ALTERNATIVES TO MEDICINAL ZINC IN FEED FOR WEANED PIGS

TRIAL REPORT NO. 1101

The effect of adding 2,500 mg zinc per kg feed 14 d post-weaning did not differ from 1,500 mg zinc, but did improve performance and lowered diarrhoea treatments compared with 0 mg zinc or OceanFeed, MiyaGold and GærPlus in the weight interval 7-30 kg.

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Abstract

The results of this trial revealed no differences in performance or health in weaned pigs given either 2,500 mg or 1,500 mg medicinal zinc per kg feed for 14 days post-weaning.

The addition of 2,500 mg zinc per kg feed for 14 days significantly improved production results and lowered the frequency of diarrhoea treatments compared with no zinc or the addition of one of three alternative products: OceanFeed, MiyaGold and GærPlus. Results demonstrated no differences in productivity or treatments for diarrhoea between weaned pigs given one of these products and the pigs given no medicinal zinc in the period 7-30 kg.

This trial comprised six groups:

- Group 1 (positive control): 2,500 mg zinc added per kg feed for 14 days post-weaning
- Group 2: 1,500 mg zinc added per kg feed for 14 days post-weaning
- Group 3: 0 mg zinc
- Group 4: OceanFeed (seaweed) added to the feed from 7 to 30 kg

- Group 5: MiyaGold (probiotic) added to the feed from 7 to 30 kg
- Group 6: GærPlus (yeast + probiotic) added to the feed from 7 to 30 kg

This trial demonstrates that it is possible to achieve a 40% drop in the zinc usage, corresponding to an annual drop in Denmark of roughly 170 tonnes in zinc leaches into soil and water, without jeopardizing performance and health, when cutting zinc levels in feed for weaned pigs from 2,500 to 1,500 mg zinc/kg.

Background

Zinc is used both as an additive in pig feed in the form of microminerals (max. 150 mg/kg feed) and as a prescription-only product to prevent and control post-weaning diarrhoea (2,500 mg/kg for 14 days post-weaning). Roughly 30% of the overall zinc consumption is used for therapeutic purposes for weaned pigs with the remaining 70% used as an additive to all pig feed.

A very large part of the zinc uptake in feed is applied to soil from pig slurry, and in such situations, zinc is considered a heavy metal. Consequently, high inclusion rates in feed for weaned pigs may lead to an accumulation of zinc in soil. This is outlined in a report made by DCE on behalf of the Danish Environmental Protection Agency [1]. Production sites with weaned pigs (7-30 kg) release up to 40 times the amount of zinc absorbed by plants. In the Danish pig production industry, annual zinc leaches to arable fields average roughly 1,300 tonnes zinc. This does not constitute an environmental risk today, but in the long term, zinc leaches to arable fields need to be cut both from an environmental point of view and because research indicates that the use of zinc in large inclusion rates is correlated to a high prevalence of MRSA in pigs [2].

A seven-point plan drawn up by SEGES illustrates the measures required to cut the use of zinc. This includes a reduction in the amounts of zinc used as additives and a reduction in the use of zinc for therapeutic purposes. The aim of this trial is to test different alternatives to using 2,500 mg medicinal zinc per kg feed.

Materials and method

Transfer of pigs and implementation

The trial was conducted at Experimental Station Grønhøj with pigs purchased from one pig producer. The trial comprised roughly 4,500 weaned pigs assigned to six groups. The trial ran for 33 weeks and the pigs were included in the trial from 7 kg to 30 kg. Six pens housing either 10 or 15 pigs constituted one batch (replicate). The trial comprised approximately 60 batches (replicates) of roughly 750 pigs per group. Upon transfer to the weaner pens, the pigs were sorted according to gender and weight so

that all six groups in a block were identical in terms of female pigs and castrates. There was a maximum difference in start weight between the pens in each block of 0.25 kg per pig.

Trial design and feed

The first 14 days post-weaning the pigs were given 2,500, 1,500 or 0 mg medicinal zinc or three alternative products that were added to the feed in the period 7-30 kg (trial design shown in table 1). All diets included 100 mg zinc/kg feed added in the form of microminerals and xylanase (5,000 U Danisco beta xylanase from Dupont) and 200% phytase (1,000 FYT Ronozyme HiPhos from DSM). Organic acids were not added to the feed. The growth period 7-30 kg was divided into three periods with a different diet for each period.

The pigs in the trial made a gradual transition to diet 2 at roughly 9 kg (approx. 11 days) and were given diet 2 only by day 14. No pigs were given medicinal zinc after day 14 post-weaning. All pigs were weighed just before the gradual transition to diet 2 (first intermediate weighing). At approx. 15 kg, the pigs were weighed again (second intermediate weighing) and subsequently switched to diet 3, which was used in the weight interval 15-30 kg (table 1).

Table 1. Trial design. Zn = medicinal zinc added to the feed

Group	**1** **2,500 Zn**	**2** **1,500 Zn**	**3** **0 Zn**	**4** **OceanFeed**	**5** **MiyaGold**	**6** **GærPlus**
Diet 1 (7-9 kg)	2,500 Zn	1,500 Zn	0 Zn	1.5% OceanFeed	2 kg/ton MiyaGold	0.5 kg/ton GærPlus
Diet 2 (9-15 kg)	0 Zn	0 Zn	0 Zn	1.5% OceanFeed	1 kg/ton MiyaGold	0.5 kg/ton GærPlus
Diet 3 (15-30 kg)	0 Zn	0 Zn	0 Zn	1.5% OceanFeed	0,5 kg/ton MiyaGold	0.25 kg/ton GærPlus

Seven basic diets (pellets) were produced (appendix 1) at Danish Agro's facilities in Sjølund, and they were subsequently mixed into 18 trial diets using the Spotmix equipment at Grønhøj (appendices 3+4). The trial diets used in the three periods varied only in terms of ingredients and the specific product added. The amino acid profile was identical in all diets for the entire period corresponding to 10.5 g digestible lysine per feed unit.

The pigs were fed ad lib in one dry feeder per pen and had access to water in one nipple drinker per pen.

Trial feed

The group given 2,500 mg medicinal zinc per kg feed the first 14 days post-weaning constituted the 'positive control group'. One group was given 1,500 mg medicinal zinc/kg feed the first 14 days to determine whether an inclusion lower than 2,500 mg might have the same positive effect on the

development of post-weaning diarrhoea. If this proved to be the case and if this was implemented on all Danish pig farms, zinc usage for therapeutic purposes would drop by 40% roughly corresponding to a 170 tonnes cut in zinc annually. One group of pigs received no medicinal zinc at all to establish whether post-weaning diarrhoea was still a challenge when pigs were given feed without zinc. This set-up was chosen to be able to document whether the alternative products might reduce diarrhoea.

All three alternative products are available on the Danish market, and the inclusion rates used followed the recommendations of the manufacturers. All three products were added to the feed for the entire trial period (7-30 kg) to determine whether they had a positive effect on performance and health compared with the pigs given 2,500 mg, 1,500 mg and 0 mg zinc for the first 14 days post-weaning.

Product information from manufacturers

OceanFeed Swine is an Irish product based on seaweed, marketed in Denmark by Chr. Hansen. It consists of brown, red and green seaweeds. According to the manufacturer, the product contains a range of bioactive compounds (polysaccharides) such as laminarin, fucoidan and fucane known to inhibit the development of various microorganisms in the intestines such as enterobacteriaceae and Coli bacteria. OceanFeed Swine protects and improves gut health thereby reducing the risk of diarrhoea in weaned pigs. With the inclusion rate used in this trial, the cost of adding OceanFeed to the feed is approx. DKK 5.7 per pig (7-30 kg).

MiyaGold (Clostridium butyricum) is marketed by Huvepharma NV. According to the manufacturer, this bacterium produces acetic and butyric acid, which stabilize gut morphology and protect the gut mucosa against pathogens. With the inclusion rate used in this trial, the cost of adding MiyaGold to the feed is approx. DKK 2.5 per pig (7-30 kg).

GærPlus consists of probiotic (bacillus) and prebiotic (yeast cell walls) and is marketed by Danish Agro. The product contains Bacillus Licheniformis & Subtilis, Mannan Oligosaccharides and beta-glucans. GærPlus modulates and stabilizes the gut flora through so-called competitive exclusion, ie. the gut favours the good microorganisms. In addition, the development of pathogens is inhibited as is the development of E.coli, +Salmonella sp, and Clostridium perfringens and the production of lactic acid is enhanced. GærPlus also promotes immunomodulation, ie. stimulation of the immune response leading to an enhanced immune response. Finally, GærPlus increases the production of enzymes that improve pig digestion and nutrient uptake. This improves FCR and daily gain and lowers mortality rates. With the inclusion rate used in this trial, the cost of adding GærPlus to the feed is approx. DKK 1.4 per pig (7-30 kg).

Feed analyses

All feed samples were collected according to the principles of the Theory Of Sampling [3]. Samples of the basic diets were collected at the feedmill, while samples of the trial diets were collected from a sampling valve on the Spotmix equipment.

The seven basic diets were produced over four rounds. At each production round, four samples of each diet were subject to analyses of energy, protein, calcium, phosphorus, phytase activity, zinc, copper and the amino acids lysine, methionine, cystine and threonine at the Eurofins Steins Laboratory.

Samples of the trial diets were collected routinely throughout the trial and analysed for zinc and copper.

Recordings

All recordings were made at pen level and analysed for each of the periods 7-9 kg, 9-15 kg, 15-30 kg and the entire trial period from 7 kg to 30 kg. Primary parameters included daily gain, feed intake and feed consumption.

Treatments for disease

Secondary parameters included treatments for disease, dead pigs and pigs moved to a hospital pen.

Treatment for diarrhoea followed these guidelines: When two pigs in a pen showed clinical signs of diarrhoea, only these two pigs were treated (= individual treatment). If more than two pigs showed signs of diarrhoea, all pigs in the pen were medicated through the feed (= group-treatment). Treatment of entire sections was not applied.

Treatments for disease were analysed partly as number of days individual pigs were treated in per cent of feeding days and partly as per cent pens subject to group-treatment. Preventive treatment with antibiotics for digestive disorders was not applied. Pigs were vaccinated against *Lawsonia* upon arrival at Grønhøj.

Statistical analyses

The variables ”Feed intake, FUgp per day”, ”FCR, FUgp per kg gain”, ”Daily gain” and ”Production value per pig place/day” were subject to statistical analysis for the periods 7-9 kg, 9-15 kg, 15-30 kg, 9-30 kg and 7-30 kg. The variables ”Weight at transfer”, ”Weight at first intermediate weighing”, ”Weight at second intermediate weighing” and ”Weight at transfer from the weaner unit” were also analysed.

The above variables were subject to analysis in proc mixed in SAS using the factor ”Group” as systematic effect. “Batch” was included as random effect. Analyses of the weaning period (7-9 kg) and the entire period (7-30 kg) were corrected for start weight at 7 kg. Analyses were made for the periods 9-15 kg, 15-30 kg and the entire weaner period 9-30 kg and were corrected either for start weight at 7 kg or for weight at the start of the period.

The variables ”Dead”, ”Dead and culled”, ”Pens treated for diarrhoea” and ”Diarrhoea, treatment days in % of feeding days” were subject to logistic regression in prox glimmixed in SAS with the factor “Group” as systematic effect and “Batch” as random effect. Correction was made for weight at transfer to the weaner pens.

In all analyses, the group given 2,500 mg zinc is compared with the other five groups. In addition, the group given 0 mg zinc is compared with the other five groups. Thus analyses do not include pairwise comparisons between all groups.

Prerequisites for calculation of the production value

The production value (PV) per pig place per day for the entire weaner period was calculated according to the following equation:

- Production value in DKK per pig place per day = (value of gain – feed costs) / feeding days.

The calculation applied the same feed price for all groups (average of the period September 2011 – September 2016) and the value of 1 kg gain:

- Average price of 7 kg pigs of DKK 219 per pig DKK ± 11.17 per kg (7-9 kg), DKK ± 7.85 per kg (9-12 kg) and DKK ± 6.14 per kg (12-25 kg).
- Average price of 30 kg pigs of DKK 374 per pig with regulations of DKK -6.01 per kg (25-30 kg) and DKK + 6.00 per kg (30-40 kg).
- Feed (7-10 kg): DKK 3.46 per FUgp and (10-30 kg): DKK 2.09 per FUgp – used in calculations for all six groups.

Definition individual variables:

- Value of gain = kg gain in the trial period × value of 1 kg gain (DKK 6.70).

Feed costs were determined using the below equation and are calculated on the basis of the analysed feed units (based on EDMOi analyses) of the basic diets and the amount of feed actually used of each individual basic diet per pen:

- Feed costs = (end weight – start weight) × FUgp per kg gain × DKK per FUgp

’Feeding days’ defines the average number of days a pig was recorded as active in the trial.

Results and discussion

Feed analyses

Analyses of the basic diets revealed a higher energy content (2-5 FUgp) and fewer amino acids than expected. Several of the basic diets were found to have a lack of roughly 10% digestible amino acids per feed unit than planned.

Analyses of, in particular, basic diets B, C, D and E, all produced in small quantities per batch (2,500 kg), revealed deviations from the expected nutrient content. Analyses of diets F and G, both produced in large quantities (35 and 8 tonnes, respectively), revealed a fine correspondence with the expected nutrient content (appendix 2).

The abovementioned deviations did affect the nutrient content of the trial diets: In diet 1 (7-9 kg) there was a lack of roughly 10% digestible amino acids per feed units in the feed for all six groups. In diet 2 (9-15 kg) analyses demonstrated a lack of 3-4%, whereas analyses of diet 3 (15-30 kg) demonstrated a fine correspondence between the analysed and the expected nutrient content.

As these deviations were identical for all six trial groups, they are not assumed to have affected the outcome of the trial.

Analyses of OceanFeed Swine

Prior to formulation of the diets, OceanFeed was analysed for nutrient content, including minerals (four samples per batch of OceanFeed). As the seaweed clotted the filters during the analysis process, it was not possible to make EDOM/EMDOMi analyses for this product. Consequently, table values for beet pellets (that also contains a large amount of fermentable carbohydrates) for FUgp were used in the formulation of basic diet C that contained OceanFeed. This inaccuracy is unlikely to affect the energy content of the trial feed in any way as basic diet C only contained 1.5% OceanFeed and as this diet only constituted 20% of the trial diets. OceanFeed was delivered over two rounds, and analysis results are provided in appendix 5.

According to EU legislation, seaweed products can contain maximum 40 mg arsenic per kg. Analyses revealed a content of 21 and 26 mg arsenic, respectively, per kg.

The content of lamarin and fucoidan, the two most significant bioactive compounds, averaged 8.7% and 3.7%, respectively, of the product. With an inclusion of 1.5% OceanFeed Swine in the trial feed, this corresponds to 1,300 mg laminarin and 550 mg fucoidan per kg feed, which is the content seen in many studies with seaweed products.

Production results

Table 2 provides an outline of the production results where different superscripts in a row indicate significant differences (p value < 0.05) compared with the group given 2,500 Zn. The trial comprised 60 batches (pens) and roughly 750 pigs per group. Nine pens were excluded from the data due to various errors (pigs jumping out of the pens, missing record sheets etc.).

7-9 kg

The pigs given 2,500 mg zinc had a significantly higher feed intake, a higher daily gain, a better feed conversion ratio (FCR) and a better production value (PV) than the pigs given 0 mg zinc and the pigs given the three alternative products. There were no differences between the pigs given 0 mg zinc and the pigs given the three alternative products. Analyses revealed a slight, but significant, difference between the pigs given 2,500 mg zinc and those given 1,500 mg zinc in feed intake and daily gain, while there were no differences in feed conversion and production value. This shows that the pigs given 1,500 mg zinc per kg feed managed largely as well as those given 2,500 mg zinc per kg feed the first 14 days post-weaning.

9-15 kg

Analyses of the subsequent period (9-15 kg) revealed the same differences as in the previous period when results are corrected for start weight (not shown in table 2). The effect of zinc primarily affects performance in the period when it is supplied, but has no impact on the subsequent performance. When corrected for differences in weight at first intermediate weighing (roughly 0.6-0.7 kg between 2,500 mg zinc and 1,500 mg zinc and the other four groups), results generally show no differences between the six groups in the period 9-15 kg (see table 2). The pigs that had a lower productivity in the period 7-9 when they were not given medicinal zinc (groups 3-6) were not negatively affected in the subsequent period with the exception of the pigs given GærPlus where analyses revealed a significantly lower production value compared with 2,500 mg zinc.

7-30 kg

Looking at the entire growth period, the pigs given 2,500 mg zinc did not differ from the pigs given 1,500 mg zinc, but did differ significantly from the other four groups in terms of feed conversion and performance. Results revealed no differences between 0 mg zinc, OceanFeed, MiyaGold and GærPlus.

Table 2. Production results.

Group	1 2,500 Zn	2 1,500 Zn	3 0 Zn	4 OceanFeed	5 Miya Gold	6 GærPlus
Pens	59	60	62	62	58	61
Weight at transfer, kg	6.87	6.85	6.86	6.84	6.86	6.87
Weight at 1st intermediate weighing, kg	9.31[a]	9.16[b]	8.58[b]	8.66[b]	8.56[b]	8.60[b]
Weight at 2nd intermediate weighing, kg	16.85[a]	16.45[b]	15.46[b]	15.54[b]	15.47[b]	15.50[b]
Weight at departure, kg	29.62	30.13	30.24	30.00	30.17	29.92
7 – 9.0 kg (d 0-11) *Corrected for start weight*						
Feed intake, FUgp per pig/day	0.31[a]	0.29[b]	0.25[b]	0.26[b]	0.25[b]	0.26[b]
Daily gain, g	222[a]	207[b]	153[b]	164[b]	153[b]	156[b]
FCR, FUgp per kg gain	1.40[a]	1.44[a]	1.68[b]	1.62[b]	1.72[b]	1.71[b]
PV, 7-9 kg	0.43[a]	0.38[a]	0.17[b]	0.21[b]	0.15[b]	0.16[b]
9.0 - 15 kg (d 12-27) *Corrected for weight at 1st intermediate weighing*						
Feed intake, FUgp per pig/day	0.67	0.66	0.66	0.67	0.67	0.67
Daily gain, g	435	429	424	423	427	419
FCR, FUgp per kg gain	1.57	1.56	1.57	1.59	1.57	1.61
PV, 9-15 kg	1.51[a]	1.50[a]	1.47[a]	1.45[a]	1.48[a]	1.43[b]
7- 30 kg (d 0-52) *Corrected for start weight*						
Feed intake, FUgp per pig/day	0.88[a]	0.87[a]	0.85[b]	0.86[b]	0.86[b]	0.86[b]
Daily gain, g	523[a]	520[a]	502[b]	502[b]	503[b]	501[b]
FCR, FUgp per kg gain	1.68[a]	1.69[a]	1.70[b]	1.71[b]	1.71[b]	1.71[b]
PV, 7-30 kg	1.59[a]	1.59[a]	1.53[b]	1.51[b]	1.52[b]	1.52[b]

a,b Different superscripts within the same row indicate significant difference (p value < 0.05) compared with group 1 (2,500 mg zinc). No superscripts indicate no difference from group 1.

Treatments for diarrhoea

Table 3 shows treatments for diarrhoea and dead and culled pigs; different superscripts in a row indicate significant difference (p value < 0.05) compared with the pigs given 2,500 mg zinc. There were no differences between the groups in dead and culled pigs.

In the period **7-9 kg** there were no differences in the number of individual treatments for diarrhoea between group 1 (2.500 mg zinc) and group 2 (1,500 mg zinc), but the number was significantly lower than in the other four groups. There were no differences between the pigs given no medicinal zinc and the pigs given OceanFeed, MiyaGold and GærPlus. The percentage of group-treatments was significantly lower in group 1 compared with the groups 3 and 4.

In the period **9-15 kg** results reveal no difference between the pigs given 2,500 mg zinc and the pigs given 1,500 mg zinc. There were significantly fewer group-treatments in group 1 (2,500 mg zinc)

compared with the groups given 0 mg zinc, OceanFeed, MiyaGold and GærPlus, while analyses reveal significantly fewer individual treatments in group 1 2,500 mg zinc compared with 0 mg zinc, OceanFeed and MiyaGold, but not fewer than in the group given GærPlus.

There were no differences between the groups in the period **15-30 kg**.

When results are analysed for the entire period **7-30 kg** there were no differences between the pigs given 2,500 and 1.500 mg zinc in terms of group-treatments and individual treatments. There were significantly more group-treatments in groups 4 and 6 (OceanFeed and GærPlus) compared with group 1(2,500 mg zinc). Analyses show significantly more individual treatments in the groups given 0 mg zinc, OceanFeed, MiyaGold and GærPlus compared with group 1.

There are no indications that the alternative products given in the entire trial period (7-30 kg) improved the health of the pigs and thereby affected the development of diarrhoea compared with the pigs that received no zinc in the period 9-30 kg.

It may be difficult to establish the importance of individual treatments as this includes pigs that were treated only once (no subsequent group-treatment of the pen) and pigs that were treated individually and then subsequently included in group-treatment of the pen.

The percentage of pens subjected to group-treatment (figure 1) indicates the extent of diarrhoea, ie. the number of pens in each group that were subject to group-treatment during the trial. Pigs may have been treated without showing clear signs of diarrhoea as part of group-treatment of a pen where more than two pigs show signs of diarrhoea. A pen that is group-treated twice constitutes only one recording in the data material.

Figure 2 shows the **total** number of days when treatment was administered for each of the six groups recorded in days post-weaning.

Table 3. Diarrhoea and treatment frequency and dead/culled.

Group	1 2,500 Zn	2 1,500 Zn	3 0 Zn	4 Ocean Feed	5 Miya Gold	6 GærPlus
7-9 kg						
Diarrhoea, group-treatments, % pens	0.0[a]	1.7[a]	16.1[b]	12.9[b]	12.1[a]	9.8[a]
Diarrhoea, individual treatments, days, % of feeding days	0.2[a]	0.6[a]	2.7[b]	3.5[b]	2.2[b]	2.4[b]
9-15 kg						
Diarrhoea, group-treatments, % pens	13.4[a]	26.7[a]	38.7[b]	50.0[b]	50.0[b]	34.4[b]
Diarrhoea, individual treatments, days, % of feeding days	2.9[a]	3.4[a]	5.5[b]	7.0[b]	6.1[b]	5.1[a]
15-30 kg						
Diarrhoea, group-treatments, % pens	48.6	31.0	46.7	43.8	42.7	49.0
Diarrhoea, individual treatments, days, % of feeding days	4.5	3.3	4.6	4.4	3.8	4.6
7-30 kg						
Diarrhoea, group-treatments, % pens	54.0[a]	51.7[a]	68.0[a]	84-4[b]	69.2[a]	72.4[b]
Diarrhoea, individual treatments, days, % of feeding days	2.9[a]	2.7[a]	4.8[b]	5.1[b]	4.2[b]	4.2[b]
Dead and culled						
Mortality, %	0.4	0.4	0.5	0.1	0.5	0.4
Dead and culled, %	2.8	2.8	3.9	2.0	3.3	3.6

Difference superscripts in a row indicate significant difference (p value < 0.05) compared with group 1 (2,500 mg zinc). No superscripts indicate no significant difference compared with group 1.

*Feeding days = feeding days minus days when group-treatment is administered.

In groups 1 (2,500 mg zinc) and 2 (1,500 mg zinc) results reveal hardly any group-treatments in the period **(7-9 kg)** they were given zinc, whereas in the other four groups group-treatment was administered in 10-16% of the pens in the first two weeks post-weaning (figure 1).

In the period **9-15 kg** (12-27 days) when no medicinal zinc was added to the feed in groups 1 and 2, the percentage of group-treatmeants increased considerably, but to a smaller extent than in the groups given 0 mg zinc, OceanFeed, MiyaGold and GærPlus.

In the period **15-30 kg** (28-52 days) there were no differences between the groups.

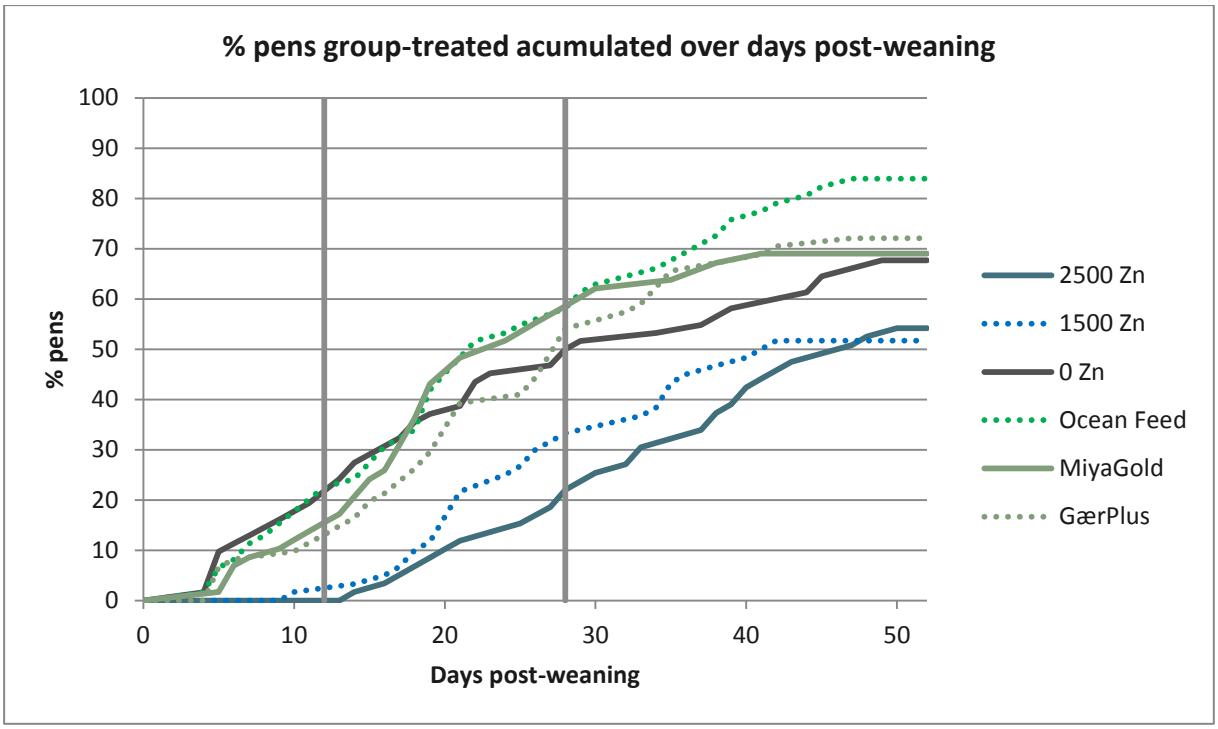

Figure 1. Group-treatments, % pens, accumulated over days post-weaning.

Figure 2 shows the total number of pigs treated per day in the six groups. This is the sum of all treatments (individual and groups), ie. the number of pigs treated daily for diarrhoea. Figure 2 does not provide information on whether individual pens suffered in particularly from diarrhoea and thereby needed treatment repeatedly or whether treatments were evenly distributed among all pens in the group.

Figure 2 indicates that the outbreaks of diarrhoea peaked at two specific points in time: at roughly day 7 and roughly day 20 post-weaning. In all groups, the number of daily treatments increased after day 14. It seems that in the period 9-15 kg there was still a protective effect of zinc. This may be explained by a higher zinc concentration in plasma in groups 1 and 2 due to the high inclusion of zinc in the first 14 days post-weaning (not investigated). This, however, is not substantiated by previous research that showed that the concentration of zinc in plasma drops fairly quickly when zinc intake stops [3]. Another possible explanation may be that a high concentration of zinc affects the gut microflora, which in turn has a positive effect in the subsequent period. Research shows [4] that the microflora and its production of organic acids are significantly affected by a high inclusion of zinc, but the differences between a high and a low inclusion of zinc are neutralized within 14 days when zinc intake stops. This trial does not confirm whether this effect on the microflora affects the development of diarrhoea.

The figure also illustrates an even drop in daily treatments for diarrhoea after roughly day 28 in all groups.

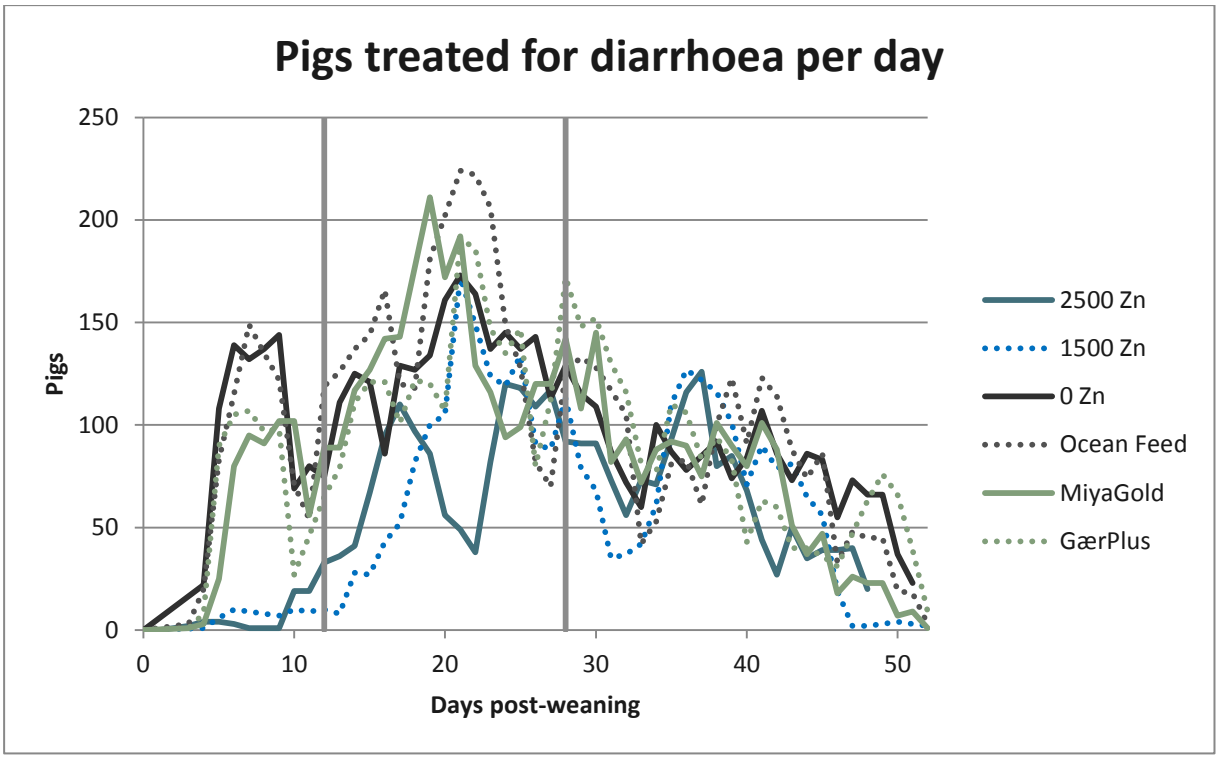

Figure 2. Pigs treated for diarrhoea per day (individual as well as groups) post-weaning.

Effect of start weight

At transfer to the trial, the pigs were assigned to batches according to weight. To be able to determine whether weight at transfer to the weaner pens affect the subsequent productivity and outbreaks of diarrhoea, data material was divided into batches of large pigs and small pigs (average pen weight above or below 7 kg). Results are shown in table 4.

Results show an average difference in start weight of 1.0 kg between the two groups, but this only had a very small impact on the subsequent productivity (table 4).

In the period 7-9 kg, the large pigs ate significantly more and grew slightly faster than the small pigs, but results show no differences in FCR or in production value (PV).

In the period 9-15 kg, results show no effect of start weight. Seen over the entire period (7-30 kg), the large pigs gained 10 g more a day than the small pigs, but there were no differences FCR and production value.

Table 4. Productivity and treatment frequency, according to start weight.

Factor	Small	Large
Pens	187	175
Average start weight, kg	6.4	7.4
7 – 9 kg (day 0 – 11)		
Feed intake, FUgp/pig/day	0.26[a]	0.28[b]
Daily gain, g	170	181
FCR, FUgp/kg gain	1,60	1.59
PV, 7-9 kg	0.24	0.25
9 – 15 kg (day 12 – 27)		
Feed intake, FUgp/pig/day	0.67	0.66
Daily gain, g	427	421
FCR, FUgp/kg gain	1.58	1.59
Entire period, 7 – 30 kg (day 0 – 52)		
Feed intake, FUgp/pig/day	0.85	0.87
Daily gain, g	501[a]	511[b]
FCR, FUgp/kg gain	1.71	1.70
PV, 7-30 kg	1.52	1.54

Different superscripts within a row indicate significant difference (p value < 0.05) compared with group 1 (2,500 mg zinc).

Table 5 shows the treatment frequency, partly as individual treatments and partly as group-treatments of entire pens. Results revealed no differences in the periods 7-9 kg and 9-15 kg, and 7-30 kg.

Analysis of interactions between start weight and the six groups revealed no interaction for productivity or diarrhoea treatments. There were no indications that small and large pigs respond differently to zinc or alternative treatments.

Thus, the outcome of this trial does not indicate that small pigs perform poorer than large pigs as neither FCR nor diarrhoea outbreaks differed. However, it should be noted that pigs purchased for Grønhøj are not included in trial activities if they weigh less than 6 kg upon delivery.

Table 5. Treatment frequency according to start weight

Factor	Small	Large
7-9 kg (day 0 – 11)		
Per cent pens with group-treatments, %	9.1	9.1
Diarrhoea treatments, individual pigs, days, % of productive days	4.2	4.2
9-15 kg (day 12 – 27)		
P Per cent pens with group-treatments, %	35.8	35.4
Diarrhoea treatments, individual pigs, days, % of productive days	5.3	5.1
Entire period 7-30 kg (day 0 – 52)		
Per cent pens with group-treatments, %	62.6	70.9
Diarrhoea treatments, individual pigs, days, % of productive days	3.0	2.9

*Feeding days = feeding days minus days when group-treatment is administered.

Conclusion

This trial demonstrated that pigs given 2,500 mg medicinal zinc per kg feed the first 14 days post-weaning had a significantly higher daily gain, a better feed conversion ratio and a higher productivity in the period 7-9 kg and the entire period 7-30 kg than the pigs that were either given no medicinal zinc or one of the three alternative products OceanFeed (seaweed), MiyaGold (probiotic) or GærPlus (yeast plus probiotic) in the entire growth period. There were no differences in FCR and production value between the pigs given 2,500 mg zinc and 1,500 mg zinc per kg feed.

There were no differences in productivity between the pigs given medicinal zinc and the pigs given the three alternative products.

The above differences in productivity were also seen in the period 9-15 kg, but when data was corrected for variations in weight at first intermediate weighing results reveal no significant differences in daily gain, FCR and production value in this period between the pigs given 2,500 mg zinc and the other groups with the exception of GærPlus. This indicates that the addition of zinc did not significantly affect productivity – neither negatively nor positively – when zinc intake stopped after 14 days. It also indicates that the pigs in the four groups that were not given zinc and therefore managed poorer in the period 7-9 kg, were not ‘bad’ pigs that subsequently grew slower than the pigs that were given zinc. However, there are no indications that the pigs given one of the three alternatives to zinc in the entire growth period subsequently compensated for the low gain in the beginning.

Results revealed no differences in group-treatments and individual treatments for diarrhoea in the entire period 7-30 kg between the pigs given 2,500 mg zinc and 1,500 mg zinc. Results showed significantly more group-treatments in the groups given OceanFeed and GærPlus compared with group 1 (2,500 mg zinc). The number of individual treatments was significantly higher in the groups given 0 mg zinc, OceanFeed, MiyaGold and GærPlus compared with group 1. There are no indications that OceanFeed, MiyaGold and GærPlus, supplied in the entire trial period 7-30 kg,

improved health and thereby affected the development of diarrhoea compared with the pigs that were not given zinc in the period 9-30 kg.

There were no differences in performance and health between weaned pigs given 2,500 mg zinc and 1,500 mg medicinal zinc per kg feed in the period 0-14 days post-weaning.

In conclusion, this trial demonstrates that it is possible to achieve a 40% drop in the zinc usage, corresponding to an annual drop of roughly 170 tonnes in zinc leaches into soil and water, without jeopardizing performance and health, when cutting zinc levels in feed for weaned pigs from 2,500 to 1,500 mg zinc/kg

Pig producers are allowed to use 1,500 mg zinc per kg feed for therapeutic purposes provided the herd vet issues a prescription on 1,500 mg zinc. It is illegal not to follow the vet's prescription. Pig producers wishing to cut zinc inclusion from 2,500 to1,500 mg zinc per kg are advised only to do so after consulting with the herd vet.

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Participants

Technical assistance: Henry Aalbæk, SEGES Svineproduktion

Afprøvning nr. 1468
Aktivitetsnr.: 063-110700

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Appendix 1

Composition of ingredients, basic diets, %.

A (GREEN)	B (RED)	C (BLUE)
Wheat (51.71%)	Wheat (50.95%)	Wheat (49.36%)
Barley (20.00%)	Barley (20.00%)	Barley (25.00%)
ViloSoy, soy prot. (13.38%)	ViloSoy, soy prot. (13,47 %)	ViloSoy, soy prot. (6.10%)
Potato protein Protastar (4.50%)	Potato protein Protastar (4,50 %)	Potato protein Protastar (4.75%)
Fishmeal (3.50%)	Fishmeal (3,50 %)	Palm fatty acid destillate (3.95%)
Palm fatty acid destillate (2,85 %)	Palm fatty acid destillate (3,07 %)	Sugar beet molasses (0.50%)
Sugar beet molasses (0.50%)	Sugar beet molasses (0.50%)	Calcium carbonate, lime (1.15%)
Calcium carbonate, lime (0.76%)	Calcium carbonate, lime (0.69%)	Monocalcium phosphate (1.15%)
Monocalcium phosphate (1.02%)	Monocalcium phosphate (1.18%)	Lysine sulphate 70% BB (1.12%)
Sodium chloride (0.23%)	Sodium chloride (0.23%)	DA Vit Fravænning * 500751 (0.40%)
Sodium bicarbonate (0.10%)	Sodium bicarbonate (0.10%)	OceanFeed Swine (7.50%)
Lysine sulphate 70% BB (0.72%)	Lysine sulphate 70% BB (0.72%)	Ronozyme HiPhos GT 4000 (0.03%)
Methionine DL 98% (0.10%)	Methionine DL 98% (0.10%)	
Threonine 98% (0.13%)	Threonine 98% (0.13%)	
Tryptophan 99% (0.05%)	Tryptophan 99% (0.05%)	
Valine L 96.5% (0.03%)	Valine L 96,5% (0.03%)	
DA Vit Fravænning * 500751 (0.40%)	DA Vit Fravænning * 500751 (0.40%)	
Ronozyme HiPhos GT 4000 (0.03%)	Ronozyme HiPhos GT 4000 (0.03%)	
	Zinc oxide ZiCare Premix (0.36%)	
D (YELLOW)	E (WHITE)	F (PINK)
Wheat (54.73%)	Wheat (51.52%)	Wheat (44.79%)
Barley (25.00%)	Barley (25.00%)	Barley (20.00%)
ViloSoy, soy prot. (7,58 %)	ViloSoy, soy prot. (7,16 %)	Soybean meal, toast. dehul. (24.51%)
Potato protein Protastar (4.75%)	Potato protein Protastar (4.75%)	Potato protein Protastar (2.50%)
Palm fatty acid destillate (2.63%)	Palm fatty acid destillate (3.69%)	Palm fatty acid destillate (3.02%)
Sugar beet molasses (0.50%)	Sugar beet molasses (0.50%)	Sugar beet molasses (0.50%)
Calcium carbonate, lime (1.80%)	Calcium carbonate, lime (1.78%)	Calcium carbonate, lime (1.82%)
Monocalcium phosphate (1.10%)	Monocalcium phosphate (1.50%)	Monocalcium phosphate (0.92%)
Sodium chloride (0.30%)	Sodium chloride (0.31%)	Sodium chloride (0.34%)
Sodium bicarbonate (0.21%)	Sodium bicarbonate (0.12%)	Sodium bicarbonate (0.07%)
Lysine sulphate 70% BB (0.06%)	Lysine sulphate 70% BB (0.10%)	Lysine sulphate 70% BB (0.71%)
DA Vit Fravænning * 500751 (0.40%)	DA Vit Fravænning * 500751 (0.40%)	Methionine DL 98% (0.15%)
Ronozyme HiPhos GT 4000 (0.03%)	Ronozyme HiPhos GT 4000 (0.03%)	Threonine 98% (0.16%)
Miya-Gold S (1.00%)	GærPlus (2.50%)	Tryptophan 99% (0.03%)
	ZooLac Feed Frade (1.00%)	Valine L 96.5% (0.06%)
		Da Vit Smågrise * 500753 (0.40%)
		Ronozyme HiPhos GT 4000 (0.03%)

G (GREY)
Wheat (51.52%)
Barley (25.00%)
ViloSoy, soy prot. (7.16%)
Potato protein Protastar (4.75%)
Palm fatty acid destillate (3.69%)
Sugar beet molasses (0.50%)
Calcium carbonate, lime (1.78%)
Monocalcium phosphate (1.50%)
Sodium chloride (0.31%)
Sodium bicarbonate (0.12%)
Lysine sulphate 70% BB (0.10%)
DA Vit Fravænning * 500751 (0.40%)
Ronozyme HiPhos GT 4000 (0.03%)

Appendix 2

Declared and analysed nutrient content of basic diets (A, B & C).

Basic diet	A (GREEN)		B (RED)		C (BLUE)	
	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg**	116.0	117.6	116.0	118.3	112.0	114.6
EDOMi, %**	84.9	84.9	84.9	84.6	82.6	83.6
EDOM, %**	90.7	90.0	90.7	91.7	89.9	88.5
Crude protein, g/kg**	210	202	210	195	152	145
Dig. crude protein, g/FUgp[2)]	158	150	158	144	116	109
Fat, %**	5.3	5.2	5.5	5.4	6.0	5.9
Ash, %**	5.1	4.6	5.5	5.1	7.6	6.5
Water, %**	12.7	11.4	12.6	10.9	13.1	11.8
Phosphorus, g/kg*	6.3	6.1	6.6	6.6	5.4	5.4
Dig. phosphorus, g/FUgp[2)]	3.4	3.3	3.6	3.5	3.0	2.9
Calcium, g/kg*	7.0	7.0	7.0	7.4	9.5	9.4
Copper, mg/kg*	140	137	140	139	140	133
Zinc, mg/kg**	100	135	3002	2612	100	179
Phytase activity, FTU/kg[1)]	1,000	1,429	1,000	1,270	1,000	1,050
Lysine, g/kg**	15.1	14.2	15.1	14.4	8.2	7.4
Dig. lysine, g/FUgp[2)]	11.6	10.8	11.6	10.8	6.1	5.4
Methionine, g/kg**	4.7	4.2	4.7	4.5	2.6	2.4
Dig. methionine, g/FUgp[2)]	3.7	3.3	3.7	3.5	2.0	1.8
Threonine, g/kg**	9.5	8.7	9.5	9.5	6.1	5.7
Dig. threonine, g/FUgp[2)]	7.1	6.5	7.1	7.0	4.4	4.1

[1)] Declared = added amount; Analysed = total content.

[2)] Based on analysed value of basic diets.

* Average of 4 analyses per batch, 4 batches, totalling 16 analyses – except basic diet B, which is an average of 8 analyses.

** Average of 4 analyses per batch, 4 batches, totalling 16 analyses – except basic diet B, which is an average of 4 analyses per batch, 3 batches, totalling 12 analyses.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix 2 cont.

Declared and analysed nutrient content of basic diets (D, E & F).

Basic diet	D (YELLOW)		E (WHITE)		F (PINK)	
	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg*	113.0	114.9	113.0	118.7	112.0	114.4
EDOMi, %*	84.6	84.5	84.7	84.3	84.0	83.8
EDOM, %*	90.0	89.0	90.0	89.3	91.1	90.3
Crude protein, g/kg*	157	148	152	147	206	208
Dig. crude protein, g/FUgp[2)]	119	110	115	106	159	157
Fat, %*	4.8	4.8	5.8	5.9	5.2	5.2
Ash, %*	5.5	4.7	6.3	5.2	6.0	5.6
Water, %*	14.1	11.8	15.2	11.7	13.2	11.8
Phosphorus, g/kg*	5.5	5.6	5.5	5.8	5.6	6.0
Dig. phosphorus, g/FUgp[2)]	3.0	3.0	3.0	3.0	3.1	3.3
Calcium, g/kg*	9.6	9.1	9.6	9.8	9.6	9.9
Copper, mg/kg*	140	127	140	130	140	138
Zinc, mg/kg*	100	151	100	204	100	149
Phytase activity, FTU/kg[1)*]	1,000	1,266	1,000	1,385	1,000	1,540
Lysine, g/kg*	8.2	7.5	8.2	7.6	14.5	14.9
Dig. lysine, g/FUgp[2)]	6.1	5.5	6.1	5.4	11.6	11.7
Methionine, g/kg*	2.7	2.5	2.7	2.4	4.5	4.5
Dig. methionine, g/FUgp[2)]	6.3	5.9	6.2	5.9	9.2	9.3
Threonine, g/kg*	2.1	1.9	2.1	1.8	3.7	3.6
Dig. threonine, g/FUgp[2)]	4.6	4.2	4.5	4.1	7.1	7.0

[1)] Declared = added amount; Analysed = total content.

[2)] Based on analysed value of basic diets.

* Average of 4 analyses per batch, 4 batches, totalling 16 analyses.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix 2 cont.

Declared and analysed nutrient content of basic diets (G).

Basic diet	**G (GREY)**	
	Declared	Analysed
FUgp per 100 kg*	113.0	114.8
EDOMi, %*	84.7	84.3
EDOM, %*	89.9	89.4
Crude protein, g/kg*	154.3	154.8
Dig. crude protein, g/FUgp[2)]	116.2	114.8
Fat, %*	4.4	4.4
Ash, %*	5.8	4.7
Water, %*	13.4	12.0
Phosphorus, g/kg*	5.5	5.8
Dig. phosphorus, g/FUgp[2)]	3.0	3.1
Calcium, g/kg*	9.6	9.8
Copper, mg/kg*	140	135
Zinc, mg/kg*	100	144
Phytase activity, FTU/kg[1)]	1,000	1,281
Lysine, g/kg*	8.2	8.0
Dig. lysine, g/FUgp[2)]	6.1	5.8
Methionine, g/kg*	2.7	2.6
Dig. methionine, g/FUgp[2)]	2.1	2.0
Threonine, g/kg*	6.2	6.2
Dig. threonine, g/FEsv[2)]	4.5	4.4

[1)] Declared = added amount; Analysed = total content.

[2)] Based on analysed value of basic diets.

* Average of 4 analyses per batch, 4 batches, totalling 16 analyses.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix3

Composition of the 18 trial diets based on seven basic diets.

Group	1	2	3	4	5	6
Name	**2,500 Zn**	**1,500 Zn**	**0 Zn**	**OceanFeed**	**MiyaGold**	**GærPlus**
7-9 kg	80% diet **B**	50% diet **B**	80% diet **A**	80% diet **A**	80% diet **A**	80% diet **A**
	20% diet **G**	30% diet **A**	20% diet **G**	20% diet **C**	20% diet **D**	20% diet **E**
		20% diet **G**				
9-15 kg	40% diet **A**	40% diet **A**	40% diet **A**	40% diet **A**	40% diet **A**	40% diet **A**
	40% diet **F**	40% diet **F**	40% diet **F**	40% diet **F**	40% diet **F**	40% diet **F**
	20% diet **G**	20% diet **G**	20% diet **G**	20% diet **C**	10% diet **G**	20% diet **E**
					10% diet **D**	
15-30 kg	80% diet **F**	80% diet **F**	80% diet **F**	80% diet **F**	80% diet **F**	80% diet **F**
	20% diet **G**	20% diet **G**	20% diet **G**	20% diet **C**	15% diet **G**	10% diet **G**
					5% diet **D**	10% diet **E**

Appendix 4: Groups 1-3 (7-9 kg)

Declared and analysed nutrient content of trial diets (1, 2 and 3).

Group	1		2		3	
Name	2,500 Zn		1,500 Zn		0 Zn	
7-9 kg	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg	115.4	117.6	115.4	117.4	115.4	117.0
EDOMi, %	84.9	85.2	84.9	85.0	84.9	84.7
EDOM, %	90.5	89.6	90.5	89.7	90.5	89.9
Crude protein, g/kg	199	187	199	189	199	192
Dig. crude protein, g/FUgp[2)]	149	138	149	140	149	143
Fat, %	5.3	5.3	5.2	5.2	5.1	5.0
Ash, %	5.5	4.8	5.4	4.7	5.2	4.6
Water, %	12.8	11.4	12.8	11.5	12.9	11.5
Phosphorus, g/kg	6.4	6.4	6.3	6.3	6.1	6.1
Dig. phosphorus, g/FUgp[2)]	3.5	3.5	3.4	3.4	3.3	3.3
Calcium, g/kg	7.5	7.9	7.5	7.7	7.5	7.6
Copper, mg/kg[2)]	140	138	140	138	140	137
Copper, mg/kg (control)[3)]		139		141		137
Zinc, mg/kg[2)]	2421	2404	1551	1554	100	137
Zinc, mg/kg (control)[3)]		2380		1583		155
Phytase activity, FTU/kg[1)]	1000	1272	1000	1320	1000	1399
Lysine, g/kg	13.7	12.6	13.7	12.8	13.7	12.9
Dig. lysine, g/FUgp[2)]	10.5	9.5	10.5	9.6	10.5	9.8
Methionine, g/kg	4.3	3.9	4.3	3.9	4.3	3.9
Dig. methionine, g/FUgp[2)]	3.4	3.0	3.4	3.0	3.4	3.0
Threonine, g/kg	8.8	8.2	8.8	8.2	8.8	8.2
Dig. threonine, g/FUgp[2)]	6.6	6.0	6.6	6.0	6.6	6.1

[1)] Declared = added amount; Analysed = total content

[2)] Based on analysed value of basic diets

[3)] Verification of content, ie. the analysed value of the trial diets. Average of four sampling rounds.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix 4 cont.: Groups 1-3 (9-15 kg)

Declared and analysed nutrient content of trial diets (1, 2 and 3)

Gruppe	1		2		3	
Betegnelse	2.500 Zn		1.500 Zn		0 Zn	
9-15 kg	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg	113.8	115.7	113.8	115.7	113.8	115.7
EDOMi, %	84.5	84.3	84.5	84.3	84.5	84.3
EDOM, %	90.7	90.0	90.7	90.0	90.7	90.0
Crude protein, g/kg	197	195	197	195	197	195
Dig. crude protein, g/FUgp[2)]	150	146	150	146	150	146
Fat, %	5.1	5.0	5.1	5.0	5.1	5.0
Ash, %	5.5	5.0	5.5	5.0	5.5	5.0
Water, %	13.1	11.7	13.1	11.7	13.1	11.7
Phosphorus, g/kg	5.9	6.0	5.9	6.0	5.9	6.0
Dig. phosphorus, g/FUgp[2)]	3.2	3.3	3.2	3.3	3.2	3.3
Calcium, g/kg	8.5	8.7	8.5	8.7	8.5	8.7
Copper, mg/kg[2)]	140	137	140	137	140	137
Copper, mg/kg (control)[3)]		126		130		129
Zinc, mg/kg[2)]	100	143	100	143	100	143
Zinc, mg/kg (control)[3)]		140		144		143
Phytase activity, FTU/kg[1)]	1000	1444	1000	1382	1000	1444
Lysine, g/kg	13.5	13.2	13.5	13.2	13.5	13.2
Dig. lysine, g/FUgp[2)]	10.5	10.2	10.5	10.2	10.5	10.2
Methionine, g/kg	4.2	4.0	4.2	4.0	4.2	4.0
Dig. methionine, g/FUgp[2)]	3.4	3.2	3.4	3.2	3.4	3.2
Threonine, g/kg	8.7	8.4	8.7	8.4	8.7	8.4
Dig. threonine, g/FUgp[2)]	6.6	6.3	6.6	6.3	6.6	6.3

[1)] Declared = added amount; Analysed = total content

[2)] Based on analysed value of basic diets

[3)] Verification of content, ie. the analysed value of the trial diets. Average of four sampling rounds.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix 4 cont.: Groups 1-3 (15-30 kg)

Declared and analysed nutrient content of trial diets (1, 2 and 3).

Group	1		2		3	
Name	2.500 Zn		1.500 Zn		0 Zn	
15-30 kg	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg	112.2	114.5	112.2	114.5	112.2	114.5
EDOMi, %	84.2	83.9	84.2	83.9	84.2	83.9
EDOM, %	90.8	90.1	90.8	90.1	90.8	90.1
Crude protein, g/kg	196	198	196	198	196	198
Dig. crude protein, g/FUgp[2)]	150	149	150	149	150	149
Fat, %	5.1	5.0	5.1	5.0	5.1	5.0
Ash, %	5.9	5.4	5.9	5.4	5.9	5.4
Water, %	13.3	11.8	13.3	11.8	13.3	11.8
Phosphorus, g/kg	5.6	5.9	5.6	5.9	5.6	5.9
Dig. phosphorus, g/FUgp[2)]	3.1	3.2	3.1	3.2	3.1	3.2
Calcium, g/kg	9.6	9.9	9.6	9.9	9.6	9.9
Copper, mg/kg[2)]	140	137	140	137	140	137
Copper, mg/kg (control)[3)]		129		127		132
Zinc, mg/kg[2)]	100	148	100	148	100	148
Zinc, mg/kg (control)[3)]		144		143		144
Phytase activity, FTU/kg[1)]	1000	1488	1000	1488	1000	1488
Lysine, g/kg	13.2	13.5	13.2	13.5	13.2	13.5
Dig. lysine, g/FUgp[2)]	10.5	10.5	10.5	10.5	10.5	10.5
Methionine, g/kg	4.1	4.1	4.1	4.1	4.1	4.1
Dig. methionine, g/FUgp[2)]	3.4	3.3	3.4	3.3	3.4	3.3
Threonine, g/kg	8.6	8.7	8.6	8.7	8.6	8.7
Dig. threonine, g/FUgp[2)]	6.6	6.5	6.6	6.5	6.6	6.5

[1)] Declared = added amount; Analysed = total content

[2)] Based on analysed value of basic diets

[3)] Verification of content, ie. the analysed value of the trial diets. Average of four sampling rounds.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix 4 cont.: Groups 4-6 (7-9 kg)

Declared and analysed nutrient content of trial diets (4, 5 and 6).

Group	4		5		6	
Name	OceanFeed		MiyaGold		GærPlus	
7-9 kg	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg	115.2	117.0	115.4	117.0	115.4	117.8
EDOMi, %	84.5	84.6	84.9	84.8	84.9	84.7
EDOM, %	90.5	89.7	90.5	89.8	90.5	89.9
Crude protein, g/kg	198	190	199	191	198	191
Dig. crude protein, g/FUgp[2)]	149	141	150	142	149	141
Fat, %	5.4	5.3	5.2	5.1	5.4	5.3
Ash, %	5.6	5.0	5.2	4.6	5.3	4.7
Water, %	12.8	11.5	13.0	11.5	13.2	11.4
Phosphorus, g/kg	6.1	6.0	6.1	6.0	6.1	6.1
Dig. phosphorus, g/FUgp[2)]	3.3	3.2	3.3	3.3	3.3	3.3
Calcium, g/kg	7.5	7.5	7.5	7.4	7.5	7.6
Copper, mg/kg[2)]	140	136	140	135	140	136
Copper, mg/kg (control)[3)]		133		138		151
Zinc, mg/kg[2)]	100	144	100	138	100	149
Zinc, mg/kg (kontrol)[3)]		154		150		168
Phytase activity, FTU/kg[1)]	1000	1353	1000	1396	1000	1420
Lysine, g/kg	13.7	12.8	13.7	12.9	13.7	12.9
Dig. lysine, g/FUgp[2)]	10.5	9.7	10.5	9.7	10.5	9.7
Methionine, g/kg	4.3	3.9	4.3	3.9	4.3	3.9
Dig. methionine, g/FUgp[2)]	3.4	3.0	3.4	3.0	3.4	3.0
Threonine, g/kg	8.8	8.1	8.9	8.1	8.8	8.2
Dig. threonine, g/FUgp[2)]	6.6	6.0	6.6	6.0	6.6	6.0

[1)] Declared = added amount; Analysed = total content

[2)] Based on analysed value of basic diets

[3)] Verification of content, ie. the analysed value of the trial diets. Average of four sampling rounds.

EDOMi = Enzyme Digestible Organic Matter at ileum

EDOM = Enzyme Digestible Organic Matter

Appendix 4 cont.: Groups 4-6 (9-15 kg)

Declared and analysed nutrient content of trial diets (4, 5 and 6).

Group	4		5		6	
Name	OceanFeed		MiyaGold		GærPlus	
9-15 kg	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg	113.6	115.7	113.8	115.8	113.8	116.5
EDOMi, %	84.1	84.2	84.5	84.3	84.5	84.3
EDOM, %	90.7	89.8	90.7	90.0	90.7	90.0
Crude protein, g/kg	197	193	198	194	197	193
Dig. crude protein, g/FUgp[2)]	150	144	150	145	150	144
Fat, %	5.4	5.3	5.1	5.1	5.4	5.3
Ash, %	6.0	5.4	5.5	5.0	5.7	5.1
Water, %	13.0	11.6	13.1	11.6	13.4	11.6
Phosphorus, g/kg	5.8	5.9	5.8	6.0	5.8	6.0
Dig. phosphorus, g/FUgp[2)]	3.2	3.2	3.2	3.2	3.2	3.2
Calcium, g/kg	8.5	8.7	8.5	8.7	8.5	8.7
Copper, mg/kg[2)]	140	137	140	136	140	136
Copper, mg/kg (control)[3)]		124		135		125
Zinc, mg/kg[2)]	100	150	100	143	100	155
Zinc, mg/kg (control)[3)]		144		140		149
Phytase activity, FTU/kg[1)]	1000	1398	1000	1442	1000	1464
Lysine, g/kg	13.5	13.1	13.5	13.2	13.5	13.1
Dig. lysine, g/FEsv[2)]	10.5	10.1	10.5	10.1	10.5	10.1
Methionine, g/kg	4.2	4.0	4.2	4.0	4.2	4.0
Dig. methionine, g/FEsv[2)]	3.4	3.1	3.4	3.1	3.4	3.1
Threonine, g/kg	8.7	8.3	8.7	8.4	8.7	8.4
Dig. threonine, g/FUgp[2)]	6.6	6.2	6.6	6.3	6.6	6.2

[1)] Declared = added amount; Analysed = total content

[2)] Based on analysed value of basic diets

[3)] Verification of content, ie. the analysed value of the trial diets. Average of four sampling rounds.

EDOMi = Enzyme Digestible Organic Matter at ileum

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Appendix 4 cont.: Groups 4-6 (15-30 kg)

Declared and analysed nutrient content of trial diets (4, 5 and 6).

Group	4		5		6	
Name	OceanFeed		MiyaGold		GærPlus	
15-30 kg	Declared	Analysed	Declared	Analysed	Declared	Analysed
FUgp per 100 kg	112.0	114.5	112.2	114.5	112.2	114.9
EDOMi, %	83.8	83.7	84.2	83.9	84.2	83.9
EDOM, %	90.8	89.9	90.8	90.1	90.8	90.1
Crude protein, g/kg	195	196	196	197	196	197
Dig. crude protein, g/FUgp[2)]	150	147	151	148	150	148
Fat, %	5.4	5.3	5.1	5.0	5.2	5.2
Ash, %	6.3	5.8	5.9	5.4	6.0	5.5
Water, %	13.2	11.8	13.3	11.8	13.4	11.8
Phosphorus, g/kg	5.6	5.9	5.6	5.9	5.6	5.9
Dig. phosphorus, g/FUgp[2)]	3.1	3.2	3.1	3.2	3.1	3.2
Calcium, g/kg	9.5	9.8	9.6	9.9	9.6	9.9
Copper, mg/kg[2)]	140	137	140	137	140	137
Copper, mg/kg (control)[3)]		151		148		148
Zinc, mg/kg[2)]	100	155	100	149	100	154
Zinc, mg/kg (kontrol)[3)]		131		137		127
Phytase activity, FTU/kg[1)]	1000	1442	1000	1487	1000	1498
Lysine, g/kg	13.2	13.4	13.2	13.5	13.2	13.4
Dig. lysine, g/FUgp[2)]	10.5	10.4	10.5	10.5	10.5	10.5
Methionine, g/kg	4.1	4.0	4.1	4.1	4.1	4.1
Dig. methionine, g/FUgp[2)]	3.4	3.2	3.4	3.3	3.4	3.2
Threonine, g/kg	8.6	8.6	8.6	8.6	8.6	8.6
Dig. threonine, g/FUgp[2)]	6.6	6.4	6.6	6.5	6.6	6.5

[1)] Declared = added amount; Analysed = total content

[2)] Based on analysed value of basic diets

[3)] Verification of content, ie. the analysed value of the trial diets. Average of four sampling rounds.

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Appendix 5

Analysis of OceanFeed Swine (seaweed).

Analyses of seaweed (Eurofins)	Seaweed 1	Seaweed 2	Average
Arsenic, mg/kg	26	21	23
Water, %	11.7	14.2	12.9
Crude protein, %	9.1	7.9	8.5
Fat, %	0.8	1.1	0.9
Ash, pct.	43.8	43.1	43.4
Carbohydrates, %	34.6	33.8	34.2
EDOSi, sugar beet pellets	31.2	31.2	31.2
EDOM, sugar beet pellets	87.6	87.6	87.6
FUgp	18.2	18.2	18.2
Calcium, g/kg	32	47	40
Iron, mg/kg	5,860	2,070	3,965
Copper, mg/kg	6.9	4.9	5.9
Phosphorus, g/kg	1.4	0.9	1.1
Dig. phosphorus, g/kg	0.7	0.5	0.6
Potassium, g/kg	42	24	33
Zinc, mg/kg	21	10	15
Magnesium, g/kg	14	15	15
Sodium, g/kg	28	26	27
Manganese, mg/kg	1,248	374	811
Lysine, g/kg	3.0	3.1	3.0
Dig. lysine, g/kg	1.5	1.5	1.5
Methionine, g/kg	1.3	1.4	1.3
Dig. methionine, g/kg	0.6	0.7	0.7
Threonine, g/kg	3.5	3.7	3.6
Dig. threonine, g/kg	1.8	1.9	1.8
Tryptophan, g/kg	0.9	1.1	1.0
Dig. tryptophan, g/kg	0.4	0.5	0.5
Valine, g/kg	4.1	4.3	4.2
Dig. valine, g/kg	2.0	2.1	2.1

Analysis of bioactive compounds (JHG Analytical Services, Ireland)			
% of product	Seaweed 1	Seaweed 2	Average
Mannitol	10.0	9.4	9.7
Alginine	13.6	14.5	14.0
Laminarin	9.1	8.2	8.7
Fucoidan	3.8	3.6	3.7
Rhamnose sulphate	15.0	12.4	13.7
Fucoxanthin	0.2	0.3	0.3

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