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# SANGROVIT AND SALOCIN IN FEED FOR GROWING - FINISHING PIGS

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## SUMMARY

Sangrovit and Salocin in the feed for growing-finishing pigs were tested. The trial was designed as a factorial investigation and included the following experimental treatments:

* Control feed without growth promoter
* Salocin 25 ppm
* Sangrovit 30 ppm
* Salocin 25 ppm and Sangrovit 30 ppm

The trial was carried out in cooperation with Hoechst Roussel Vet A/S, who also analysed the feed for their own products: Sangrovit and Salocin. The products were tested on pigs approximately in the growth period from 30 to 100 kg. The trial was carried out in one herd. Each treatment included 9 repeats, totalling 90 pigs per treatment.

The chemical analyses of the feed showed good agreement with the calculated nutritional contents. The analysed contents of Salocin was in agreement with the calculated contents, but the contents of Sangrovit was lower than expected, which may be due to the fact, that up to now there has not been developed a satisfactory analytical method for Sangrovit.

The production value of feed mixes with Sangrovit and Salocin was calculated on the basis of the production results as gross margin per place unit per year at the same price for all mixes. Neither Sangrovit nor Salocin did significantly increase the production value of the feed.

Microbial and enzymatic activity in the gastrointestinal tract as well as ileal digestibility (digestibility in the small intestine) and faecal digestibility (total digestibility) of nutrients were investigated in 6 pigs per treatment, totalling 24 pig. Sangrovit was found to reduce the population of lactic acid bacteria and the production of lactic acid in the small intestine, but only when Salocin was not included in the feed. Salocin on the other hand caused a strong and significant reduction of the microbial activity in general in the small intestine. A reduced population and activity of bacteria in the gastrointestinal tract may increase the amount of nutrients available for growth of the pigs. The activity of digestive enzymes in the pancreas and small intestine was not enhanced by Sangrovit or Salocin. Sangrovit or Salocin did not significantly affect ileal or faecal digestibility of nutrients.

The results indicate that Sangrovit affects the microbial population in the intestine to the same effect as Salocin, but to a lower extent at the tested dose.

## BACKGROUND

The risk of developing resistant bacteria when using antibiotic growth promoters in feed for pigs is the cause of some concern. This has increased the need for finding alternative products that can replace the antibiotic growth promoters.

Previously, a testing of commercial feed products for growing-finishing pigs has been carried out (Report No. 341 from the National Committee for Pig Breeding, Health and Production, Denmark). In this trial it was found that the feed had a significantly higher production value when 30 mg of Sangrovit was added per kilo of feed. Sangrovit is produced by drying and grinding roots from the plant *Sanguinaria canadensis*, which grows in North-East America. The main ingredient in Sangrovit is Sanguinarin, which is presumed to have a bactericidal effect. The improved production value found after addition of Sangrovit to the feed was due to a higher weight gain, particularly during the last part of the growth period, and an improved feed conversion ratio. Addition of Sangrovit to the feed did not increase the feed price to any major degree compared with addition of an antibiotic growth promoter. The effect of Sangrovit in the feed was compared with that of the antibiotic growth promoter Salocin. The trial did not show a significantly higher production value of the feed following addition of Salocin, but the results did show a tendency towards a higher production value.

Several trials abroad have shown a positive effect of Sangrovit on weight gain and feed conversion ratio. However, none of these trials have come up with an explanation of why Sangrovit increases weight gain and feed conversion ratio. Several explanations have been suggested, one of them being that Sangrovit enhances the excretion of digestive enzymes in the digestive tract, thereby increasing feed digestibility. However, this theory does not agree with the facts that the effect of Sangrovit is higher towards the end of the growth period and that the belief is that Sangrovit has no effect in weaners. The digestive system is not fully developed at the time of weaning, and consequently intestinal enzyme activity is restrictive for feed conversion ratio and weight gain during the early stages of the growth period. Towards the end of the growth period, however, the enzyme secretion is not

regarded as restrictive for the feed conversion ratio and average gain. Another possible explanation of the mechanism of action of Sangrovit could be that it inhibits bacteria in the intestine and thereby lowers the risk of diarrhoea. Moreover inhibition of bacterial growth may reduce bacterial consumption of nutrients, which can instead be exploited by the pig.

The aim of this trial was to examine the effect and mechanism of action of Sangrovit compared with Salocin in feed for growing - finishing pigs. The effect was measured on the production parameters weight gain, feed conversion ratio and lean meat percentage. In addition, the effect was measured on the activity of digestive enzymes, the composition of microorganisms in the digestive tract and digestibility of nutrients.

The trial was carried out in collaboration with Hoechst Roussel Vet A/S.

## MATERIALS AND METHODS

The trial was carried out in one conventional herd with own production of weaners. It was designed as a factorial investigation of Sangrovit and Salocin and comprised of four experimental groups, cf. table 1.

**Table 1. Experimental groups**

| Group | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Sangrovit, 30 ppm | - | - | + | + |
| Salocin, 25 ppm | - | + | - | + |

The feed mixes were produced by *Aarhusegnens Andels Grovvareforening a.m.b.a.* The feed was heat treated and pelleted. Appendix 1 lists their compositions, and Appendix 2 describes the tested products. The feed was produced in three lots. During each production sequence the mix was sampled for a complete feed analysis, including amino acids, calcium and phosphorus. In addition, Hoechst Roussel Vet A/S received a feed sample from each feed production for analysis for contents of Sangrovit and Salocin.

The pigs entered the trial at an average weight of 29 kg. The trial comprised a total of 360 pigs, divided into 9 blocks (repeats), with 90 pigs per group. Sows and gilts were evenly distributed between the four groups. The pig house was built with pens holding ten pigs each. The pens had fully slatted flooring. There were single space feeders (with water) and one additional water nipple per pen. The pigs were fed ad libitum. Feed was supplied manually once or twice a day. Feed consumption, weight gain, treatment of disease and slaughter information were recorded. Intermediate weighing of the pigs took place about one month after they had entered the trial. Gross margin/place unit/year was calculated from the production results measured after correction to same weight at entry and same weight at slaughter.

Towards the end of the experimental period 24 pigs weighing an average of 102 kg were transferred to the Danish Institute of Agricultural Sciences at Foulum. The pigs were housed individually in metabolic cages and given the same feed mixes that they had been fed in the herd. However, $Cr_2O_3$ was added to the feed mixes as a marker. After a period of acclimatisation of six to eight days, faeces was collected over 3 days for determination of faecal (total) digestibility of dry matter, protein, starch, fat and energy.

At an average weight of 110 kg the pigs were sacrificed three hours after the morning feed and the digestive tract and pancreas were removed immediately. The digestive tract was divided into nine sections comprising stomach (ST), four even-sized sections of the small intestine (SI1, SI2, SI3 and SI4), caecum (Cae) and three sections of colon and rectum (Co1, Co2 and Rec). The total contents in each of the nine sections of the digestive tract were removed and weighed. Immediately after the removal the pH-value of the digesta was determined. Samples of the digesta from all nine sections were analysed for contents of dry matter, ATP (an expression for microbial activity) and volatile fatty acids (VFA) and the production of acetic and lactic acid in digesta were determined. The digesta from the last quarter of the small intestine (SI4) were also analysed for contents of protein, starch, fat, energy and $Cr_2O_3$ to determine the ileal digestibility (digestibility in the small intestine).

The composition of the micro biota was examined in four sections of the gastrointestinal tract: the stomach (ST), the last quarter of the small intestine (SI4), the caecum (Cae) and the middle section of the colon (Co2). It was tested by a total anaerobic count and for coliform bacteria, lactose negative enterobacteria and lactic acid bacteria.

The pancreas and the four sections of the small intestine (SI1, SI2, SI3 and SI4) were analysed for digestive enzyme activity. The analyses included amylase, which breaks down starch, lipase and its cofactor colipase, which break down fat, and trypsin and chymotrypsin, which break down protein.
Data were subjected to statistical analysis by an analysis of variance according to the GLM-procedure in SAS. The statistical model comprised the following class variables: Sangrovit, Salocin and block. The data were tested for interaction between Sangrovit and Salocin. The interaction was excluded from the model if it was not significant. The results are shown as adjusted means for each experimental group.

## RESULTS AND DISCUSSION

### Feed analyses

The calculated and analysed contents of nutrients in the feed mixes showed good agreement (cf. Appendix 3).The contents of Salocin and Sangrovit in the feed mixes were analysed by Hoechst Roussel Vet A/S. The analytical results are shown in Appendix 3. The analysed content of Salocin was in good agreement with the calculated content in the feed mixes, but the analysed content of Sangrovit in the feed mixes was lower than expected. This deviation can be due to the fact, that up to now there has not been developed a satisfactory analytical method for Sangrovit.

### Health condition

The health condition of the pigs was in general good. No pigs were treated against diarrhoea or any other digestive disorders. Nine per cent of the pigs were treated against respiratory diseases and three per cent of the pigs died or were excluded from the trial during the experimental period. There was no difference in the number of treatments against diseases or dead/excluded pigs between the four groups.

### Production results

The production results are shown both before and after the intermediate weighing and totalling for the whole experimental period (Table 2). The results are given as adjusted means at the same weight at entry, intermediate weighing and delivery of the pigs. The average body weight at entry, intermediate weighing and delivery, respectively, was 29, 66 and 101 kg.

**Table 2. Production results corrected to same weight at entry, intermediate weighing and delivery to slaughter**

| | Salocin, 0 ppm | | Salocin, 25 ppm | |
|---|---|---|---|---|
| | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm |
| **29-66 kg:** | | | | |
| Daily feed intake, FUs | 1.92 | 1.83 | 1.93 | 1.89 |
| Daily weight gain, g | 814 | 779 | 826 | 816 |
| FUs per kg of gain | 2.36 | 2.35 | 2.33 | 2.32 |
| **66-101 kg:** | | | | |
| Daily feed intake, FUs | 2.80 | 2.80 | 2.77 | 2.77 |
| Daily weight gain, g | 987 | 972 | 991 | 990 |
| FUs per kg of gain | 2.84 | 2.88 | 2.81 | 2.80 |
| **29-101 kg:** | | | | |
| Daily feed intake, FUs | 2.28 | 2.21 | 2.27 | 2.26 |
| Daily weight gain, g | 884 | 861 | 885 | 885 |
| FUs per kg of gain | 2.58 | 2.57 | 2.56 | 2.55 |
| Lean meat percentage | 60.1 | 60.6 | 59.6 | 60.4 |

The production value stated as gross margin per place unit per year is shown in Table 3. The production value is calculated on the basis of production results obtained (daily weight gain, FUs per kg of gain and lean meat percentage) at the average price for the last year of DDK 1.32 per FUs for all groups. The price for adding Salocin and Sangrovit are thereby not included in the calculation of the production value. The average purchase price for 30 kg pigs and the sales price including subsequent payment for the last year are included in the calculation of the production value (cf. Table 3). The actual gross margin/place unit/year at current prices for the tested products is also shown in Table 3.

**Table 3. Production value and actual gross margin at current prices**

| | Salocin, 0 ppm | | Salocin, 25 ppm | |
|---|---|---|---|---|
| | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm |
| **Production value** Gross margin per place unit per year[1], DKK at DKK 1.32 per FUs | 957 | 951 | 949 | 978 |
| **Actual gross margin at current prices** Gross margin per place unit per year, DKK [2] | 957 | 936 | 941 | 954 |

[1] Daily weight gain and feed consumption corrected to same weight at entry and same weight at slaughter, purchase price for 30 kilo pigs DKK 425 and sales price incl. subsequent payment DKK 11.7 per kilo.

[2] Current prices of the products appears from Appendix 2.There is not performed statistical calculation on the differences in the gross margin at current prices.

There was no significant effect of Sangrovit or Salocin on the production value, and there was no significant interaction between Sangrovit and Salocin. In this trial a minimum difference of DKK 41 was needed to prove a significant effect of the two feed additives separately. By adding 30 ppm of Sangrovit the production value was increased by DDK 12 (difference between the average of the two groups without Sangrovit and the average of the two groups with Sangrovit). By adding 25 ppm Salocin the production value was increased by DKK 10.

Previously, is was found that Sangrovit, 30 ppm, significantly increased the production value, but adding 50 ppm of Sangrovit to the feed did not significantly increase the production value (Report No. 341 from the National Committee for Pig Breeding, Health and Production, Denmark). The present trial cannot confirm that adding 30 ppm of Sangrovit to the feed will result in a significantly increase in the production value. However, it has to be taken into consideration that in the present trial, there was no effect of Salocin. In the previous trial (Report no. 341), though there was not a significant effect of Salocin, there was a tendency towards increased production value ($p=0.07$).

**Composition of the micro biota in the gastrointestinal tract**

The results of bacterial counts are shown in Table 4. The total anaerobic bacteria covers all the cultivable bacteria in the gastrointestinal tract. The group of lactose negative enterobacteria (among these Salmonella) and coliform bacteria includes the pathogene bacteria.

No effect of Sangrovit was detected on the total population of anaerobe bacteria neither in the stomach, the small intestine, the caecum nor the colon. On the other hand, Salocin significantly reduces the population of anerobe bacteria in the stomach, and almost significantly reduced the population in the caecum (p=0.05).

There was a significant interaction between Sangrovit and Salocin on the population of coliform bacteria in the colon. This interaction may not immediately be explained.

**Table 4. Bacteria in the gastrointestinal tract**

| | Salocin, 0 ppm | | Salocin, 25 ppm | | Effect of treatments | | Inter-action |
|---|---|---|---|---|---|---|---|
| | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 30 ppm | Salocin, 25 ppm | |
| **Total anaerobic bacteria (log CFU/g digesta)** | | | | | | | |
| Stomach (ST) | 8.0 | 6.9 | 5.5 | 6.3 | | * | |
| Small intestine (SI4) | 9.4 | 7.9 | 7.6 | 7.9 | | | |
| Caecum (Cae) | 9.8 | 9.6 | 9.2 | 9.5 | | | |
| Colon (Co2) | 9.7 | 9.4 | 9.4 | 9.6 | | | |
| **Coliform bacteria (log CFU/g digesta)** | | | | | | | |
| Stomach (ST) | 5.2 | 4.2 | 4.1 | 4.8 | | | |
| Small intestine (SI4) | 6.7 | 7.2 | 7.4 | 7.6 | | | |
| Caecum (Cae) | 7.8 | 8.6 | 8.7 | 8.6 | | | |
| Colon (Co2) | 8.0 | 8.5 | 8.9 | 8.1 | *1) | *3) | * |
| **Lactose negative enterobacteria (log CFU/g digesta)** | | | | | | | |
| Stomach (ST) | 5.1 | 3.7 | 3.8 | 4.0 | | | |
| Small intestine (SI4) | 6.0 | 4.6 | 3.9 | 4.3 | | | |
| Caecum (Cae) | 6.4 | 5.8 | 5.4 | 5.1 | | | |
| Colon (Co2) | 7.2 | 5.5 | 5.6 | 4.9 | | | |
| **Lactic acid bacteria (log CFU/g digesta)** | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Stomach | (ST) | 7.8 | 6.5 | 5.5 | 6.5 | | **3) | * |
| Small intestine | (SI4) | 9.4 | 7.6 | 7.2 | 7.7 | *2) | **3) | * |
| Caecum | (Cae) | 9.6 | 9.4 | 8.9 | 9.0 | | ** | |
| Colon | (Co2) | 9.5 | 9.3 | 9.2 | 8.9 | | | |

* p<0.05
**p<0.01
1) Effect of Sangrovit only when Salocin was in the feed
2) Effect of Sangrovit only when Salocin was not in the feed
3) Effect of Salocin only when Sangrovit was not in the feed

The population of lactose negative enterobacteria in the gastrointestinal tract was not significantly affected by Sangrovit or Salocin. However, there was a tendency to decreased population in the colon by adding Sangrovit (p=0.06) or Salocin (p=0.06) to the feed.

There was a significant interaction between Sangrovit and Salocin on the population of lactic acid bacteria in the small intestine as Sangrovit significantly reduced the population in the small intestine when Salocin was not included in the feed. This interaction shows that when the population of lactic acid bacteria was reduced by adding Salocin to the feed, there was no additional reduction in the population of lactic acid bacteria by adding Sangrovit.

Salocin reduced the population of lactic acid bacteria in both the stomach and small intestine, but only when Sangrovit was not in the feed. Moreover, Salocin reduced the population in the caecum. Earlier on similar effects have been found for other growth promoting antibiotics (Virginiamycin and Zinkbacitracin).

**Microbial activity in the gastrointestinal tract**

The contents of ATP, pH and the contents of total VFA in the gastrointestinal tract are shown in Table 5. In general, the content of ATP in the gastroinintestinal tract was lower than normally observed in pigs at the same age. This shows that the activity of bacteria in the gastrointestinal tract in these pigs in general was lower than normally observed. This may explain why there was no positive effect of the growth promoter Salocin measured on the production results in this trial.
No significant effects were found of Sangrovit on microbial activity (ATP) or pH in any of the intestinal segments investigated. However, Sangrovit tended to decreased pH in the second quarter of the small intestine (SI2) (p=0.07).

Salocin significantly reduced the microbial activity (ATP) in the last two quarters of the small intestine (SI3 and SI4). This reduction was followed by a significant increase in the pH in the last quarter of the small intestine (SI4). Previously we have found that the growth promoting antibiotics Virginiamycin and Zinkbacitracin reduced the microbial activity in the small intestine.

There was a significant interaction between Sangrovit and Salocin on the contents of total VFA in mid

segment of the colon (Co2), as Sangrovit significantly increased the VFA contents, but only when the feed did not contain Salocin. The effect of Salocin on the contents VFA in the mid segment of colon was opposite with or without Sangrovit in the feed. This interaction may not immediately be explained.

### Production of acetic and lactic acid in the gastrointestinal tract

The production of acetic and lactic acid was reduced in the small intestine of the pigs fed the Sangrovit supplemented diets (Table 6). However, this difference was only significant for lactic acid in the last quarter of the small intestine (SI4) when no Salocin was in the diet.

Salocin on the other hand had a strong influence on the production of as well acetic as lactic acid in the stomach and small intestine. The production of both acids was significantly reduced in the pigs fed the Salocin supplemented diets (Table 6).

The production of acetic acid in the caecum and the colon was not significantly affected by Sangrovit or Salocin. There was no production of lactic acid in the caecum and the colon.

The reduction in the production of lactic acid in the small intestine especially caused by Salocin and to a lower extent also caused by Sangrovit is in good agreement with the reduced population of lactic acid bacteria in the small intestine (Table 4). Therefore, these results show that Sangrovit has a similar but weaker effect compared to Salocin on the population and activity of lactic acid bacteria in the small intestine. Lactic acid bacteria are the majority of the bacterial population in the small intestine, and therefore, a reduced population and activity of lactic acid bacteria will reduce the loss of nutrients used for bacterial growth in the small intestine. This will result in more nutrients available for growth of the pigs. However, in this trial, no significant effect of Sangrovit or Salocin was found on the production value (Table 3).

| Table 5. ATP, pH and total VFA in the gastrointestinal tract | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Salocin, 0 ppm | | Salocin, 25 ppm | | Effect of treatments | | Inter-action |
| | | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 30 ppm | Salocin, 25 ppm | |
| **ATP (µg/g digesta)** | | | | | | | | |
| Stomach | (ST) | 0.23 | 0.17 | 0.18 | 0.12 | | | |
| Small intestine | (SI1) | 0.23 | 0.18 | 0.27 | 0.22 | | | |
| | (SI2) | 0.30 | 0.41 | 0.13 | 0.21 | | | |
| | (SI3) | 0.83 | 0.92 | 0.19 | 0.22 | | * | |
| | (SI4) | 3.15 | 3.75 | 1.10 | 1.63 | | * | |
| Caecum | (Cae) | 17.65 | 17.23 | 16.60 | 16.95 | | | |
| Colon | (Col) | 17.17 | 17.62 | 17.63 | 18.81 | | | |
| | (Co2) | 9.59 | 12.33 | 11.87 | 8.12 | | | |
| | (Rec) | 1.84 | 4.86 | 5.43 | 3.70 | | | |
| **pH** | | | | | | | | |
| Stomach | (ST) | 3.47 | 3.54 | 2.76 | 3.30 | | | |
| Small intestine | (SI1) | 6.01 | 5.85 | 5.83 | 5.92 | | | |
| | (SI2) | 7.00 | 6.73 | 6.87 | 6.67 | | | |
| | (SI3) | 7.14 | 7.31 | 7.29 | 7.42 | | | |
| | (SI4) | 6.72 | 7.05 | 7.14 | 7.11 | | * | |
| Caecum | (Cae) | 5.74 | 5.87 | 5.77 | 5.99 | | | |
| Colon | (Col) | 6.05 | 6.06 | 6.05 | 6.07 | | | |
| | (Co2) | 6.50 | 6.28 | 6.30 | 6.52 | | | * |
| | (Rec) | 6.69 | 6.68 | 6.51 | 6.77 | | | |
| **Total VFA (mmol/kg digesta)** | | | | | | | | |
| Stomach | (ST) | 3.9 | 3.2 | 3.7 | 2.9 | | | |
| Small intestine | (SI1) | 10.5 | 7.6 | 9.6 | 10.8 | | | |
| | (SI2) | 8.9 | 7.2 | 9.0 | 6.7 | | | |
| | (SI3) | 16.2 | 15.7 | 7.9 | 13.8 | | | |
| | (SI4) | 44.6 | 46.7 | 21.5 | 34.6 | | | |
| Caecum | (Cae) | 137.3 | 141.0 | 141.4 | 130.9 | | | |
| Colon | (Col) | 140.0 | 148.1 | 136.1 | 136.6 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Co2) | 109.3 | 131.0 | 120.7 | 119.3 | ***1) | *2) ** |
| (Rec) | 104.5 | 104.4 | 113.2 | 99.1 | | |

*p<0.05

**p<0.01

***p<0.001

1) Effect of Sangrovit only when Salocin was not in the feed

2) Opposite effect of Salocin with or without Sangrovit in the feed, respectively

**Table 6. Production of acetic and lactic acid in digesta**

| | | Salocin, 0 ppm | | Salocin, 25 ppm | | Effect of treatments | | Inter-action |
|---|---|---|---|---|---|---|---|---|
| | | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 30 ppm | Salocin, 25 ppm | |
| **Acetic acid (mmol/kg digesta/h)** | | | | | | | | |
| Stomach | (ST) | 0.7 | 0.6 | 0.1 | 0.1 | | * | |
| Small intestine | (SI2) | 1.8 | 0.7 | 0.8 | 1.0 | | | |
| | (SI3) | 5.1 | 3.7 | 2.8 | 1.6 | | * | |
| | (SI4) | 8.3 | 6.7 | 5.7 | 4.3 | | * | |
| Caecum | (Cae) | 10.7 | 13.2 | 12.2 | 9.2 | | | |
| Colon | (Co2) | 12.7 | 15.2 | 15.1 | 10.7 | | | |
| **Lactic acid (mmol/kg digesta/h)** | | | | | | | | |
| Stomach | (ST) | 3.7 | 4.4 | 0.5 | 0.8 | | ** | |
| Small intestine | (SI2) | 5.8 | 4.3 | 0.6 | 0.4 | | *** | |
| | (SI3) | 12.1 | 7.0 | 2.1 | 1.9 | | *** | |
| | (SI4) | 13.2 | 6.9 | 4.4 | 6.0 | *1) | **2) | * |

*p<0.05
**p<0.01
***p<0.001
1) Effect of Sangrovit only when Salocin was not in the feed
2) Effect of Salocin only when Sangrovit was not in the feed

### Enzymes

The activity of amylase, trypsin, chymotrypsin, lipase and colipase in the pancreatic tissue and in the contents of small intestinal segments is shown in Table 7. The inclusion of Sangrovit or Salocin in the feed did not result in any change in enzyme activities in pancreatic tissue, however, an interaction between Sangrovit and Salocin was observed for the activity of chymotrypsin. This interaction may not immediately be explained. The regulation of the synthesis of digestive enzymes in the pancreas is very complex but one of the main regulators is the composition of the feed that is the contents of starch, protein and fat. During the passage through the gastrointestinal tract the composition of the digesta may differ from the composition of the feed due to variations in the degree of breakdown of the components. Such variance may result in stimulation of the synthesis of certain enzymes in the pancreas. In the present trial the composition of the feed did not differ between the treatment groups (Appendix 3) and the results show that the synthesis of digestive enzymes in the pancreas was not affected by the treatments suggesting that the composition of the digesta in the small intestine did not

vary either.

Once secreted into the duodenum the role of the digestive enzymes is to digest their respective substrates, however, at the same time the enzymes, e.g. protein, are susceptible to hydrolysis by proteolytic enzymes. The activity of amylase was not measured in the first quarter of the small intestine (SI1) due to lack of material for the analysis. But the activity of amylase is very stable and the activity of this enzyme only decreased slightly during passage in the small intestine, this is in agreement with other studies. The activity of trypsin and chymotrypsin decreased during small intestine transit, the reduction in trypsin activity was seen in the third quarter of the small intestine (SI3) whereas the chymotrypsin activity declined in the last quarter of the small intestine (SI4).

**Table 7. Enzymes in the pancreas and the small intestine**

| | Salocin, 0 ppm | | Salocin, 25 ppm | | Effect of treatments | | Inter-action |
|---|---|---|---|---|---|---|---|
| | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 30 ppm | Salocin, 25 ppm | |
| **Amylase** | | | | | | | |
| Pancreas (U/g tissue) | 11,827 | 12,744 | 15,025 | 13,196 | | | |
| Small intestine | | | | | | | |
| (U/g dry matter) (SI2) | 74 | 64 | 47 | 63 | | | |
| (SI3) | 88 | 95 | 82 | 111 | | | |
| (SI4) | 64 | 49 | 77 | 50 | | | |
| **Trypsin** | | | | | | | |
| Pancreas (U/g tissue) | 3.98 | 3.23 | 2.82 | 3.74 | | | |
| Small intestine | | | | | | | |
| (U/g dry matter) (SI1) | 4.56 | 6.03 | 2.94 | 3.19 | | | |
| (SI2) | 4.73 | 3.53 | 4.34 | 3.20 | | | |
| (SI3) | 2.91 | 3.32 | 3.07 | 3.14 | | | |
| (SI4) | 1.62 | 1.57 | 2.15 | 1.71 | | | |
| **Chymotrypsin** | | | | | | | |
| Pancreas (U/g tissue) | 146 | 103 | 105 | 140 | | | * |
| Small intestine | | | | | | | |
| (U/g dry matter) (SI1) | 87 | 120 | 64 | 72 | | | |
| (SI2) | 115 | 87 | 108 | 87 | | | |
| (SI3) | 109 | 92 | 87 | 82 | | | |
| (SI4) | 75 | 59 | 60 | 54 | | | |
| **Lipase** | | | | | | | |
| Pancreas (U/g tissue) | 3,985 | 2,470 | 2,860 | 3,496 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Small intestine | | | | | | | |
| (U/g dry matter) | (SI1) | 3,630 | 2,083 | 800 | 1,010 | | |
| | (SI2) | 1,071 | 575 | 656 | 1,233 | | |
| | (SI3) | 697 | 470 | 907 | 556 | | |
| | (SI4) | 238 | 209 | 450 | 188 | | |
| **Co-lipase** | | | | | | | |
| Pancreas (U/g tissue) | | 1,029 | 715 | 652 | 912 | | |
| Small intestine | | | | | | | |
| (U/g dry matter) | (SI1) | 1,192 | 1,862 | 327 | 401 | | * |
| | (SI2) | 369 | 262 | 311 | 565 | | |
| | (SI3) | 185 | 125 | 311 | 178 | | |
| | (SI4) | 110 | 90 | 120 | 77 | | |
| *p<0.05 | | | | | | | |

The results of the present experiment show no significant difference in the activity of amylase, trypsin and chymotrypsin in intestinal contents between treatment groups (Table 7). However, Sangrovit tended to decrease the activity of trypsin (p=0.09) and chymotrypsin (p=0.08) in the second quarter of the small intestine (SI2) and almost significantly decreased the activity of amylase in the last quarter of the small intestine (SI4) (p= 0.05).

Salocin reduced non-significantly the mean lipase activity in the first quarter of the small intestine (SI1) (p=0.07) and the activity of the co-factor colipase was significantly reduced in the same segment by Salocin. In the following segments of the small intestine (SI2-SI4) there was no effect of Salocin on the lipase and colipase activity and the activity of the enzymes in intestinal contents declined gradually. In the last quarter of the small intestine (SI4) Sangrovit tented to reduce the activity of lipase (p=0.09).

Over all, the results obtained by the used method to determine activity of digestive enzymes showed that there was no enhanced activity of the enzymes in the pancreas and in digesta in the small intestine by adding Sangrovit or Salocin to the feed.

### Ileal and faecal digestibility

The ileal digestibility (digestibility in the small intestine) and faecal digestibility (total digestibility) are shown in Table 8. There was no significant effect of Sangrovit or Salocin on the ileal digestibility of dry matter, energy, starch, protein or fat. These results support the results of the analyses of digestive enzymes in the pancreas and the small intestine, as Sangrovit and Salocin did not enhance the enzyme production and secretion (Table 7).

| Table 8. Ileal digestibility (digestibility in the small intestine) and faecal digestibility (total digestibility) | | | | |
|---|---|---|---|---|
| | Salocin, 0 ppm | | Salocin, 25 ppm | |
| | Sangrovit, 0 ppm | Sangrovit, 30 ppm | Sangrovit, 0 ppm | Sangrovit, 30 ppm |
| **Ileal digestibility, per cent** | | | | |
| Dry matter | 69.1 | 65.6 | 66.7 | 67.4 |
| Energy | 69.2 | 65.9 | 68.0 | 67.0 |
| Starch | 97.5 | 96.5 | 97.7 | 97.7 |
| Protein | 79.8 | 78.8 | 80.2 | 79.3 |
| Fat | 67.4 | 65.0 | 66.8 | 66.2 |
| **Faecal digestibility, per cent** | | | | |
| Dry matter | 84.2 | 83.8 | 83.9 | 85.5 |
| Energy | 84.2 | 83.5 | 83.7 | 85.5 |
| Starch | 100.0 | 100.0 | 100.0 | 100.0 |
| Protein | 82.4 | 83.6 | 82.7 | 85.0 |
| Fat | 70.2 | 68.2 | 69.6 | 71.6 |

The faecal digestibility of dry matter, energy, starch, protein and fat was not significantly changed by Sangrovit or Salocin, but there was an almost significantly increased faecal digestibility of protein by adding Sangrovit to the feed ($p=0.05$). However, the faecal digestibility of nutrients is influenced by the microbial fermentation in the colon, so the tendency to higher faecal digestibility of protein caused by Sangrovit may be explained by higher microbial fermentation resulting in higher contents of VFA in the colon (Table 5).

Due to the microbial fermentation in the colon, the ileal digestibility is a more valid estimate than faecal digestibility for the amount of nutrients in the diet available for the pigs.

## CONCLUSION

Neither Sangrovit nor Salocin did significantly increase the production value of the feed. Sangrovit was found to reduce the population of lactic acid bacteria and production of lactic acid in the small intestine, but only when Salocin was not included in the feed. Salocin on the other hand caused a strong and significant reduction of the microbial activity in general in the small intestine. A reduced population and activity of bacteria in the gastrointestinal tract may increase the amount of nutrients available for growth of the pigs. The activity of digestive enzymes in the pancreas and small intestine was not enhanced by Sangrovit or Salocin. Sangrovit or Salocin did not significantly affect ileal or faecal digestibility of nutrients.

The results indicate that Sangrovit affects the microbial population in the intestine to the same effect as Salocin, but to a lower extent at the tested dose.

## REFERENCES

Pedersen, A. Ø. 1996. Commercial products in the feed for finishers - Salocin, Sangrovit, ToyoCerin and Acid Lac. Report No. 341 from the National Committee for Pig Breeding, Health and Production, Denmark.8 pp.

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## Appendix 1

### Feed mixes, ingredients in per cent

| | Group 1<br>Control | Group 2<br>25 ppm Salocin | Group 3<br>30 ppm Sangrovit | Group 4<br>25 ppm Salocin +<br>30 ppm Sangrovit |
|---|---|---|---|---|
| Wheat | 36.35 | 36.25 | 36.25 | 36.25 |
| Barley | 36.35 | 36.25 | 36.25 | 36.25 |
| Soy meal, toasted | 19.94 | 19.94 | 19.94 | 19.94 |
| Molasses, sugar beet | 2.00 | 2.00 | 2.00 | 2.00 |
| Animal fat | 2.34 | 2.34 | 2.34 | 2.34 |
| Vitamins and minerals | 2.52 | 2.72 | 2.72 | 2.72 |
| L-lysin | 0.22 | 0.22 | 0.22 | 0.22 |
| Methionine 40 per cent | 0.16 | 0.16 | 0.16 | 0.16 |
| Threonine 50 per cent | 0.12 | 0.12 | 0.12 | 0.12 |
| Salocin premix [1)] | - | 0.2 | - | - |
| Sangrovit premix [2)] | - | - | 0.2 | - |
| Sangrovit-Salocin premix [3)] | | | | 0.2 |

[1)] Salomycin sodium (12,500 mg/kg) mixed into fine wheat bran

[2)] Sangrovit (15,000 mg/kg) mixed into fine wheat bran

[3)] Sangrovit (15,000 mg/kg) and salinomycin sodium (12,500 mg/kg) mixed into fine wheat bran

Appendix 2

## DESCRIPTION OF PRODUCT
## BASED ON COMPANY INFORMATION

**Name of product:** Salocin

**Supplier:** Hoechst Roussel Vet A/S
Islevdalvej 110
DK-2610 Rødovre, Denmark
Telephone: +45 44 88 82 00

**Contents:** 120 g of salinomycin per kilo. The carrier is calcium carbonate.

**Price:** DKK 1.12 per 100 kg of feed at admixture of Salocin 25 ppm.

**Name of product:** Sangrovit

**Supplier:** Hoechst Roussel Vet A/S
Islevdalvej 110
DK-2610 Rødovre, Denmark
Telephone: +45 44 88 82 00

**Contents:** This product is a natural feed additive with flavour and appetite regulating effect. It is produced from roots of the plant *Sanguinaria canadensis*, which grows in North-East America. The main ingredient in Sangrovit is Sanguinarin.

**Price:** DKK 2.00 per 100 kg of feed at admixture of Sangrovit 30 ppm

Appendix 3

Calculated and analysed nutritional contents in feed mixes (average of three feed supplies)

| Mix | All mixes | Control | Salocin 25 ppm | Sangrovit 30 ppm | 25 ppm Salocin + 30 ppm Sangrovit |
|---|---|---|---|---|---|
| Calculated/ analysed | Calculated | Analysed | Analysed | Analysed | Analysed |
| FUs/100 kg | 108 | 110 | 109 | 109 | 109 |
| Crude protein, per cent | 17.0 | 17.0 | 16.9 | 17.1 | 16.6 |
| Lysin, g/kg | 10.1 | 9.7 | 9.7 | 9.7 | 9.7 |
| Methionine, g/kg | 3.2 | 3.1 | 2.9 | 2.9 | 3.0 |
| Cystin, g/kg | 2.8 | 2.9 | 2.9 | 2.9 | 3.0 |
| Threonine, g/kg | 6.5 | 6.6 | 6.5 | 6.6 | 6.6 |
| Total phosphorus, g/kg | 4.6 | 5.5 | 5.2 | 5.3 | 5.2 |

Contents of tested products in feed mixes analysed by Hoechst Roussel Vet A/S (average of three feed supplies)

| Product | Salocin | Sangrovit | Salocin + Sangrovit |
|---|---|---|---|
| Calculated | 25 ppm | 30 ppm | 25 ppm + 30 ppm |
| Analysed | 24 ppm | 20 ppm | 22 ppm + 16 ppm |