Organic micro minerals in sow feed

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Replacing inorganic with organically bound micro minerals showed no biological effects in sows when their need for micro minerals is covered via their feed.

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Abstract

Sows' micro mineral requirements are met when 100 ppm iron, 15 ppm cobber, 40 ppm manganese, 100 ppm zinc and 0.35 ppm selenium in the form of salts are added to their feed. With these concentrations, no additional effect is obtained on productivity, longevity and claw health by adding organically bound micro minerals from the Alltech Ltd. products Bio-Plex and Sel-Plex. The lack of effect is mainly attributed to the fact that Danish sows have their micro mineral requirements covered in the above concentrations.

Analyses of sow milk, liver tissue, and carcase and blood from newborn piglets revealed that neither sows, piglets nor weaners had a deficiency in the micro minerals selenium, iron, zinc, cobber and manganese compared with reference values. The results also indicated that the concentration of micro minerals in this trial was high compared with the sows' requirement.

The aim of this trial was to establish whether the addition of organically bound micro minerals improved sow productivity, longevity and claw health compared with micro minerals bound as salts. Hypothetically, an effect will occur if old sows, in particular, have a micro mineral deficiency and will consequently have a higher intake when organically bound micro minerals are added.

The trial comprised a control group and a trial group. Micro minerals bound as salts were added to the feed in the control group, whereas the sows in the trial group were fed diets with organically bound

micro minerals. The control and trial diets were identical in terms of nutrients and ingredients, ie. the only difference was the source of micro minerals.

The trial ran for 36 months on two farms where the sows were fed individually in feeding stations during gestation. One diet was used for lactating sows and one for gestating sows. The sows were included in the trial after their first service.

Micro mineral status in liver tissue and sow milk as well as haemoglobin levels in the blood were analysed to document changes, if any, when different micro mineral sources were used. The concentration of micro minerals in newborn piglet carcases was also determined.

The highest concentration of micro minerals in liver tissue was found in the trial sows, which indicates that organically bound micro minerals have a higher absorbability than micro minerals bound as salts as the liver acts as a buffer for a number of micro minerals. However, with the exception of selenium, the increased concentration of micro minerals in liver tissue did not result in an increased concentration in the sow milk. In fact, with the exception of selenium, the concentration of micro minerals was generally lower in the sow milk. This is not practical as the results revealed a correlation between the concentration of micro minerals in sow milk and the concentration of micro minerals in liver tissue from 28-day-old pigs.

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Background

Sow productivity is increasing and sows' feed conversion ratio improving as a consequence of the genetic progress in Danish pig production. On top of that, Danish sows must be able to produce approx. six litters before they are slaughtered.

Macro minerals such as calcium, phosphorus, sodium and magnesium are essential to sows' function, reproductive abilities, milk production, claw health and leg strength. Several Danish trials have therefore been conducted to attune the calcium and phosphorus standards to the requirement of the sows [1], [2], [3], [4]. The micro minerals selenium, iron, zinc, cobber and manganese also play a part in sows' function, and deficiency in or excess of one or more micro minerals will reduce reproductive abilities, longevity and claw health.

The standards for micro minerals are several years old and are based on old, foreign trials. When these trials were conducted, sow productivity was considerably lower, and today's prolific sows may therefore experience a deficiency in one or more micro minerals. The standards are furthermore based on a recommendation per feed unit in sow feed (FUsow). In practice, this means that the daily supply per kg sow is approx. 25% higher for a young sow weighing approx. 160 kg if compared with an older sow weighing approx. 240 kg. This is due to the fact that all sows are given the same amount of feed every day regardless of their weight, as young sows need more energy for growth. These differences are even more distinct for heavy sows.

In 1995, an American study [5] demonstrated that a sow that had weaned three litters had a 15-20% lower concentration of micro minerals than a non-reproductive sow of the same age. This indicates that the daily supply of micro minerals must be increased with the sow's age. In 2000, a British study [6] revealed that the supply of organic micro minerals instead of regular minerals increased sows' productivity and longevity after the third litter. Both studies [5], [6] investigated concentrations of micro minerals lower than the concentrations used in Danish diets. The use of organically bound micro minerals as opposed to minerals bound as salts is expected to increase the absorption in the intestines in case of deficiencies [7], [8], [9]. The addition of micro minerals to pig feed is also governed by legislation; an excess amount of micro minerals in pig feed will increase discharge from manure, which is undesirable from an environmental point of view.

Table 1 shows the maximum concentration of micro minerals in pig feed according to current legislation. The concentrations are significantly higher than the Danish standards stating added inclusion rates of micro minerals. Danish sow diets largely follow the Danish standards for micro minerals - only selenium and cobber standards are slightly higher.

Table 1. Micro minerals added to sow feed.

Micro mineral	Complete diet, max. concentration in diets, mg/kg (ppm) pursuant to legislation	DK standard for concentrations in Danish diets, mg/kg (ppm)	Average addition to Danish diets, mg/kg (ppm)
Iron – Fe	750	80	100
Cobber – Cu	25	6	15
Manganese – Mn	150	40	40
Zinc – Zn	150	100	100
Selenium – Se	0.5	0.2	0.35

The aim of the trial was to establish whether the addition of organically bound micro minerals increase sow productivity, longevity and claw health compared with micro minerals bound as salts. Several types of organically bound micro minerals are available in Denmark, but few have been studied for sows in scientific trials. Two of the products that have been studied are Bio-Plex and Sel-Plex from Alltech Ltd., and they were therefore selected for this trial [5], [6].

The concentrations in this trial of selenium, zinc, cobber, iron and manganese were identical to the concentrations of Danish diets, but the sources differed. On the basis of a literature review [9], it was expected that the sows' requirement for selenium, cobber, iron, zinc and manganese would be a limiting factor for their productivity after the third litter when micro minerals bound as salts were used. When organically bound micro minerals were used, it was expected that sows older than three litters would absorb more micro minerals as these minerals are expected to have a higher absorbability. Organically bound selenium stands out in that it is bound to an amino acid and will therefore be absorbed together with an amino acid. Consequently, it was expected that all sows in the trial group, and not only the old sows, would have a higher absorption of selenium. The other four micro minerals are absorbed as free minerals.

The concentration of micro minerals in claws differs between abaxial wall, sole and the axial surface of the pad [10]. It is therefore expected that, if an animal has a deficiency, the concentration of micro minerals can be affected through feeding.

The trial was conducted in co-operation with Alltech Ltd. and received financial support from the European Agricultural Fund for Rural Development.

Materials and method

The trial ran for 36 months on two farms one of which used purchased feed (dry feed) and the other feed mixed on-farm (liquid feed). On both farms, the sows were fed individually in feeding stations during gestation.

Groups

The trial comprised two groups (control and trial), and the sows were included in the trial after the first service. The sows in the control group were given micro minerals bound as salts and the sows in the trial group were given organically bound micro minerals.

Feed

The diets in both groups were identical with the exception of the source of the micro minerals added. The organically bound micro minerals originated from the products Bio-Plex and Sel-Plex delivered by Alltech Ltd. Bio-Plex contains iron, cobber, manganese and zinc bound to small peptides (<1500 D) and amino acids originating from soyprotein. Sel-Plex is a specific strain of Saccharomyces cerevisiae cultivated to maximise the amount and binding of selenium-bound amino acids (selenium methionine and selenium cystein) and other selenious proteins. These organic forms of selenium are absorbed and transported as amino acids to various tissues in a pig's body.

The nutrient content of the diets was formulated on the basis of the standards applying in 2007 [11], whereas the concentration of micro minerals added per FUsow was determined on the basis of the average concentration in Danish diets for sows (see Table 1). The diets were re-calculated annually according to current standards and the latest analyses of grain. The diets used are described in Appendix 2.

Farms

Farm A: 900 sows/year housed in groups from service to transfer to the farrowing facility. Dry feed is purchased from H C Handelscenter, Venslev A/S and Danish Agro, respectively.
Farm B: 1,000 sows/year housed in groups from weaning to transfer to the farrowing facility. Liquid feed mixed on-farm was used.

Mineral diets for production of feed for both farms were delivered by Dansk Vilomix A/S.

Recordings

Production control reports were completed on both farms supplemented with recordings of causes for piglet mortality, treatments for disease and causes for culling of sows. Below, all recordings in the trial period are summarised. Diagnoses, recording of causes for piglet mortality and culling of sows were made by the farm owner.

The pigs' claws were also examined. In all, 600 right feet including tarsal bone were collected from slaughter sows from the control and trial groups on the two farms. On each farm, a range of additional recordings were made on the first 75 control gilts and the first 75 trial gilts. These recordings, shown below, were continued for the next five litters from these sows:

Maternal traits: Post-farrowing, litter size was standardised to 13 pigs per litter and cross-fostering only took place within the first 24 hours post-partum. If a sow had fewer than 13 liveborn piglets, average-sized piglets (max. 72 hours old) were taken from the same group to establish standardised litters. If a sow had more than 13 liveborn piglets per litter, the biggest piglets were taken from the litter when standardised litters were established. The piglets were weighed after cross-fostering and at weaning.

Feed intake: The sows' overall feed intake during lactation was recorded individually on farm B.

Weight changes: All sows were weighed individually at transfer to and departure from the farrowing facility.

Micro minerals: The concentration of micro minerals in milk, liver tissue and carcase was determined from samples taken according to table 2. Guidelines for collection and storage of samples are described in Appendix 1.

Haemoglobin: Haemoglobin levels were determined in blood samples taken according to table 2. Guidelines for collection and storage of samples are described in Appendix 1.

Table 2. Trial design, samples.

Litter	Group	Sows				Piglets (0-72 hrs)			Weaners (approx. 28 d)	
		Blood, 0-72 hrs	Colostrum, 0-72 hrs	Milk, 28 d	Liver tissue, 28 d	Blood	Liver tissue	Carcase	Liver tissue	Blood
1	Control	75	15	15	2	15	15	15	15	15
	Trial	75	15	15	2	15	15	15	15	15
2	Control	58	15	15	2	15	15	15	15	15
	Trial	58	15	15	2	15	15	15	15	15
3	Control	45	15	15	2	15	15	15	15	15
	Trial	45	15	15	2	15	15	15	15	15
4	Control	34	15	15	2	15	15	15	15	15
	Trial	34	15	15	2	15	15	15	15	15
5	Control	26	15	15	2	15	15	15	15	15
	Trial	26	15	15	2	15	15	15	15	15
Samples, total		476	150	150	20	150	150	150	150	150

Analyses

Feed: Samples were taken from all diets delivered to farm A. Pooled samples of two samples from the same diet were analysed for crude protein, fat, ash, cellulose, energy (EFOS), calcium, phosphorus, lysine, methionine, cystine, threonine, selenium, iron, manganese, cobber and zinc. On farm B, one sample was taken from each diet on a quarterly basis. The samples were analysed according to the same guidelines as for farm A. Analyses were made of the total micro mineral concentration in the diet. It was not possible to distinguish between added micro minerals and the concentration of micro minerals in other ingredients. All analyses were made at Eurofins Steins Laboratory A/S.

Blood: All blood samples were analysed for level of haemoglobin using HemoCue hb 201+ immediately after sampling.

Claws: The right front foot was analysed for injuries to heel, sole and dewclaw, and for vertical and horizontal clefts and cracks in the white line. The injuries were assessed according to a scale on which 1 was small, 2 medium, and 3 large. Pathological examinations and analyses were made at the Laboratory for Pig Diseases in Kjellerup. Claws were not analysed for concentration of micro minerals.

Liver tissue, carcase and milk: Every two weeks, samples were analysed for selenium, cobber, iron, zinc and manganese at Laboratory UT2A, Hélioparc Pau – Pyrénées 2, Avenue du president in France. All samples were subject to Inductively Coupled Plasma (ICP) micro mineral analyses.

Statistics

The primary parameters for production traits were total born pigs per litter; farrowing rate; weaned per litter; litter weight at weaning; and percentage culled sows (to record sow longevity). These parameters were subject to analyses of variance in SAS with the procedures GLM and MIXED. Causes for piglet mortality, disease treatments and causes for culling of sows were recorded as secondary parameters.

Analyses of piglet liver tissue and entire carcase and of liver tissue from weaners include analysis results of the chemical concentration of selenium, iron, manganese, zinc and cobber. The chemical content was analysed with a general linear model with systematic effects of treatment, sow's age (young <= third litter; old > third litter), farm (A, B) and piglet weight at birth (small <= 0.95 kg; big > 0.95 kg) or piglet weight at weaning (small <= 5.0 kg; big > 5.0 kg).

The basic model checked for three-factor interaction between weight, sow's age and treatment effect and interactions between sow's age and farm and between sow's age and treatment. The model was reduced successively until 5 per cent significant level was reached.

Analyses of sows' liver tissue and milk include analysis results of the chemical content of selenium, iron, manganese, zinc and cobber. The chemical content was analysed with a general linear model with systematic effects of treatment (groups 1 and 2), sow's age (young <= third litter; old > third litter) and farm (A, B). The basic model checked for interaction between sow's age and farm, between farm and treatment, and between sow's age and treatment. The model was reduced successively until 5 per cent significant level was reached.

A general linear model was used for the statistical analysis of haemoglobin levels. The model used treatment (groups 1 and 2) and farm (A, B) as systematic effects. The basic model included analyses of interactions between farm and treatment.

Results from claw examinations were not subject to statistical analyses.

Results

Feed analyses

All feed analysis results are shown in Appendix 2.

Analyses of the feed used on farm A demonstrated a fair agreement in the micro mineral concentration of the feed, but with a selenium concentration lower than planned. Analyses on farm B also revealed good agreement, but with a higher concentration of selenium than planned. However, no differences were observed in the concentrations between the groups; ie. the difference is attributed to the selenium concentration of the ingredients.

The concentrations of iron and zinc were slightly higher than planned in all diets; this is also attributed to a concentration in the ingredients that deviated slightly from the standard values.

Production results

The statistical analyses of the production results include only litters from gilts transferred to the farms after the trial started. Consequently, 5,608 of 6,945 services conducted in the trial period were included. A total of 2,386 gilts were served during the trial period.

No interaction was observed between the farms, and the reproduction results and percentage of culled sows are therefore both shown in table 3. In Appendix 3, the results for each litter are shown.

No differences were observed between the groups on the two farms; ie. the use of organically bound micro minerals did not affect the reproduction results of the sows.

Table 3. Overall reproduction results on both farms.

Group	Control	Trial
Gilts	1,185	1,201
Services	2,822	2,786
Farrowing rate after 1st service	88	89
Returners, %	4.7	5.0
Pigs born/litter, total	15.3	15.4
Stillborn pigs/litter, %	9.6	9.9
Litters/sow/year	2.3	2.3
Non-productive days/litter	8.5	8.3
Culled sows, %	18.5	19.1

In table 4, causes for culling of sows are shown. All culled sows were examined and the cause for culling noted. The definition “Other” varies greatly between the two farms, simply because the staff on farm B was better at noting the cause for culling a sow than on farm A. There were no significant differences in the causes recorded for culling between the groups. The causes selected for culling differed between the farms, but not between the groups.

Table 4. Causes for culling of sows.

Farm	A		B	
Group	Control	Trial	Control	Trial
Culled sows, total	384	389	297	337
- of these dead	38	53	34	39
- of these killed	56	55	29	43
Causes for culling				
Reproduction problems, %	20	23	20	22
Leg problems, %	24	22	31	31
Age, %	1	0	0	0
Poor maternal traits, %	23	19	39	36
Other, %	32	36	10	11

Table 5 shows the overall production results obtained during lactation on both farms. No differences were observed in the production results obtained during lactation for the fixed litters, ie. the maternal traits of the sows were unaffected by the different micro minerals. The trial group on farm A had a lower weaning weight, which was attributed to an averagely shorter lactation period. In Appendix 4, the results are shown for each parity.

Table 5. Results – farrowing facility (standardised litters).

Farm	A		B	
Group	Control	Trial	Control	Trial
Weaned litters	264	251	279	284
Sow start weight adjusted* for embryos etc., kg	226	232	231	228
Sow end weight, kg	216	225	224	222
Feed intake during lactation, FUsow	-	-	190	191
Weight loss during lactation, kg	10	7	8	6
Standardised litter size	13.1	13.0	13.0	13.0
Litter weight at standardisation, kg	18.4	18.4	19.1	18.9
Lactation period, days	25	24	26	26
Pre-weaning mortality	16.4	16.3	10.3	11.4
Litter weight at weaning, kg	81.6	78.6	83.8	82.7

*) all sows were weighed before farrowing. A constant (mucous membranes, uterus fluid etc.) + weight per piglet adjusted to litter size was deducted from this result.

Table 6 shows the results of claw examinations (right front foot from approx. 300 sows on each farm). One claw may have more than one injury, and the table therefore shows both the number of individual injuries as well as number of injuries per claw. The extent of an injury was also evaluated with a scale on which 1 was minor, 2 medium and 3 large. However, the table does not include the extent of the injuries as 98% of the injuries were given the score 1.

Table 6. Result of claw examinations.

Farm	A		B	
Group	Control	Trial	Control	Trial
Examined claws	156	169	141	134
Normal claws with no injuries	16	20	27	25
Claws with ball injuries	82	104	59	48
Claws with dewclaw injuries	25	17	16	11
Claws with sole injuries	63	88	54	50
Claws with bleeding/crack in wall, horizontal	39	51	41	38
Claws with cracks in the white line	57	70	52	48
Claws with vertical cracks in abaxial wall	23	23	20	17
Injuries per claw				
0 injuries per claw	16	20	27	25
1 injury per claw	35	35	35	35
2 injuries per claw	32	38	32	30
3 injuries per claw	34	37	22	20
4 injuries per claw	22	22	12	13
5 injuries per claw	13	14	8	6
6 injuries per claw	3	3	4	4
7 injuries per claw	1	0	1	1
Av. number of injuries per claw	2.3	2.5	2.1	1.9

The results revealed differences in the number and type of injury on the two farms. However, no differences were found between control and trial sows. Even though the concentration of micro minerals in the claws was not analysed, it is concluded that the source of micro minerals did not affect the number of claw injuries on the two farms.

Chemical analyses

The aim of the trial was to demonstrate whether organically bound micro minerals increased sows' productivity, longevity and claw health compared with micro minerals bound as salts. It was expected that an effect would be found in an increased absorption of the individual micro minerals, but this was not possible to record in this trial. The evaluation of the absorbability of the micro minerals and the requirements of the animals is based solely on recordings of micro minerals in:

- Sows: liver tissue and milk
- Newborn piglets: liver tissue and carcase
- 28 days old piglets: liver tissue
- Haemoglobin levels in blood: sows, newborn piglets and 28 days old pigs

Mutual impact was observed between the concentrations of the micro minerals as the absorption from the intestines takes place according to the same mechanisms [9],[12]. Regard was not made to this in the statistical work.

In tables 7-12, the results of analyses of milk, liver tissue, carcase and blood are shown for selenium, cobber, iron, zinc and manganese.

The results are shown for 1st-3rd parity sows or 4th-5th parity sows when significant effect of age was seen. Otherwise only the overall result for all sows is shown.

The results are listed according to the piglets' birth weight (small = up to 950 g and normal = over 950 g) when a significant effect of size was observed. Otherwise only the overall result is shown for all piglets.

All results in tables 7-12 are 95% confidence intervals from the statistical analyses described in the section on statistics, and are thus adjusted for farm, age, parity and weight of the pigs.

Table 7. Concentration of selenium, adjusted results in ppm.

Farm	A			B			Total
Group	Control	Trial	Significance*	Control	Trial	Significance**	Significance***
Sows							
Liver tissue	[0.472-0.581]	[0.480-0.596]	NS	[0.583-0.712]	[0.593-0.730]	NS	NS
Milk	[0.118-0.141]	[0.127-0.152]	NS	[0.118-0.141]	[0.127-0.152]	NS	NS
Piglets at birth							
Liver tissue - pigs of 1-3 parity sows	[0.405-0.462]	[0.418-0.480]	NS	[0.383-0.440]	[0.465-0.521]	P<0.0001	P<0.017
Liver tissue - pigs of 4-5 parity sows	[0.374-0.439]	[0.386-0.457]	NS	[0.353-0.416]	[0.435-0.496]	P<0.0001	P<0.017
Carcase - pigs born small	[0.098-0.110]	[0.086-0.098]	P<0.003	[0.079-0.089]	[0.112-0.128]	P<0.0001	P<0.0001
Carcase - pigs born normal	[0.104-0.118]	[0.092-0.105]	P<0.003	[0.085-0.095]	[0.121-0.435]	P<0.0001	P<0.0001
Piglets 28 days old							
Liver tissue - small piglets of 1-3 parity sows	[0.359-0.422]	[0.394-0.464]	P<0.03	[0.511-0.578]	[0.718-0.817]	P<0.0001	P<0.0001
Liver tissue - small piglets of	[0.380-0.465]	[0.412-0.518]	P<0.03	[0.372-0.422]	[0.552-0.597]	P<0.0001	P<0.0001

4-5 parity sows							
Liver tissue - normal piglets of 1-3 parity sows	[0.392-0.456]	[0.430-0.502]	P<0.03	[0.492-0.554]	[0.696-0.780]	P<0.0001	P<0.0001
Liver tissue - normal piglets of 4-5 parity sows	[0.417-0.500]	[0.450-0.559]	P<0.03	[0.354-0.410]	[0.499-0.578]	P<0.0001	P<0.0001

* Significant difference between trial and control on farm A

** Significant difference between trial and control on farm B

*** Significant difference between trial and control in the overall model (if the significant difference between A and B varies: the overall main effect of treatment is interaction between treatment and farms).

Analyses of the feed on both farms revealed identical concentrations of selenium in both control and trial diets. The concentration was approx. 10% lower than expected on farm A and approx. 5% higher than expected on farm B. Previous trials revealed positive correlations between selenium concentrations in feed and in sows' liver tissue [12], and this was also found in this trial.

Samples of milk and liver tissue from the sows did not reveal any significant differences in selenium concentrations between the groups on the two farms, but liver tissue samples from 28-day-old pigs did demonstrate a significantly higher concentration of selenium in the trial group, which means that the sow milk supplied more selenium to the piglets in the trial group than in the control group. Higher selenium concentrations in carcase and liver tissue shortly after birth were also found in the piglets in the trial group on farm B.

The use of Sel-Plex in the feed thus increased selenium concentrations when recorded for individual animals. The total concentration of selenium was identical in all diets, and the effect must therefore be attributed to a higher absorbability of selenium. This is likely correlated with the fact that selenium is absorbed and stored as an amino acid.

Table 8. Concentration of cobber, adjusted results in ppm.

Farm	A			B			Total
Group	Control	Trial	Significance*	Control	Trial	Significance**	Significance***
Sows							
Liver tissue	[18.3-42.2]	[6.3-31.7]	NS	[18.3-42.2]	[6.3-31.7]	NS	NS
Milk	[3.30-3.94]	[3.23-3.85]	NS	[3.89-4.49]	[3.75-4.46]	NS	NS
Piglets at birth							
Liver tissue	[52.4-58.4]	[51.6-58.1]	NS	[48.3-54.3]	[47.8-53.7]	NS	NS
Carcase - small pigs of 1-3 parity	[1.434-1.673]	[1.489-1.739]	NS	[1.222-1.482]	[1.277-1.549]	NS	NS

sows							
Carcase - small pigs of 4-5 parity sows	[1.683-2.031]	[1.730-2.105]	NS	[1.987-2.296]	[2.047-2.358]	NS	NS
Carcase - normal pigs of 1-3 parity sows	[1.645-1.895]	[1.708-1.953]	NS	[1.451-1.685]	[1.514-1.745]	NS	NS
Carcase - normal pigs of 4-5 parity sows	[1.901-2.245]	[1.953-2.314]	NS	[2.215-2.502]	[2.281-2.557]	NS	NS
Piglets 28 days old							
Liver tissue - small piglets of 1-3 parity sows	[34.5-54.4]	[35.1-55.0]	NS	[74.0-90.1]	[74.3-90.9]	NS	NS
Liver tissue - small piglets of 4-5 parity sows	[67.4-94.0]	[67.3-95.3]	NS	[68.2-85.0]	[68.4-85.9]	NS	NS
Liver tissue - normal piglets of 1-3 parity sows	[44.9-63.1]	[45.3-63.9]	NS	[66.0-81.1]	[66.7-81.5]	NS	NS
Liver tissue - normal piglets of 4-5 parity sows	[78.3-102.3]	[77.9-103.7]	NS	[58.4-77.9]	[59.0-78.5]	NS	NS

* Significant difference between trial and control on farm A

** Significant difference between trial and control on farm B

*** Significant difference between trial and control in the overall model (if the significant difference between A and B varies: the overall main effect of treatment is interaction between treatment and farms).

Feed analyses revealed identical concentrations of cobber in control as well as trial diets on both farms. A slightly higher concentration was found in the diets on farm B. This has probably triggered the slight difference in concentrations between the farms. Analyses of milk and liver tissue from sows did not reveal significant differences in cobber concentrations between the groups on the two farms. A significant effect was observed of sow age and piglet weight at birth; the older the sows and the larger the piglets, the higher the cobber concentrations in carcase and tissue.

Feed analyses revealed identical concentrations of iron in the control and trial diets on both farms, and no differences were observed between the farms. Normally, the concentration of iron in liver tissue in sows is only affected by the inclusion rates of calcium and phosphorus [12], but analyses of liver tissue from sows revealed a significantly higher concentration in the trial group without there being any differences in calcium and phosphorus concentrations between the diets. No differences were observed in the iron concentration of the sow milk, but numerically the concentration was lowest in the trial group, which is probably the reason why liver tissue samples and blood samples (haemoglobin) from 28-day-old pigs also revealed significantly lower concentrations in the trial group. Iron concentrations in liver tissue of 28-day-old pigs was also affected by the pigs' size at birth; the smaller the pig, the higher the iron concentration. It was also affected by whether a pig was born of a young or an old sow; the younger the sow, the higher the iron concentration. The effect of the iron concentration is directly opposite the effect of the cobber concentrations and it is therefore likely that the ratio between iron and cobber will have an impact.

Table 9. Concentration of iron, adjusted results in ppm.

Farm	A			B			Total
Group	Control	Trial	Signifi-cance*	Control	Trial	Signifi-cance**	Signifi-cance***
Sows							
Liver tissue	[231.6-283.3]	[286.8-353.2]	P<0.0046	[231.6-283.3]	[286.8-353.2]	P<0.0046	P<0.0046
Milk	[1.335-1.758]	[1.251-1.697]	NS	[1.335-1.758]	[1.251-1.697]	NS	NS
Piglets at birth							
Liver tissue - small pigs of 1-3 parity sows	[133.7-192.2]	[132.7-196.3]	NS	[158.1-234.6]	[158.3-237.4]	NS	NS
Liver tissue - small pigs of 4-5 parity sows	[98.5-151.4]	[97.9-154.3]	NS	[118.0-182.3]	[118.1-184.5]	NS	NS
Liver tissue - normal pigs of 1-3 parity sows	[99.7-145.0]	[100.1-146.4]	NS	[120.9-172.6]	[122.4-172.6]	NS	NS
Liver tissue - normal pigs of 4-5 parity sows	[74.0-113.3]	[74.3-114.4]	NS	[90.7-133.4]	[91.8-133.6]	NS	NS
Carcase - small pigs of 1-3 parity sows	[17.57-19.69]	[16.72-18.99]	NS	[17.57-19.69]	[16.72-18.99]	NS	NS
Carcase - small pigs of 4-5 parity sows	[19.52-22.20]	[18.67-21.50]	NS	[19.52-22.20]	[18.67-21.50]	NS	NS
Carcase - normal pigs of 1-3 parity sows	[16.12-18.17]	[15.38-17.36]	NS	[16.12-18.17]	[15.38-17.36]	NS	NS
Carcase - normal pigs of 4-5 parity sows	[18.10-20.65]	[17.34-19.86]	NS	[18.10-20.65]	[17.34-19.86]	NS	NS
Piglets 28 days old							
Liver tissue - small pigs of 1-3 parity sows	[281.4-498.3]	[228.2-403.9]	P<0.0408	[294.5-467.8]	[237.0-382.2]	P<0.0408	P<0.0408
Liver tissue - small pigs of 4-5 parity sows	[190.6-409.4]	[151.5-338.6]	P<0.0408	[440.9-710.8]	[352.3-584.7]	P<0.0408	P<0.0408
Liver tissue - normal pigs of 1-3 parity sows	[244.1-411.8]	[196.9-335.6]	P<0.0408	[150.1-232.3]	[122.5-187.2]	P<0.0408	P<0.0408
Liver tissue - normal pigs of 4-5 parity sows	[167.6-333.9]	[132.4-277.8]	P<0.0408	[213.1-372.3]	[172.5-302.2]	P<0.0408	P<0.0408

* Significant difference between trial and control on farm A

** Significant difference between trial and control on farm B

*** Significant difference between trial and control in the overall model (if the significant difference between A and B varies: the overall main effect of treatment is interaction between treatment and farms).

Another, good indicator of an animal's iron status is the level of haemoglobin in the blood. These results are shown in Table 10. In this trial, haemoglobin levels tended to drop as the sows got older; this tendency was unaffected by the type of iron given to the sows. The same tendency was observed for piglets and weaners. Haemoglobin levels in newborn piglets are instable and the results may consequently vary greatly. Haemoglobin levels in weaners and sows correspond well with references from literature [9], [12].

Table 10. Haemoglobin levels in blood, mmol/litre.

Farm	A			B			Total
	Control	Trial	Significance*	Control	Trial	Significance**	Significance***
Sows							
Blood - 1-3 parity sows	[6.41-6.52]	[6.34-6.46]	NS	[6.65-6.77]	[6.59-6.71]	NS	P<0.068
Blood - 4-5 parity sows	[6.30-6.48]	[6.24-6.42]	NS	[6.55-6.72]	[6.48-6.66]	NS	P<0.068
Piglets at birth							
Blood - pigs of 1-3 parity sows	[4.71-5.30]	[4.68-5.27]	NS	[5.16-5.74]	[5.13-5.71]	NS	NS
Blood - pigs of 4-5 parity sows	[4.66-5.42]	[4.62-5.39]	NS	[4.36-5.04]	[4.33-5.01]	NS	NS
Piglets 28 days old							
Blood - pigs of 1-3 parity sows	[6.57-7.13]	[6.33-6.91]	NS	[6.38-6.91]	[6.15-6.69]	NS	NS
Blood - pigs of 4-5 parity sows	[6.14-7.02]	[5.91-6.80]	NS	[7.40-8.02]	[7.16-7.80]	NS	NS

* Significant difference between trial and control on farm A

** Significant difference between trial and control on farm B

*** Significant difference between trial and control in the overall model (if the significant difference between A and B varies: the overall main effect of treatment is interaction between treatment and farms).

Feed analyses revealed identical concentrations of zinc in the control as well as trial diets on both farms and no differences between the farms. Results of liver tissue analyses from sows are shown in table 11 demonstrating a slightly higher concentration of zinc in the trial group. Numerically, zinc in sow milk was lowest in the trial groups, which is probably why liver tissue samples from 28-day-old pigs revealed a tendency to have a lower zinc concentration in the trial group. Zinc in carcases of newborn piglets was also affected by the pig's size at birth; the smaller the pig, the higher the zinc concentration. It was also affected by the sow's age; the younger the sow, the lower the zinc concentration in the carcase. This observation was also made in the liver tissue of 28-day-old pigs, but in this case piglets that were normal-sized at birth had a higher concentration in the liver tissue than piglets that were small at birth. The result is likely also affected by cobber and iron concentrations, ie. the correlation between iron and cobber has probably affected the zinc concentration.

Table 11. Concentration of zinc, adjusted results in ppm.

Farm	A			B			Total
Group	Control	Trial	Signifi-cance*	Control	Trial	Signifi-cance**	Signifi-cance***
Sows							
Liver tissue	[50.1-81.9]	[52.2-86.0]	NS	[50.1-81.9]	[52.2-86.0]	NS	NS
Milk	[13.5-16.2]	[12.9-15.5]	NS	[11.8-14.4]	[11.0-14.0]	NS	NS
Piglets at birth							
Liver tissue	5.80	5.62	NS	5.80	5.62	NS	NS
Carcase - small pigs of 1-3 parity sows	[3.667-3.835]	[3.620-3.799]	NS	[3.545-3.725]	[3.504-3.685]	NS	NS
Carcase - small pigs of 4-5 parity sows	[3.943-4.166]	[3.891-4.129]	NS	[3.820-4.037]	[3.774-3.998]	NS	NS
Carcase - normal pigs of 1-3 parity sows	[3.584-3.753]	[3.543-3.712]	NS	[3.474-3.634]	[3.440-3.590]	NS	NS
Carcase - normal pigs of 4-5 parity sows	[3.857-4.073]	[3.811-4.032]	NS	[3.747-3.936]	[3.706-3.893]	NS	NS
Piglets 28 days old							
Liver tissue - small pigs of 1-3 parity sows	[5.69-6.43]	[5.46-6.19]	P<0.079	[7.03-7.78]	[6.75-7.47]	P<0.079	P<0.079
Liver tissue - small pigs of 4-5 parity sows	[5.93-6.81]	[5.67-6.56]	P<0.079	[7.38-8.18]	[7.06-7.88]	P<0.079	P<0.079
Liver tissue - normal pigs of 1-3 parity sows	[6.26-6.98]	[6.00-6.72]	P<0.079	[6.61-7.28]	[6.36-6.98]	P<0.079	P<0.079
Liver tissue - normal pigs of 4-5 parity sows	[6.52-7.38]	[6.24-7.13]	P<0.079	[6.88-7.72]	[6.59-7.42]	P<0.079	P<0.079

* Significant difference between trial and control on farm A

** Significant difference between trial and control on farm B

*** Significant difference between trial and control in the overall model (if the significant difference between A and B varies: the overall main effect of treatment is interaction between treatment and farms).

Feed analyses revealed identical concentrations of manganese in the control as well as trial diets on both farms and no differences in concentrations between the farms. Nor were there any differences in manganese concentrations in liver tissue, carcase or milk between the two groups. The analysis results are shown in table 12. Manganese concentrations in liver tissue of newborn piglets were affected by the pig's size at birth; the smaller the pig, the higher the manganese concentration. It was also affected by the sow's age; the younger the sow, the lower the concentration in the pig's liver tissue. Analyses of carcases revealed the opposite tendency of the manganese concentration in liver tissue at birth. Analyses of liver tissue from 28-day-old pigs revealed an increased manganese concentration when the pigs were normal-sized at birth and had a young sow for mother.

Table 12. Concentration of manganese, adjusted results in ppm.

Farm	A			B			Total
Group	Control	Trial	Signifi-cance*	Control	Trial	Signifi-cance**	Signifi-cance***
Sows							
Liver tissue	[1.72-2.12]	[1.73-2.15]	NS	[1.72-2.12]	[1.73-2.15]	NS	NS
Milk	[0.024-0.040]	[0.025-0.045]	NS	[0.024-0.040]	[0.025-0.045]	NS	NS
Piglets at birth							
Liver tissue - small pigs of 1-3 parity sows	[1.777-2.064]	[1.734-2.037]	NS	[1.526-1.794]	[1.495-1.765]	NS	NS
Liver tissue - small pigs of 4-5 parity sows	[1.992-2.375]	[1.945-2.343]	NS	[1.719-2.056]	[1.683-2.022]	NS	NS
Liver tissue - normal pigs of 1-3 parity sows	[1.640-1.911]	[1.607-1.878]	NS	[1.422-1.646]	[1.399-1.611]	NS	NS
Liver tissue - normal pigs of 4-5 parity sows	[1.845-2.192]	[1.808-2.154]	NS	[1.605-1.881]	[1.579-1.842]	NS	NS
Carcase - small pigs of 1-3 parity sows	[0.773-0.912]	[0.802-0.957]	NS	[0.844-1.013]	[0.879-1.058]	NS	NS
Carcase - small pigs of 4-5 parity sows	[0.671-0.821]	[0.694-0.863]	NS	[0.738-0.905]	[0.767-0.948]	NS	NS
Carcase - normal pigs of 1-3 parity sows	[0.644-0.763]	[0.672-0.797]	NS	[0.711-0.839]	[0.745-0.872]	NS	NS
Carcase - normal pigs of 4-5 parity sows	[0.561-0.685]	[0.583-0.717]	NS	[0.632-0.747]	[0.651-0.780]	NS	NS
Piglets 28 days old							
Liver tissue - small pigs of 1-3 parity sows	[1.90-2.31]	[1.86-2.27]	NS	[2.61-3.06]	[2.55-3.01]	NS	NS
Liver tissue - small pigs of 4-5 parity sows	[1.63-2.02]	[1.59-1.99]	NS	[2.26-2.64]	[2.20-2.61]	NS	NS
Liver tissue - normal pigs of 1-3 parity sows	[2.05-2.43]	[2.00-2.39]	NS	[2.31-2.69]	[2.27-2.63]	NS	NS
Liver tissue - normal pigs of 4-5 parity sows	[1.75-2.13]	[1.71-2.10]	NS	[1.98-2.36]	[1.93-2.32]	NS	NS

* Significant difference between trial and control on farm A

** Significant difference between trial and control on farm B

*** Significant difference between trial and control in the overall model (if the significant difference between A and B varies: the overall main effect of treatment is interaction between treatment and farms).

The concentration of the five micro minerals will affect absorption processes, which is also indicated by the analysis results. Furthermore, the inclusion of calcium and phosphorus influences the absorption of manganese and iron, but in this trial the concentrations of calcium and phosphorus were identical in both groups. The concentration of zinc in the feed also affects the absorption of iron and cobber.

The results of this trial depend on the selected concentration of micro minerals in the feed; here, normal Danish diets (see table 1) were used, and the results indicate that the concentrations were too high in proportion to the animals' requirement. The liver acts as a buffer for a variety of micro minerals, and the results reveal that the sows in the trial group had the highest concentration of micro minerals in liver tissue. This might indicate that organically bound micro minerals have a higher absorbability than micro minerals bound as salts.

However, the increased concentration of micro minerals in liver tissue from the sows in the trial group did result in an increased concentration in the sow milk – with the exception of selenium. This may be attributed to the fact that micro minerals become more immobile when the concentration increases. Part of the selenium will be bound as an amino acid, and even though the concentration in tissue is higher, it is likely to be immobile selenium. This may explain why the concentration is generally lower in sow milk - with the exception of selenium.

This trial also demonstrated a correlation between the concentration of micro minerals in sow milk and the concentration in liver tissue in 28-day-old pigs. This was also observed in other trials [5].

Analyses of micro minerals in piglets' liver tissue indicate that the concentration of micro minerals is affected by the size of the pig and thereby also by the size of the liver tissue.

Conclusion

In this trial, two different sources of the micro minerals selenium, cobber, zinc, iron and manganese were studied in feed for sows. The sows in the control group were given micro minerals bound as salts, and the trial group was given organically bound micro minerals. The diets for the two groups contained identical concentrations of the micro minerals. Several types of organically bound micro minerals are available; in this trial, Bio-Plex and Sel-Plex from Alltech Ltd. were chosen as an effect was previously observed of these [5] [6].

Analyses of sow milk, liver tissue, samples of newborn piglets' carcases and blood revealed high concentrations compared with literature [9], [12], which indicates that sows, piglets and weaners in this trial were not in a deficiency of the micro minerals selenium, iron, zinc, cobber and manganese. The hypothesis that older sows have a micro mineral deficiency could not be proven in this trial. This is probably also the reason why the trial did not demonstrate any significant effects on reproduction results, maternal traits, longevity and claw health.

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Trial no. 958

Appendix 1

All equipment used for taking and storing samples must not contain any of the micro minerals (Fe, C, Zn, Mn and Se). Procedures for sampling and for killing of pigs in the trial complied with current Danish legislation.

Blood samples

Blood samples from piglets and sows were taken 0-72 hrs post-partum. Blood samples from weaners were taken approx. 28 days post-partum. All blood samples were stabilised with EDTA and stored in blood sample tubes at 4 °C until haemoglobin analysis.

Milk

Samples were taken 0-72 hrs post-partum and approx. 28 days post-partum. If milk was expressed manually, 5 ml milk were taken from teats 2-6. Samples were stored at minus 18 °C.

Liver tissue

Piglets were weighed before they were killed 0-72 hrs post-partum. A piglet was killed by hitting its head into the concrete floor followed by exsanguination within 2 minutes. The entire liver was removed and cut into three equally large pieces.

Weaners were killed with a captive bolt pistol approx. 28 days post-partum followed by exsanguination and severing of the spinal cord within 2 minutes. A sample of approx. 30 g was taken of the lobus dexter lateral cranial part of the liver and cut into three equally large pieces.

Sows were killed with a captive bolt pistol followed by exsanguination and severing of the spinal cord within 2 minutes. The liver was removed, and a sample of approx. 30 g was taken of the lobus dexter lateral cranial part of the liver and cut into three equally large pieces.

All liver tissue samples were placed in test tubes and stored in liquid nitrogen until analysis.

Carcase

Piglets that liver tissue samples were taken from were stored. Gastric and intestinal contents were emptied, and the carcase was stored at minus 18 °C in a plastic bag. Subsequently, piglets were homogenized in a meat mincer, and representative samples of 50-100 ml taken. This part of the work was completed at the Faculty of Agricultural Sciences at Aarhus University.

Claws

Front feet were labelled with a manila label showing date, CHR number and sow number. Front feet were routinely transported from the slaughterhouse to the Laboratory for Pig Diseases in Kjellerup where they were stored at minus 18 °C until analysis.

Appendix 2

Farm A – purchased ready-mixed feed, dry lactation diet.

Composition, %	Control	Trial
Barley	35.00	35.00
Wheat	42.61	42.18
Soybean meal	10.70	10.80
Rapeseed cake, rich in fat	4.00	4.00
Vegetable fat	3.29	3.41
Molasses, sugar cane	1.00	1.00
Mono calcium phosphate	0.63	0.63
Animal feed lime	1.39	1.41
Phytase (Ronozyme P)	0.03	0.03
Other minerals + vitamins	1.15	1.14
HC VIT 500417	0.20	0
HC VIT 500418	0	0.40

Analyses of lactation feed

	Control		Lactation	
	Declared	Analysed	Declared	Analysed
Samples	-	12	-	12
Crude protein, %	15.4	15.2	15.4	15.3
Crude fat, %	5.5	5.3	5.5	5.4
FUsow per 100 kg	112	111	112	112
Lysine, g/FUsow	7.7	7.6	7.7	7.7
Methionine, g/FUsow	2.4	2.4	2.4	2.3
Threonine, g/FUsow	5.1	5.3	5.1	5.3
Calcium, g/FUsow	7.5	7.4	7.5	7.3
Phosphorus, g/FUsow	5.0	5.2	5.0	5.0
Iron, mg/FUsow	193	220	194	214
Cobber, mg/FUsow	20	19	20	19
Zinc, mg/FUsow	137	150	136	142
Manganese, g/FUsow	65	68	64	65
Selenium, mg/FUsow	0.40	0.35	0.40	0.36

Purchased ready-mixed feed, dry gestation diet

Composition, %	Control	Trial
Barley	20.00	20.00
Wheat	45.07	44.87
Wheat bran	10.00	10.00
Rapeseed cake, rich in fat	8.00	8.00
Pulpetter	7.00	7.00
Oat	5.00	5.00
Soybean meal	1.25	1.22
Vegetable fat	1.00	1.00
Molasses, sugar cane	1.00	1.00
Dietary salt	0.46	0.46
Animal feed lime	0.99	1.02
Phytase (Ronozyme P)	0.03	0.03
HC VIT 500417	0.20	0
HC VIT 500418	0	0.40

Analyses of gestation feed

	Control		Trial	
	Declared	Analysis	Declared	Analysis
Samples	-	12	-	12
Crude protein, %	12.9	13.0	12.9	13.3
Crude fat, %	4.0	3.6	4.0	3.8
FUsow per 100 kg	102	100	102	101
Lysine, g/FUsow	5.3	5.6	5.3	5.6
Methionine, g/FUsow	2.0	2.0	2.0	2.0
Threonine, g/FUsow	4.2	4.1	4.2	4.4
Calcium, g/FUsow	6.5	6.6	6.5	6.3
Phosphorus, g/FUsow	3.8	4.0	3.8	3.9
Iron, mg/FUSOW	197	222	198	217
Cobber, mg/FUsow	20	20	20	19
Zinc, mg/FUsow	140	150	139	140
Manganese, mg/FUsow	69	77	67	72
Selenium, mg/FUsow	0.40	0.35	0.40	0.34

Appendix 2 (cont.)

Farm B

Lactation feed: liquid feed mixed on-farm, composition in %

	Control	Trial
Water	57.00	57.00
Brewer's yeast	15.00	15.00
Barley	11.60	11.60
Wheat	11.35	11.35
Soybean meal	3.30	3.30
Palm oil	0.70	0.70
Gårdmix 15603 Minerals + vitamins + phytase	0	1.05
Gårdmix 15601 Minerals + vitamins + phytase	1.05	0

Analyses of lactation feed

	Control		Trial	
	Declared	Analysis	Declared	Analysis
Samples	-	12	-	12
Crude protein, %	5.0	5.1	5.0	5.1
Crude fat, %	1.4	1.4	1.4	1.4
FUsow per 100 kg	34	34	34	34
Lysine, g/FUsow	8.0	8.3	8.0	8.2
Methionine, g/FUsow	2.5	2.5	2.5	2.5
Threonine, g/FUsow	5.3	5.4	5.3	5.4
Calcium, g/FUsow	7.5	7.4	7.5	7.3
Phosphorus, g/FUsow	5.2	5.3	5.2	5.1
Iron, mg/FUSOW	187	212	186	205
Cobber, mg/FUsow	20	22	20	23
Zinc, mg/FUsow	132	140	132	135
Manganese, mg/FUsow	64	67	64	68
Selenium, mg/FUsow	0.40	0.42	0.40	0.43

Gestation feed: liquid feed mixed on-farm, composition in %

	Control	Trial
Water	64.00	64.00
Brewer’s yeast	15.00	15.00
Soybean meal	0.80	0.80
Wheat	17.74	17.74
Pulpetter	1.90	1.90
Gårdmix 15602 Minerals + vitamins + phytase	0.56	0
Gårdmix 15604 Minerals + vitamins + phytase	0	0.56

Analyses of gestation feed

	Control		Trial	
	Declared	Analysis	Declared	Analysis
Samples	-	12	-	12
Crude protein, %	3.7	3.8	3.7	3.7
Crude fat, %	0.4	0.6	0.4	0.6
FUsow per 100 kg	25	26	25	26
Lysine, g/FUsow	6.0	6.1	6.0	7.3
Methionine, g/FUsow	2.0	2.0	2.0	2.0
Threonine, g/FUsow	4.2	4.1	4.2	4.3
Calcium, g/FUsow	6.5	6.6	6.5	6.9
Phosphorus, g/FUsow	3.8	3.9	3.8	3.9
Iron, mg/FUSOW	186	210	185	205
Cobber, mg/FUsow	20	23	20	22
Zinc, mg/FUsow	133	139	133	135
Manganese, mg/FUsow	67	70	67	65
Selenium, mg/FUsow	0.40	0.43	0.40	0.42

Appendix 3

Average reproduction results and culling of sows

Farm A

Control group						
Parity	1	2	3	4	5	Total
Litters	590	375	214	83	19	1281
Pigs born in total per litter	14.0	15.3	16.5	17.0	16.3	15.0
Stillborn per litter, %	7.8	7.5	10.6	12.1	11.4	8.5
Farrowing rate	86	91	85	84	89	87
Culled sows, %	17.6	22.1	34.6	27.7	31.6	22.6
Trial group						
Parity	1	2	3	4	5	Total
Litters	590	351	188	80	23	1232
Pigs born in total per litter	13.9	15.5	17.1	16.4	16.8	15.2
Stillborn per litter, %	7.7	8.1	11.5	13.0	13.0	8.8
Farrowing rate	86	89	91	88	91	88
Culled sows, %	21.2	23.4	23.4	27.5	34.8	22.8

Farm B

Control group						
Parity	1	2	3	4	5	Total
Litters	595	420	269	182	75	1541
Pigs born in total per litter	14.2	15.8	16.6	17.2	16.4	15.5
Stillborn per litter, %	9.2	10.0	11.5	12.0	15.9	10.5
Farrowing rate	87	89	94	92	89	89
Culled sows, %	14.8	14.1	16.4	15.4	17.3	15.1
Trial group						
Parity	1	2	3	4	5	Total
Litters	611	411	266	184	82	1554
Pigs born in total per litter	14.5	15.6	16.9	16.9	16.6	15.6
Stillborn per litter, %	9.2	10.6	11.2	13.3	18.3	10.9
Farrowing rate	89	88	92	91	82	89
Culled sows, %	15.7	17.0	13.5	14.1	29.3	16.2

Appendix 4

Average production results for fixed litters in the farrowing facility

Farm A

Control group						
Parity	1	2	3	4	5	Total
Fixed litters	75	66	55	45	23	264
Sow's start weight adjusted for embryos etc., kg	183	209	246	255	282	226
Sow's end weight, kg	170	197	236	248	278	216
Weight loss during lactation, kg	13	12	10	7	4	10
Days of lactation	30	24	25	25	24	25
Litters size	14.0	13.0	13.0	13.0	13.0	13.1
Mortality until weaning, %	16.2	14.7	16.8	18.8	16.6	16.4
Litter weight at birth, kg	17.8	18.4	18.1	18.8	19.0	18.4
Litter weight at weaning, kg	83.8	78.4	81.9	84.5	81.9	81.6
Trial group						
Parity	1	2	3	4	5	Total
Fixed litters	75	62	49	40	25	251
Sow's start weight adjusted for embryos etc., kg	185	220	242	260	282	232
Sow's end weight, kg	180	212	232	257	277	225
Weight loss during lactation, kg	5	8	10	3	5	7
Days of lactation	29	24	24	24	24	24
Litters size	13.6	12.8	12.8	12.8	12.7	13.0
Mortality until weaning, %	17.1	16.2	15.2	16.7	15.9	16.3
Litter weight at birth, kg	17.7	18.3	18.4	19.0	18.9	18.4
Litter weight at weaning, kg	81.4	76.0	80.6	78.6	78.6	78.6

Farm B

Control group						
Parity	1	2	3	4	5	Total
Fixed litters	75	65	52	48	39	279
Sow's start weight adjusted for embryos etc., kg	196	226	240	257	267	231
Sow's end weight, kg	188	214	233	251	263	224
Weight loss during lactation, kg	8	12	7	6	4	8
Feed intake during lactation, FUsow	171	183	196	202	216	190
Days of lactation	25	25	26	27	26	26
Litters size	13.0	13.0	13.0	13.0	13.0	13.0
Mortality until weaning, %	11.4	6.0	9.5	12.7	13.7	10.3
Litter weight at birth, kg	17.0	21.2	19.9	18.8	18.5	19.1
Litter weight at weaning, kg	76.1	89.0	85.6	86.5	84.0	83.8
Trial group						
Parity	1	2	3	4	5	Total
Fixed litters	77	65	60	48	34	284
Sow's start weight adjusted for embryos etc., kg	183	216	239	258	288	228
Sow's end weight, kg	180	210	236	252	270	222
Weight loss during lactation, kg	3	6	3	6	18	6
Feed intake during lactation, FUsow	170	188	202	211	202	191
Days of lactation	25	26	26	27	26	26
Litters size	13.0	13.0	13.0	13.0	13.0	13.0
Mortality until weaning, %	10.0	8.1	11.2	15.1	15.6	11.4
Litter weight at birth, kg	17.0	20.2	19.4	19.0	19.0	18.9
Litter weight at weaning, kg	7.5	88.6	84.9	84.7	83.5	82.7