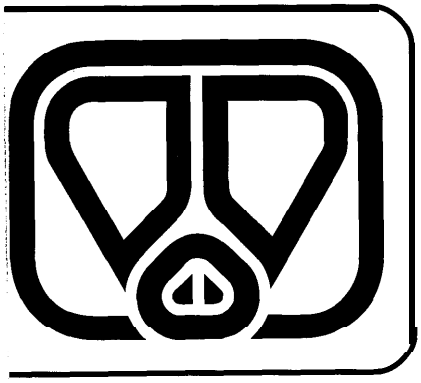
ir. C.M.C. van der Peet-Schwering
ing. J.G. Plagge

Influence of Enteroguard on the performance and health of weaned piglets



Research Institute for Pig Husbandry

Location:
Experimental Farm for
Pig Husbandry
"Not-th- and East-Netherlands"
Drosteweg 8
8101 NB Raalte
Phone + 31 57 23 52 174

P 5.11
April 2000
ISSN 1385 - 5883

CONTENTS

SUMMARY

In a 39 day 2 x 2 factorial study, 660 cross-bred piglets were used to examine whether Enteroguard (a combination of freeze-dried garlic and cinnamon oil) is an alternative feed additive to growth promoting antibiotics. Four experimental treatments were tested:

1 piglets were fed a prestarter and a starter diet without a growth promoting antibiotic and without Enteroguard;
2 piglets were fed a prestarter and a starter diet without a growth promoting antibiotic but with Enteroguard Starter (1 kg/tonne);
3 piglets were fed a prestarter and a starter diet with a growth promoting antibiotic (40 ppm avilamycine) but without Enteroguard;
4 piglets were fed a prestarter and a starter diet with a growth promoting antibiotic (40 ppm avilamycine) and with Enteroguard Starter (1kg/tonne).

The prestarter diets were fed from day 1 to 15 postweaning. After a three day switch over period piglets were fed the starter diets from day 19 to 39 postweaning. The diets were provided ad libitum.

The most important results and conclusions are given below:

- The addition of Enteroguard to a diet without a growth promoting antibiotic improved daily weight gain and feed conversion ratio from day 1 to 15 by 6.5% and 4.2%, respectively. From day 15 to 39, Enteroguard did not improve the performance of the piglets.
- The increased performance observed for piglets fed Enteroguard in the diet from day 1 to 15 was not as large as that obtained with a growth promoting antibiotic.
- Enteroguard significantly reduced the occurrence and gravity of post-weaning diarrhoea in the second week of the trial. The growth promoting antibiotic reduced them in the first two weeks.
- The addition of Enteroguard to the diet reduced the percentage of piglets that died during the experiment caused by intestinal disorders from 3.9% tot 1.2%. The number of piglets that received a veterinary treatment was not reduced.
- The addition of a growth promoting antibiotic to the diet reduced the number of veterinary treatments but the mortality of the piglets was not decreased.
- The addition of Enteroguard as well as the addition of a growth promoting antibiotic to the diet increased the gross margin per delivered piglet significantly. Piglets that received diets with both Enteroguard and a growth promoting antibiotic had the highest gross margin.

1 INTRODUCTION

Since the 1950s, growth promoting antibiotics have been used in sub-therapeutic doses in animal feed. In recent years, there has been an increasing concern about the use of these growth promoting antibiotics. The reason for this concern is the risk for the development of resistance of pathogenic micro-organisms in animals to these antibiotics and the transmission of this resistance to human pathogenic micro-organisms (Thomke and Elwinger, 1998). Since the 1st of July 1999, in the Netherlands the use of the growth promoting antibiotics tylosin, virginiamycin, zinc bacitracin and spiramycine has been forbidden. The Health Council of the Netherlands (1998) proposes to ban all the growth promoting antibiotics for all pig categories within three years.

In general, growth promoting antibiotics enhance the growth rate, improve the feed conversion ratio and prevent the development of diseases. The response in piglets is higher than in growing-finishing pigs (Health Council of the Netherlands, 1998; Thomke and Elwinger, 1998). The Health Council of the Netherlands (1998) concludes that growth promoting antibiotics improve the growth rate by 3 - 8% and 1 - 3% in piglets and growing-finishing pigs, respectively. The feed conversion ratio will be enhanced by 3 - 7% and 2 - 5% in piglets and growing-finishing pigs, respectively. A ban on growth promoting antibiotics probably will reduce the performance of the piglets on many farms.

In Sweden, in 1986 the use of growth promoting antibiotics was prohibited. This resulted in an increased incidence of post weaning diarrhoea, an increased post weaning mortality, a decreased growth rate after weaning and an increase in feed medication (Robertsson and Lundeheim, 1994). Alternative strategies to prevent these problems have to be developed. Therefore, more research on alternative feed additives is necessary.

Herbs, like garlic and cinnamon, together with acids, enzymes, probiotics and yeasts are possible alternative feed additives. Garlic is among others used as an anti-microbial, a lipidemic and an anti-oxidant agent, an anti-carcinogen and an immune system modulator (Rees et al., 1993). Freeze-dried garlic inhibits the growth of many bacteria (like Staphylococus aureus, Salmonella and E. Coli), yeasts and fungi (Rees et al., 1993; Skyrme, 1996). Lactic acid bacteria were the least sensitive micro-organisms to the inhibitory effects of garlic. The anti-microbial activity of garlic is mainly mediated through the activity of allicin (Skyrme, 1996). Cinnamon also has an anti-microbial activity and it is an antifungal agent (Morozumi, 1978). The essential oil, cinnamaldehyde, is responsible for this anti-bacterial activity. Cinnamaldehyde inhibits the growth of some bacteria (like Staphylococcus aureus) and of mycotoxin-producing fungi (Morozumi, 1978). Cinnamaldehyde is also active against lactic acid bacteria (Yousef and Tawil, 1980). Cultech Limited (Swansea, United Kingdom) has combined freeze-dried garlic and cinnamaldehyde in the products Enteroguard Starter and Enteroguard Finisher. Enteroguard Starter is used in diets for weaned pigs and has a high allicin to cinnamaldehyde ratio. Enteroguard Finisher is used for growing-finishing pigs and has a high cinnamaldehyde to allicin ratio. Enteroguard is a possible alternative feed additive to growth promoting antibiotics.

The objective of this experiment was to examine whether Enteroguard Starter is an alternative feed additive to antibiotics in diets for weaned piglets.

The experiment was conducted in cooperation with Cultech Limited.

2 MATERIAL AND METHODS

2.1 Animals and experimental size

The research was carried out at the Experimental Farm for Pig Husbandry "North- and East-Netherlands" at Raalte with weaned piglets of crossbred GY_s-boar x (GY, x NL)-sow. At an average age of 27 days and an average weight of 8.3 kg the piglets were weaned and divided into groups for the experiment. The piglets were monitored for 39 days from the moment of weaning. The research comprised a total of 660 piglets in 8 batches from February to July 1999.

2.2 Experimental treatments

Four experimental treatments were compared in a 2 x 2 factorial arrangement:

1 piglets were fed a prestarter and a starter diet without a growth promoting antibiotic and without, Enteroguard;
2 piglets were fed a prestarter and a starter diet without a growth promoting antibiotic but with Enteroguard Starter (1 kg/tonne);
3 piglets were fed a prestarter and a starter diet with a growth promoting antibiotic (40 ppm avilamycine) but without Enteroguard;
4 piglets were fed a prestarter and a starter diet with a growth promoting antibiotic (40 ppm avilamycine) and with Enteroguard Starter (1 kg/tonne).

The prestarter diets were fed from day 1 to 15 postweaning. From day 16 to 18 the diets were gradually changed to the starter diets which were fed from day 19 to 39 postweaning. The diets were provided ad libitum. The ingredients and the calculated chemical composition of the experimental diets are presented in appendix 1. All the diets for the experiment were produced at the same time from the same batches of ingredients. Water was provided ad libitum during the whole period.

2.3 Experimental design

The piglets were blocked by initial weight, sex and ancestry. Piglets that weighed 5 kg or less at weaning or that showed (visible) physical abnormalities were not used in the experiment. The piglets within one block were of approximately equal weight at weaning. The assignment to the four experimental groups over the pens within one block was at random. A compartment was always filled at the same time. Each treatment had 9 or 10 pigs per pen and 17 replicates (pens).

2.4 Housing and climate

The experiment was conducted in four compartments, two of which consisted of 10 pens for 10 piglets each, one consisting of 10 pens for 9 piglets and one consisting of 12 pens for 9 piglets. All pens had a solid spherical floor that was heated and contained metal tribar slats. The compartments were mechanically ventilated. The aeration and heating were computer controlled. On day 1 of the experiment the compartment temperature was set at 27°C, dropping to 21°C gradually in five weeks. The floor temperature was fixed at 40°C at the start of the experiment and was lowered to 21°C within five weeks.

2.5 Data collection

2.5.1 Feed samples

Before the experiment began, samples were taken from all the diets to determine the content of dry matter, crude protein, crude fat, crude fibre, ash and avilamycine. During the experiment two collective samples were taken from all feeds. These collective samples were made by collecting a small amount of feed each week for the first 8 replicates in the trial and for the last 9 replicates in the trial. The 16 samples (8 diets x 2 samples) were analysed for dry matter, crude protein, crude fat, crude fibre, and ash.

2.5.2 Performance

All piglets were individually weighed at the start of the experiment and on day 15 and 39 after weaning. The amount of feed supplied per pen of pigs was recorded at day 15, at day 39 and at disposal of piglets.

These data were used to calculate growth rate per day, feed intake per day and feed conversion ratio.

Veterinary treatments were registered per animal. If an animal died, the date, weight and cause of death were recorded. The dead animals were not included in the analyses of the weaner results.

During the first three weeks after weaning all the pens were assessed for the occurrence of post-weaning diarrhoea three times a week (on Monday, Wednesday and Friday). The incidence of post-weaning diarrhoea was determined by looking at the consistency of the faeces in the pen and by assessing the pigs. The consistency of the faeces was divided into three classes: normal faeces (no diarrhoea), mild diarrhoea and watery diarrhoea. At the same time an estimate of the number of animals within each class was made per pen.

2.6 Data processing

The experiment was set up in accordance with a 2 x 2 factorial design. The main factors were growth promoting antibiotic (included or not included in the diet) and Enteroguard (included or not included in the diet). The daily growth rate, feed intake and feed conversion ratio were analysed using analysis of variance (SAS, 1990) in accordance to model 1. In this model, 'the pen' was the experimental unit:

$$y = \mu + \text{block} + \text{growth promoting antibiotic} + \text{Enteroguard} + \text{growth promoting antibiotic} \times \text{Enteroguard} + \text{error} \quad \text{(model 1)}$$

A chi-square test was used to determine whether there were differences between the treatments as to number of pigs that died and the number of veterinary treatments. The incidence of post-weaning diarrhoea was analysed using logistic regression (Oude Voshaar, 1995).

3 RESULTS

3.1 Composition of experimental diets

The results of the chemical analyses of the experimental diets are presented in table 1.

From table 1 and appendix 1 can be seen that the planned and actual amounts of crude protein, crude fat, crude fibre and ash were fairly similar in both the prestarter diet and the starter diet. The avilamycine contents analysed were in most of the diets also fairly similar with those calculated in advance. In the starter diet without Enteroguard, the actual amount of avilamycine was somewhat lower than the planned amount.

3.2 Performance during the weaning period

In table 2, the performance of the weaned piglets from day 1 to 15, day 15 to 39 and day 1 to 39 of the experiment is presented.

From table 2 can be seen that from day 1 to 15, the piglets that received a growth promoting antibiotic in the diet, grew faster, had a higher feed intake and a better feed conversion ratio than those piglets that did not receive a growth promoting antibiotic in the diet. From day 1 to 15, there were no significant differences in growth rate, feed intake and feed conversion ratio between piglets that received a diet with or without Enteroguard.

The results from day 15 to 39 show that the piglets receiving a growth promoting antibiotic in the diet grew faster, had a slightly better feed intake and had the same feed conversion ratio than piglets that did not receive a growth promoting antibiotic. Among the piglets that received a diet with or without Enteroguard, no differences were found in performance from day 15 to 39. From day 1 to 39, the piglets receiving a growth promoting antibiotic in the diet, grew faster and had a higher feed intake than piglets that did not receive a growth promoting antibiotic in the diet. There was no effect of growth promoting antibiotic on the feed conversion ratio. From day 1 to 39, there were no significant differences in growth rate, feed intake and feed conversion ratio between piglets that received a diet with or without Enteroguard.

3.3 Health and mortality

3.3.1 The occurrence of post-weaning diarrhoea

In table 3, the occurrence and gravity of post-weaning diarrhoea during the first three weeks of the weaner period are presented.

Table 1: Analysed chemical composition of the experimental diets (g/kg)

	prestarter diet				starter diet			
antibiotic:			+	+			+	+
Enteroguard:		+		+		+		+
number of samples	3	3	3	3	3	3	3	3
dry matter	895	894	895	895	889	888	887	887
crude protein	182	183	180	183	180	178	182	180
crude fat	50	49	48	50	50	47	48	48
crude fibre	38	35	37	35	43	44	45	45
ash	50	51	51	51	51	51	54	53
avilamycine[1] (mg/kg)	0	0	36	41	0	0	32	40

[1] number of samples is 1

Table 2: Performance of piglets receiving prestarter and starter diets with or without growth promoting antibiotic and with or without Enteroguard

	without antibiotic		with antibiotic			significance[2]		
	without Enteroguard	with Enteroguard	without Enteroguard	with Enteroguard	SEM[1]	antibiotic	Enteroguard	interaction
number of animals	158	160	157	162				
number op pens	17	17	17	17				
Day *1* to 15:								
initial body weight (kg)	8.3	8.3	8.3	8.3				
growth (g/d)	168	179	198	199	7.7	**	n.s.	n.s.
feed intake (kg/d)	0.23	0.24	0.25	0.25	0.007	**	n.s.	n.s.
feed conversion ratio	1.44	1.38	1.30	1.30	0.038	**	n.s.	n.s.
Day 15 *to 39.*								
body weight (kg)	10.8	10.9	11.3	11.3				
growth (g/d)	507	501	528	529	9.4	*	n.s.	n.s.
feed intake (kg/d)	0.75	0.76	0.78	0.78	0.016	#	n.s.	n.s.
feed conversion ratio	1.48	1.51	1.49	1.47	0.021	n.s.	n.s.	n.s.
Day 1 to 39:								
final body weight (kg)	23.3	23.5	24.0	24.0				
growth (g/d)	378	380	401	402	7.7	**	n.s.	n.s.
feed intake (kg/d)	0.55	0.56	0.58	0.58	0.011	*	n.s.	n.s.
feed conversion ratio	1.46	1.48	1.45	1.44	0.018	n.s.	n.s.	n.s.

[1] SEM = pooled standard error of the mean (gives an indication of the accuracy of the estimate of the variable measured). A difference of more than 2.77 x SEM is significant.

[2] Significance: n.s. = not significant; # = ($p < 0.10$); * = ($p < 0.05$); ** = ($p < 0.01$)

Table 3: Occurrence and gravity of post-weaning diarrhoea (% of the number of observations) in piglets receiving prestarter and starter diets with or without growth promoting antibiotic and with or without Enteroguard

	without antibiotic		with antibiotic		significance[1]	
	without Enteroguard	with Enteroguard	without Enteroguard	with Enteroguard	antibiotic	Entero-guard
number of animals	158	160	157	162		
First week after the start of the experiment:					*	n.s.
no diarrhoea	71.6	75.8	85.3	78.9		
mild diarrhoea	8.3	8.1	4.3	8.6		
watery diarrhoea	20.1	16.1	10.4	12.5		
Second week after the start of the experiment:						
no diarrhoea	70.7	81.1	86.3	90.4		
mild diarrhoea	15.6	12.7	9.0	2.5		
watery diarrhoea	13.7	6.2	4.7	7.1		
Third week after the start of the experiment:					n.s.	n.s.
no diarrhoea	88.2	94.3	94.5	94.8		
mild diarrhoea	11.3	5.7	5.5	4.9		
watery diarrhoea	0.5	0.0	0.0	0.3		

[1]significance: n.s. = not significant; * = ($p < 0.05$); ** = ($p < 0.01$)

Piglets that received a growth promoting antibiotic in the diet exhibited less post-weaning diarrhoea than piglets that did not receive a growth promoting antibiotic in the diet in the first and second week after weaning. In the third week, there was no difference in the ocurrence and gravity of post-weaning diarrhoea. In the second week, the piglets that received Enteroguard in the diet exhibited less post-weaning diarrhoea than those that did not receive Enteroguard in the diet. In the first and third week, there was no difference in the occurrence and gravity of post-weaning diarrhoea in piglets fed diets with or without Enteroguard.

3.3.2 Mortality and veterinary treatments

In table 4, the number of animals that died and the number of animals that had to be treated for health problems are presented. The reasons for the mortality and treatments are also given. In this experiment pigs were treated individually. In the case that more than 60% of the pigs in the pen had to be treated all the pigs in the pen were individually treated.

From table 4 can be seen that there is no significant difference in the mortality of piglets between the four experimental treatments. There is a significant difference, however, in the reason of mortality. Fewer pigs from the groups that received Enteroguard in the diet died from intestinal disorders.

Fewer piglets receiving a growth promoting antibiotic in the diet were treated for health problems, especially intestinal disorders and skin lesions, than piglets that did not receive a growth promoting antibiotic in the diet. No differences were found in the number of pigs treated for health problems and in the reasons for treatment between the piglets that received a diet with or without Enteroguard.

Table 4: Mortality and veterinary treatments of piglets receiving prestarter and starter diets with or without growth promoting antibiotic and with or without Enteroguard

	without antibiotic		with antibiotic		significance[1]	
	without Enteroguard	with Enteroguard	without Enteroguard	with Enteroguard	antibiotic	Entero-guard
number of animals	165	165	165	165		
number of pens	17	17	17	17		
number of dead animals	7	5	8	3	n.s.	n.s.
reason of mortality:						
- intestinal disorders		2	6	2	n.s.	*
- miscellaneous	0	3	2	1	[2]	[2]
number of treated piglets	128	130	92	80	***	n.s.
reason for treatment:						
- intestinal disorders[3]	109	116	78	75	***	n.s.
- leg disorders	4	0	3	1	[2]	[2]
- skin lesions	8	5		1	**	n.s.
- nervous signs	6	4		3	n.s.	n.s.
- miscellaneous		5	3	0	[2]	[2]

[1] significance: n.s. = not significant; * = ($p < 0.05$); ** = ($p < 0.01$); *** = ($p < 0.001$)

[2] number was too low to test

[3] all piglets in the pen were individually treated in 8, 8, 3 and 4 pens (in sequence of the experimental treatments), respectively

3.4 Economic results

The economic analysis deals with the differences in performance, number of dead animals, the costs of veterinary treatment and the labour costs involved in treating the animals. The following assumptions were used for the economic evaluation:

- Yield:
  Piglets price is ƒ 92.- at 25 kg (KWIN-V, 1999). Piglets lighter than 25 kg were ƒ 2.20 less per kg.
- Feed costs per 100 kg:

	prestarter	starter
no growth promoting antibiotic, no Enteroguard	ƒ 73.40	ƒ 54.00
no growth promoting antibiotic, with Enteroguard	ƒ 75.38	ƒ 55.98
with growth promoting antibiotic, no Enteroguard	ƒ 74.90	ƒ 55.50
with growth promoting antibiotic, with Enteroguard	ƒ 76.88	ƒ 57.48

- Medical costs:
  An average of 2 ml is injected per veterinary treatment. The costs of medicine are ƒ 0.20 per ml.
- Labour costs:
  Labour costs are ƒ 38.54 per hour. Observations at the Research Institute for Pig Husbandry have shown that it takes 1.13 minutes to individually treat a weaned piglet.
- Costs of diposal of dead piglets:
  The costs of disposal are ƒ 58.63 per piglet.

In table 5, the results of the economic evaluation per delivered piglet are presented.

Table 5 shows that the piglets receiving a growth promoting antibiotic in the diet had a higher gross margin than those that did not receive a growth promoting antibiotic in the diet. The piglets fed Enteroguard in the diet had a higher gross margin than the piglets that did not receive Enteroguard in the diet. The piglets that received the diets with both a growth promoting antibiotic and Enteroguard had the highest gross margin.

Table 5: Economic results per delivered piglet for piglets receiving prestarter and starter diets with or without growth promoting antibiotic and with or without Enteroguard

	without antibiotic		with antibiotic			significance[2]		
	without Enteroguard	with Enteroguard	without Enteroguard	with Enteroguard	SEMI	antibiotic	Enteroguard	interaction
yield	ƒ 87.99	ƒ 88.73	ƒ 89.61	ƒ 89.62	0.66	#	n.s.	n.s.
feed costs	ƒ 12.38	ƒ 13.36	ƒ 13.35	ƒ 13.67	0.25	*	*	n.s.
medical costs	ƒ 0.32	ƒ 0.32	ƒ 0.23	ƒ 0.20				
labour costs	ƒ 0.59	ƒ 0.59	ƒ 0.43	ƒ 0.36				
costs of disposal	ƒ 2.60	ƒ 1.83	ƒ 2.99	ƒ 1.09				
Gross margin[3]	ƒ 72.09	ƒ 72.62	ƒ 72.61	ƒ 74.31	0.49	*	*	n.s.

[1] SEM = pooled standard error of the mean (gives an indication of the accuracy of the estimate of the variable measured). A difference of more than 2.77 x SEM is significant.

[2] significance: n.s. = not significant; # = ($p < 0.10$); * = ($p < 0.05$)

[3] gross margin = yield - feed costs - medical costs - labour costs - costs of disposal

4 DISCUSSION AND CONCLUSIONS

4.1 Performance and health

In this experiment the effect of Enteroguard on performance and health of weaned piglets was studied. Enteroguard was added to a diet without a growth promoting antibiotic (negative control) or to a diet with a growth promoting antibiotic (positive control). From day 1 to 15 post weaning, daily weight gain was increased by 6.5% and feed conversion ratio was improved by 4.2% when Enteroguard was added to the negative control diet although the effects were not statistically significant. Jost (1996) and Cerpentier et al. (1999) found similar results in the first two weeks post weaning. Jost (1996) conducted research in which piglets received a negative control diet containing 0%, 0.05% or 0.25% garlic powder. From day 1 to 14 and from day 1 to 35, 0.05% garlic powder increased daily weight gain by 7.2% and 8.3%, respectively. The feed conversion ratio was improved by 5.6%. The addition of 0.25% did not improve the performance of the piglets compared to 0% garlic powder. Cerpentier et al. (1999) studied the effect of the addition of 0.1% Enteroguard to a negative control diet. From day 1 to 14 post-weaning, the daily weight gain and feed conversion ratio were improved by 6% and 3.2%, respectively. From all these results, it can be concluded that the addition of Enteroguard to a prestarter diet without growth promoting antibiotic improves daily weight gain and feed conversion ratio from day 1 to 14 by about 6.5% and 4%, respectively. While these differences are not statistically significant, the differences are numerically consistent.

From day 15 to 39, the addition of Enteroguard to the negative control did not influence the performance of the piglets. In the research of Cerpentier et al. (1999), however, daily weight gain and feed conversion ratio were improved by 6.8% and 6.3%, respectively. Jost (1996) found an increase in daily weight gain of 8.5%. In the Netherlands, most post weaning diarrhoea problems occur in the first two weeks after weaning and, thereafter, there are hardly any diarrhoea problems. This was also the case in this research. Probably, Enteroguard has the biggest effect on the performance of piglets at the time when the piglets are most vulnerable and most problems occur.

The addition of Enteroguard to the positive control did not improve the performance of the piglets. Apparently, Enteroguard does not have an extra benefit when there is already a growth promoting antibiotic in the diet.

The addition of the growth promoting antibiotic avilamycine to the diet improved overall daily weight gain, feed intake and feed conversion ratio by 6.1%, 5.5% and 0.7%, respectively from day 1 to 39. These results are consistent with other research (Health Council of the Netherlands, 1998; Van der Ploeg, 1998). The greatest response was seen from day 1 to 15. In this period, the addition of avilamycine to the negative control diet enhanced daily weight gain, feed intake and feed conversion ratio by 17.9%, 8.7% and 9.7%, respectively. Similar results were reported by Van der Ploeg (1998). It seems that avilamycine, like Enteroguard, has the biggest benefit during the first two weeks after weaning, the period when piglets are most vulnerable. It can be concluded that from day 1 to 15, Enteroguard has a positive effect on the performance of piglets, but not as large as avilamycine.

In the experiment, most post-weaning diarrhoea occurred in the first two weeks after weaning. The addition of Enteroguard to the diet had no effect on the occurrence of post-weaning diarrhoea in the first week after weaning. In the second week, however, Enteroguard significantly reduced the occurrence and gravity of post-weaning diarrhoea. The number of piglets that received a veterinary treatment was not influenced by Enteroguard. Noticeable is the effect of Enteroguard on the mortality of the piglets. The addition of Enteroguard to the diet reduced mortality caused by intestinal disorders from 3.9% to 1.2%. In the experiment of Jost (1998), the addition of 0.05% garlic powder reduced mortality from 15.6% to 0.0%. In research from the Danish Slaughter-

houses (not published) mortality was reduced from 3.3% to 1.3% when Enteroguard was added to the diet. The number of veterinary treatments, however, was also reduced. In the present experiment, it is not clear why the mortality caused by intestinal disorders was reduced but the number of veterinary treatments stayed the same. It may be that Enteroguard is not preventing the incidence of post-weaning diarrhoea so much but it enables the piglets to cope better with the resulting intestinal disorders.

The addition of a growth promoting antibiotic to the diet reduced the number of piglets that required a veterinary treatment for intestinal disorders by about 30% but it did not reduce the mortality of the piglets. In the literature there is not much data concerning the effect of growth promoting antibiotics on the mortality of piglets. Jongbloed and Prins (1998) suppose that a ban on growth promoting antibiotics would increase the mortality rate of piglets by 0.5%. Van der Ploeg (1999), however, also did not report an effect of avilamycine on the mortality of piglets although the number of veterinary treatments was reduced.

The addition of Enteroguard to the diet increased the gross margin per delivered piglet. The main reason for this was the reduced mortality. The addition of a growth promoting antibiotic increased the gross margin per delivered piglet because of the improved performance of the piglets. Piglets that received diets with both Enteroguard and a growth promoting antibiotic had the highest gross margin because the performance was improved and the mortality was decreased.

4.2 Conclusions

- The addition of Enteroguard to a diet without a growth promoting antibiotic improved daily weight gain and feed conversion ratio from day 1 to 15 by 6.5% and 4.2%, respectively. From day 15 to 39, Enteroguard did not improve the performance of the piglets.
- The increased performance observed for piglets fed Enteroguard in the diet from day 1 to 15 was not as large as that obtained with a growth promoting antibiotic.
- Enteroguard significantly reduced the occurrence and gravity of post-weaning diarrhoea in the second week of the trial. The growth promoting antibiotic reduced the occurrence and gravity of post-weaning diarrhoea in the first two weeks.
- The addition of Enteroguard to the diet reduced the percentage of piglets that died during the experiment caused by intestinal disorders from 3.9% to 1.2%. The number of piglets that received a veterinary treatment was not reduced.
- The addition of a growth promoting antibiotic to the diet reduced the number of veterinary treatments, but the mortality of the piglets was not decreased.
- The addition of Enteroguard as well as the addition of a growth promoting antibiotic to the diet increased the gross margin per delivered piglet significantly. Piglets that received diets with both Enteroguard and a growth promoting antibiotic had the highest gross margin.

LITERATURE

Cerpentier, K., H. Coenen, J. Aerts en D. Fremaut *1999. Zin en onzin van plantenextracten in de biggenvoeding.* Varkensbedrijf, 24-25.

Health Council of the Netherlands 1998. *Antimicrobial growth promotors.* Publication no. 1998/15, Rijswijk.

Jongbloed, A.W. and H. Prins 1998. *Consequenties verbod anti-microbiële voerbespaarders in de varkenshouderij.* Notitie Productschap Diervoeder.

Jost, M. 1996. *Einsatz van knoblauchpulver im Ferkelaufzuchtfutter* Agrarforschung, 3 (10), 479-481.

Morozumi, S. 1978. *Isolation, purification and antibiotic activity of 0-Methoxycinnamaldehyde from cinnamon.* Applied and environmental microbiology, 36, 577-583.

KWIN-V 1999. *Kwantitatieve Informatie Veehouderij 19992000.* Praktijkonderzoek Rundvee, Schapen en Paarden.

Oude Voshaar, J.H. 1995. *Statistics for researchers.* Wageningen Press, Wageningen.

Ploeg, H. van der *1998. Selacid en Selacid Balance-Liquid.* De Molenaar, 12, 13-20.

Rees, L.P., S.F. Minney, N.T. Plummer, J.H. Slater and D.A. Skyrme 1993. *A quantitative assessment of the anti-microbial activity of garlic (Allium sativum).* World Journal of Microbiology and Biotechnology, 9, 303-307.

Robertsson, J.A. and N. Lundeheim 1994. *Prohibited use of antibiotics as a feed additive for growth promotion - effects on piglet health and production parameters.* Proceedings of the 13th IPVS Congress, Thailand, 282.

SAS 1990. *SAS/STAT Users's guide: Statistics* (Release 6.04 Ed.). SAS Inst. Inc., Cary, NC, USA.

Skyrme, D.A. 1996. *An investigation into the anti-microbial activity of Allium sativum.* PhD-thesis, School of Pure and Applied Biology, University of Wales College of Cardiff.

Thomke, S. and K. Elwinger 1998. *Growth promotants in feeding pigs and poultry. 1. Growth and feed efficiency responses to antibiotic growth promotants.* Ann. Zootech., 47, 85-97.

Yousef, R.T. and G.G. Tawil 1980. *Antimicrobial activity of volatile oils.* Pharmazie, 35, 698-701.

APPENDIX

Appendix 1: Ingredients and calculated chemical composition of the experimental diets (g/kg)

	prestarter diet		starter diet	
antiobiotic:	-	+	-	+
Enteroguard:	-/+	-/+	-/+	-/+
barley	525.0	525.0	350.0	350.0
wheat	134.5	131.5	175.0	173.2
maize			50.0	50.0
tapioca			60.2	60.9
linseed	15.0	15.0	32.4	32.4
soya beans, extracted	74.5	73.8	150.0	150.0
sunflower seed, extracted	20.0	20.0	45.3	44.7
wheat middlings	25.0	25.0	26.6	25.0
cane molasses			20.0	20.0
wheypowder	96.2	96.2	31.3	31.3
fish meal	30.0	30.0	15.0	15.0
potato protein	25.0	25.0		
animal fat	10.0	10.0	10.0	10.0
coconut oil	11.8	12.1	7.5	7.5
synthetic amino acids	4.1	4.1	5.4	5.4
rest (incl. Enteroguard and/or Avilamycine)	29.0	32.4	21.3	24.6
EW[1]	1.12	1.12	1.09	1.09
crude protein	184.5	184.5	180.0	180.0
crude fat	53.4	53.6	49.8	49.8
crude fibre	37.1	37.2	44.3	44.2
ash	51.4	51.7	51.9	52.2
starch	366.2	365.2	374.8	374.6
lactose	39.1	38.4	12.2	11.4
ileal digestible lysine	10.2	10.2	9.6	9.6
ileal digestible meth.+cyst.	6.2	6.2	5.8	5.8
phosphorus	5.6	5.6	5.2	5.2
digestible phosphorus	3.6	3.6	3.3	3.3
avilamycine (mg)		40.0		40.0

[1] EW = 8.79 MJ NE