin C, B complex and glucose were applied in oral to 5 days into 2 groups. Activated charcoal was bought from Xuyen Viet Environment *Ltd., Co.* at Ho Chi Minh city, and wood vinegar was produced by laboratory of Specified Veterinary Medicine, CTU.

2.2 Experimental design for evaluation of effectiveness of activated charcoal and wood vinegar on prevention of piglet diarrhea

The evaluation of effectiveness of activated charcoal and wood vinegar on prevention of piglet diarrhea was arranged in Table 1.

Table 1: Experimental design

Parameter	Suckling Pigs		Post Weaning Pigs	
	Experimental	Control	Experimental	Control
Number of Experimental farms	4	4	3	3
Total herds	19	6	21	6
Average number of piglets/litter	11	11	11	11
Suckling Pig Feed	Apollo Cargill	Apollo Cargill	ApolloCargill	ApolloCargill
Weaned Pig Feed	Windmill 3120	Windmill 3120	Windmill 3120	Windmill 3120
Ratio AC:WV/1kg Feed	8:2	0	8:2	0
Feeding way	Mixed feed		Mixed feed	

AC: activated charcoal, WV: wood vinegar. Proportion 8:2: 8g activated charcoal: 2ml wood vinegar.

2.3 Evaluation of diarrhea preventing efficiency

Diarrhea preventing efficiency was measured by

$$\text{Diarrhea ratio (week)} = \frac{\text{the number of weekly diarrhea piglet}}{\text{the number of weekly surveyed piglet}} \times 100$$

$$\text{Average diarrhea ratio} = \frac{\text{the number of average diarrhea piglet(}i>period)}{\text{the number of surveyed piglet (}i>period)} \times 100$$

$$\text{Seasonal diarrhea ratio} = \frac{\text{the number of average diarrhea piglet(}i>season)}{\text{the number of surveyed piglet (}i>season)} \times 100$$

2.4 Evaluation of feed consuming efficiency

Feed consuming efficiency was measured by formulas as follows:

$$\text{Average daily feed intake (ADFI)} = \frac{\text{amount of feed intake (}i>period)/ \text{total days}}{\text{total piglets of litter}}$$

$$\text{Average daily gain (ADG)} = \frac{\text{average weight gain (}i>period)}{\text{number of day (}i>period)}$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{total number feed consumed (}i>period)/\text{total piglets of litter}}{\text{average weight gain (}i>period)}$$

2.5 Weight gain performance evaluation

Weight of suckling pig was measured in the early morning, before feeding at day 1, 7 and 28. Weight of post weaning pig was measured at day 28 and 60.

2.6 Economic efficiency comparison

Economic efficiency of experimental treatment was evaluated by gap between total income and total outcome of each period: Gap = total outcome– total income.

2.7 Statistical analysis

The data were analyzed by Chi-square and general linear model using Minitab 16.0 software.

3 RESULTS AND DISCUSSIONS

3.1 Result of diarrhea rate observation of piglets in experimental treatment

The diarrhea rate observation of piglets in experimental treatment was shown in Table 2.

Table 2: The proportion of piglet diarrhea in experimental treatment

Period	No. of farms	No. of herds	No. of piglets	Average No. of diarrheic piglets	Ratio (%) [Treatment/Control]
Suckling	4	19	217	16	7.37/27.94
Post weaning	3	21	226	3	1.32/30.30
<i>P=0.002</i>					

The ratio of suckling pigs with diarrhea was 7.37% which was higher than that of post weaning pig (1.32%) ($P<0.01$). The different rates might be due to low resistance of suckling pigs and mostly dependence on passive antibody receiving from colostrum. These passive antibodies have been decreased in very low level at fourth week of age (Zivkovic and Kovcin, 1989). Antibody production in suckling pig had just activated in this period compared to post weaning pig with nearly immune completion. In the other hand, suckling pig has an immature digestive tract, consuming a large amount of feed, low HCl level in stomach, low capable protein digestion creating favorable conditions for

E. coli growth which caused piglet diarrhea. In contrast, gastrointestinal tract (GI) of post weaning pig is completely developed with sterilized capability by increasing amount of free HCl, therefore, the ratio of diarrhea in weaned pig is lower than that in suckling pig when charcoal and wood vinegar were added (Zivkovic and Kovcin, 1989).

3.2 The proportion of diarrheic piglets in the groups by period of time

The proportion of diarrheic suckling pigs by period of time was shown in Table 3.

Table 3: The diarrhea rate of suckling pigs in two groups by period

Week	Experimental treatment			Control group			P
	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	
1	217	13	5.99	68	4	5.88	0.79
2	217	44	20.20	68	24	35.29	0.01
3	217	6	2.76	68	23	33.82	0.00
4	217	2	0.92	68	25	36.76	0.00

The diarrhea rate of suckling pigs in the experimental and control groups at the first week were 5.99% and 5.88%, respectively, and there was no significant difference with $P=0.79$. The result was probably explained that in this period, all piglets of two treatments did not consume any feed, so there is no significant difference. When piglets started consuming feed in the second week, the diarrhea rate in the second, third, fourth week of the experimental group was 20.2%, 2.76%, 0.92%, respectively; that were completely lower than those of the control group with 35.29% ($P<0.005$),

33.82% and 36.76%, respectively ($P<0.001$). These results showed the similarities with the report by Naka *et al.* (2000) that providing activated charcoal and wood vinegar in feed reduced diarrhea rate by absorption of activated charcoal to *E. coli* in digestive system. The older piglets at three and four weeks of age consumed more feed, thus the diarrhea prevention capability of activated charcoal and wood vinegar was obviously demonstrated in the experimental group compared to the control group. The proportion of diarrheic post-weaning pigs by period of time was shown in Table 4.

Table 4: The diarrhea rate of post-weaning pigs in two groups by period of time

Week	Experimental Treatment			Control group			P
	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	
5	226	5	2.12	66	21	31.81	0.000
6	226	4	1.76	66	32	48.48	0.000
7	226	1	0.44	66	15	22.72	0.000
8	226	3	1.32	66	11	16.67	0.000

The ratios of post weaning pig diarrhea at fifth, sixth, seventh and eighth week were 2.12%; 1.76%; 0.44% and 1.32%, respectively that were highly significant difference ($P < 0.01$) when compared to the control group in 31.81%, 48.48%, 22.72% and 16.67%, respectively. These results might be due to post weaning pigs depended on feed and amount of feed increased by age after separated far from sows. In the control group, the amount of feed intake rose while indigestible feed amount increased. It is a good condition for multiplication of *E. coli*,

Salmonella, stress caused by weaning and change of feed, leading to easily effected low digestive feed ability (Thomson, 2006). In the experimental group, there was the presence of activated charcoal and wood vinegar, which killed bacteria efficiently to assist pigs in digestive feed, activated stomach pepsin and stimulated beneficial bacteria to develop and compete with *E. coli* for attachment on gut receptor; when *E. coli* cannot attach to gut receptor, it lost capability to cause diarrhea (Watarai and Tana, 2005).

Table 5: The diarrhea rate in suckling pigs of two groups by seasons

Season	Experimental treatment			Control group			P
	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	
Dry	159	6	3.77	42	7	16.67	0.003
Rainy	36	1	2.77	11	4	36.36	0.007

The rates of suckling pig diarrhea in the experimental and control groups in dry and rainy seasons were 3.77% and 16.67%; 2.77% and 36.36%, respectively. This result indicated that the ratios of diarrhea in suckling pigs in the control group were higher than those in the experimental group in both dry and rainy seasons ($P < 0.01$). In the control group, the diarrhea rate was increased when climate changes from dry to rainy season. Supplementing activated charcoal and wood vinegar in suckling pig diet of the experimental group

reduced the ratio of piglet diarrhea even under temperature and humidity factors. Supplying activated charcoal and wood vinegar played an important role in piglet immunity and digestibility in different weather conditions. As diets of suckling pigs were supplemented with activated charcoal and wood vinegar which continued to increasing effective impact on decimating harmful bacteria and stimulating useful bacteria's growth in piglet GI tract (Naka *et al.*, 2000).

Table 6: The diarrhea rate in post weaning pigs in two groups by seasons

Season	Experimental treatment			Control group			P
	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	No. of surveyed piglets	No. of diarrheic piglets	Ratio (%)	
Dry	204	12	5.88	55	14	25.45	0.000
Rainy	22	1	4.54	11	6	54.54	0.002

In the same suckling pigs, diarrhea rates in post weaning pigs of the experimental and control groups in dry and rainy seasons were 5.88% and 25.45%; 4.54% and 54.54%, respectively. There was significant difference between diarrhea rates of the experimental and control groups in both dry and rainy seasons ($P < 0.01$). The efficiency of supplementing activated charcoal and wood vinegar for piglet diet proved piglet ability in reducing impact of humidity and temperature to diarrhea rate of suckling and weaned piglets.

3.3 Results of treatment of piglet diarrhea

The results of treatment of piglet diarrhea was shown in Table 7 and Table 8.

In the control group, 76 diarrhea piglets (100%) treated by antibiotic recovered in one to five days (17 out of 76 piglets recovered after five days), while suckling pigs at the experimental treatment, 52 out of 65 piglets with slight diarrhea (80%) were not treated by antibiotic and self-recovered after one day, 13 out of 65 piglets (20%) were treated by

antibiotic. Because at the first week of age, piglets did not consume feed supplemented with activated charcoal and wood vinegar, there was no effect in diarrhea prevention.

In the experimental group, there were 13 diarrheic piglets recovering themselves after one day. It reveals that activated charcoal and wood vinegar

showed effectiveness in diarrhea prevention. In the control group, 10 out of 79 piglets with diarrhea recovering after one day, 69 out of 79 piglets recovering after 2-5 days, were treated by antibiotics. It means that activated charcoal and wood vinegar showed effectiveness in preventing and reducing diarrhea rate in post weaning pigs.

Table 7: Result of treatment of suckling pig diarrhea

Parameter	Experimental treatment		Control group	
	No. of piglets	Ratio (%)	No. of piglets	Ratio (%)
Diarrheic piglets	65	7.37	76	27.94
Piglets were not treated with antibiotics	52	80.00	0	0
Piglets were treated with antibiotic	13	20.00	76	100
Recovered day (day)				
1	52	80.00	10	13.15
2	0	0	29	38.15
3	13	20.00	20	26.31

Table 8: Result of treatment of post weaning pig diarrhea

Parameter	Experimental treatment		Control group	
	No. of piglet	Ratio (%)	No. of piglet	Ratio (%)
Diarrheic piglet	13	1.32	79	30.30
Piglets were not treated with antibiotic	13	100		
Piglets were treated with antibiotic	0	0	79	100
Recovered day (day)				
1	13	100	10	12.65
2	0		31	39.24
3	0		35	44.30
5	0		3	3.79

3.4 Results of weight gain, feed consumed efficiency and conversion ratio of piglets

The weight gain, feed consumed efficiency and conversion ratio of piglets were shown in Table 9, 10 and 11.

Results of the study showed that average weights of neonatal piglet in the experimental and control groups were 1.418kg and 1.440kg, respectively. There was similarity in 1-week-old piglet weight of experimental (3.992 kg) and control (4.093 kg) (P=0,204). These consequences could be explained that piglets of each treatment did not consume any feed, required nutrition for their growth almost from sow's milk. From fourth week, average weight of piglets in the experimental group (7.123 kg) was

higher than that in the control group (6.681 kg), (P=0,005). The same result was witnessed in eighth week with average piglet weight of the experimental (16.827kg) higher than that of the control group (15.637kg) (P=0.000). In these stages, the ratio of piglet diarrhea in the experimental group which consumed feed mixed with activated charcoal and wood vinegar, was decrease; therefore, nutrient absorption was improved as well as health improvement and weight gain. According to Mekbungwan *et al.* (2004), activated charcoal and wood vinegar were non-toxic ingredients and unaffected in weight gain of piglets, besides they could contribute to the absorption of anti-nutritional factors and toxic in the feed ensuring normal growth of piglets.

Table 9: The results of weight gain of piglets being neonatal to 60 days old

Week	Average weight (kg)		SE	P
	Experimental	Control		
Neonatal	1.418	1.440	0.013	0.255
1	3.992	4.093	0.053	0.204
4	7.123	6.681	0.106	0.005
8	16.827	15.637	0.226	0.000

Table 10: The weight gain parameters in suckling pigs

Parameter	Group		SE	P
	Experimental	Control		
ADG (g/piglet/day)	181.58	175.24	9.877	0.666
ADFI (g/piglet/day)	44.720	40.50	4.187	0.500
FCR	0.462	0.505	0.349	0.414

ADG: average daily gain, ADFI: average daily feed intake

The result showed that ADG and ADFI of piglets in the experimental group were 181.58g and 44.72g, which was similar to these data in the control group with 175.24g and 40.50g (P>0.05). FCR of experimental piglets was 0.462, and there was no statistically significant difference between the experi-

mental and control groups. The data showed that activated charcoal and wood vinegar added to piglet diet did not affected feed consume, DGW and FCR of suckling pig. It means that activated charcoal and wood vinegar used in this experiment were not toxic and did not affect weight gain of suckling pigs.

Table 11: The weight gain in post weaning pigs

Parameter	Group		SE	P
	Experimental	Control		
ADG (g/piglet/day)	301.61	282.76	16.55	0.448
ADFI (g/piglet/day)	448.15	445.63	25.34	0.947
FCR	1.47	1.59	0.04	0.070

In the same suckling pigs, ADG and ADFI of post weaning pigs in the experimental group were 301.61g and 448.15g; which were similar to those data of the control group with 282.76 g and 445.63 g, respectively (P>0,05. FCR of both groups were 1.47 and 1.59, respectively and not statistically significant (P>0.05). These results showed that activated charcoal and wood vinegar mixed into diet

were not toxic and did not affect weight gain of post weaning pigs.

3.5 Economic efficiency of two groups

The economic efficiency of two groups were measured Table 12.

Table 12: Comparison of economic efficiency between two groups

Parameter	Experimental treatment	Control group	Price per kg	Total (cost) (Unit: thousand VND)	
				Experimental	Control
TF(0-28) (kg)	1.25	1.13	24.72	30.90	27.93
TF(28-60) (kg)	14.34	14.26	14.88	213.30	212.18
TAC0-60 (kg)	1.7	0	14	1.7	0
Diarrhea treated cost				2	46
Total outcome				245.90	286.11
TGW (KG)	16.82	15.63	42	706.44	656.46
Total income				706.44	656.46
Gap between total income and outcome				460.54	370.34
Profit comparison (%)				124%	100%

(TF0-28: Amount of feed period 0-28 day; TF28-60: Amount of feed period 28-60 day; TAC0-60: Amount of activated charcoal provided in feed; TGW: Weight gain period0-60 day)

Economic efficiency was obviously witnessed; profit per pig of experimental treatment was 460.54 thousand VND that was 1.24 times higher than that control group (370.34 thousand VND). In experimental treatment, it was spent about 1.7 thousand VND for activated charcoal and wood vinegar, no cost for diarrhea treatment because of slight diarrhea and self-recovery. Average weights at the end of the experimental group were also higher than those of

the control group. However, FCR of the experimental treatment was low so that it brought more profit than the control for farmers. This result indicated that activated charcoal and wood vinegar supplement in diets of piglet contributed to reducing diarrhea rate in both suckling and post weaning pigs. Activated charcoal and wood vinegar added to piglet diet were not toxic and did not affect piglets'

weight gain (Mekbungwan *et al.*, 2004); it was effective to reduce antibiotic use in treatment, reduce production cost, and increase productivity and profit (124%).

4 CONCLUSIONS

Combination of activated charcoal and wood vinegar mixed with feed effectively reduced diarrhea in suckling and post weaning pigs, both in dry and rainy seasons. It did not affect piglet weight gain, FCR, daily feed intake. It helps to restrict the use of antibiotics, increase the quality of products, reduce input costs, and increase profits for farmers (124 %).

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