0.5% BENZOIC ACID CAN REPLACE COPPER IN FEED FOR WEANED PIGS

TRIAL REPORT NO. 1065

The addition of 0.5% benzoic acid results in the same production value as 1% benzoic acid in combination with 20 ppm copper in feed for weaned pigs. Both levels of benzoic acid result in the same production value as feed containing 150 ppm copper.

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Abstract

It is possible to lower the content of copper in feed for weaned pigs to 20-30 ppm provided minimum 0.5% benzoic acid is also added to the feed. This is the outcome of a trial performed at Experimental station Grønhøj.

Results show that the production value of weaned pigs given 1% and 0.5% benzoic acid in combination with a low content of copper (20-30 ppm) did not differ significantly from the pigs fed a conventional diet with a high content of copper (150 ppm). The level of treatments for disease and diarrhoea did not differ regardless of whether the feed contained 1% or 0.5% benzoic acid and was close to that of the pigs given feed with a high content of copper.

The pigs given feed with a low content of copper and no benzoic acid had a lower production value than the pigs fed any of the other diets. The number of treatments for diarrhoea was also higher in this group.

The addition of 0.5% benzoic acid costs roughly DKK 6 per 100 kg feed, whereas an increase in copper from 20 to 150 ppm only costs roughly DKK 1.50 per 100 kg feed.

Background

A report published by Aarhus University in October 2015 concluded that zinc and copper levels in soils are increasing and the report attributes this increase to the spreading of slurry from pig farming. This underlines the importance of finding alternatives that may allow a reduction in the use of copper as well as zinc in pig feed.

The addition of copper and zinc to feed for weaned pigs affects the frequency of diarrhoea and the pigs' overall performance. Research shows that the addition of 90-175 ppm copper to feed improves gain and feed intake significantly for weaned pigs in the weight interval 5-25 kg, whereas feed conversion improves only slightly or remains unaffected [1], [2]. The effect of copper is attributed to an antibacterial effect in the pigs' intestines [1].

Feed for pigs up to 12 weeks post-weaning may contain 170 mg copper per kg feed (170 ppm) [3]. In addition, in Denmark, veterinarians are furthermore allowed to prescribe the addition of 2,500 ppm zinc to feed the first 14 days post-weaning for treatment of post-weaning diarrhoea.

For finishers, the addition of 0.5% and 1% benzoic acid to feed with a normal copper content of 20 ppm was previously seen to significantly increase the production value [4]. Research has also shown a significant increase in productivity when 0.5% benzoic acid was added to feed for weaned pigs with a normal content of copper (150 ppm) [5].

In 2015, a trial demonstrated that a low content of copper of 20 ppm compared with 150 ppm significantly lowered daily gain, lowered FCR and increased the number of treatments for diarrhoea. Results also revealed that 1% benzoic acid made up for the negative effect of lowering copper levels. However, the addition of 1% benzoic acid is expensive compared with the cost price of a lower content of copper [6], and it is therefore relevant to investigate whether it is possible to achieve the same effect of benzoic acid only with a lower concentration.

The aim of this trial was to determine whether the addition of 0.5% and 1% benzoic acid may replace the inclusion of copper in feed for weaned pigs without adversely affecting performance or increasing the frequency of diarrhoea.

Materials and method

Transfer of pigs and implementation

The trial was conducted at Experimental station Grønhøj with weaned pigs purchased from an external supplier. Roughly one third of the pen consisted of solid floor and the remaining two thirds were slatted. Each pen had a feeder and a drinking bowl. The pigs were transferred to the trial when they were four weeks old and weighed about 7 kg and finished in the trial when they were 11 weeks old and weighed roughly 30 kg. Approximately 180 weaned pigs were transferred weekly over a period of 16 weeks. A pen holding either 10 or 15 weaned pigs constituted a trial unit.

Upon transfer to the pens, the pigs were assigned to blocks consisting of the four pens corresponding to the four trial treatments. The pigs were sorted according to gender and weight so that the distribution on gender was identical in each block. There was a maximum difference in average start weight of 0.25 kg between the groups within a block.

Feed and feeding

The trial comprised four groups as shown in table 1. The diets used contained varying inclusion of benzoic acid and copper during the entire trial period from 7 to 30 kg.

Table 1. Trial design. Zinc (Zn) and copper (Cu) are stated as amounts added (ppm per kg).

	Group 1	Group 2	Group 3	Group 4
	Control	Negative control	1% benzoic acid	0.5% benzoic acid
7 - 9.5 kg	150 Cu 2,500 Zn	20 Cu 2,500 Zn	20 Cu 2,500 Zn 1% benzoic acid	20 Cu 2,500 Zn 0.5% benzoic acid
9.5 - 30 kg	150 Cu 100 Zn	20 Cu 100 Zn	20 Cu 100 Zn 1% benzoic acid	20 Cu 100 Zn 0.5% benzoic acid

The trial included roughly 720 pigs per group and 56 replicates. All pigs were fed a starter diet containing 2,500 ppm zinc; this diet was used for minimum the six days post-weaning and maximum 14 days post-weaning. The pigs that had reached an average weight of 9.5 kg after six days gradually switched to the weaner diet. The pigs had ad lib access to feed via one feeder per pen and had access to water 24 hours a day.

The diets complied with the current nutrient standards for feed for weaned pigs in the weight intervals 7-9.5 kg and 9.5-30 kg. The diets were identical in composition with the exception of the content of copper and zinc. The feed was pelleted and was produced at Danish Agro's facilities in Sjølund.

Analyses of feed

Feed samples were routinely collected during the production using the automatic sampling equipment available at the production facilities. If a diet consisted of multiple charges, samples were taken of each charge and the individual samples were subsequently pooled into one sample. To ensure that all samples were representative, a sample divider was used for collecting feed samples from the pooled sample. At each production round, one sample was stored at minimum 0°C and the remaining samples forwarded to Eurofins Steins Laboratory for analysis.

The diets were analysed for energy, protein, calcium, phosphorus, phytase activity, zinc and all essential amino acids. The diets were also analysed for copper and benzoic acid.

Recordings

Data included recordings of dead pigs and relocated/culled pigs; feed conversion ratios in the periods 7-9.5 kg and 9.5-30 kg; and the weight and number of pigs at weaning (~7 kg), at first intermediate weighing (~9.5 kg) and upon departure from the weaner facility.

Disease

The pigs did not receive preventive treatments with antibiotics for digestive disorders such as diarrhoea, Lawsonia, Salmonella and dysentery. Treatments for disease were calculated as total number of treatment days.

Statistics

The production value (PV) is stated in Danish Kroner per pig place per day and calculated as:
PV = (value of gain – feed costs) / productive days.

The variables: ”feed consumption per day”, ”feed conversion per kg gain”, ”daily gain” and ”production value per pig/day” were analysed for three separate periods (7–9.5 kg, 9.5-30 kg and 7-30 kg).

The feed conversion was calculated on the basis of the analysed feed units.

The above variables were subject to analysis with proc mixed in SAS with”group” as fixed effect. ”Block” was included as random effect and in all analyses correction was made for start weight. Where significant effect of “group” is observed, comparisons in pairs from ”LSmeans statement” are reported. Bonferroni correction was performed during the comparison.

The variables ”dead” and ”dead and culled” were subject to logistic regression using proc glimmixed in SAS with ”group” as fixed effect. “Block” was included as random effect and correction was made for start weight. Where significant effect of “group” is observed, the difference is reported with odds-ratio from “LSmeans statement”. Bonferroni correction was performed during the comparison.

The variable ”pens treated” was subject to logistic regression using proc glimmixed in SAS with ”benzoic acid” and ”copper” as random effects. “Block” was included as random effect and correction was made for start weight.

The variables ”days treatment for diarrhoea / productive days” were subject to logistic regression using proc glimmixed i SAS with “benzoic acid” and “copper” as fixed effects. Interaction was observed between the two factors. The model also includes a factor for whether the pen has received group-treatment and correction is made for start weight. “Block” is included as random effect. Correction was made for overdispersion.

Results and discussion

Analysis of nutrients

Analyses of the feed, shown in appendix 1, confirm good agreement between the analysed content and the declared content. This also applies to the content of benzoic acid and copper, though analyses revealed an average content of 120 ppm copper versus 150 ppm as planned. Research has previously demonstrated a growth-promoting effect at 90 ppm copper and confirmed that this effect is the same in the interval 90-165 ppm [2].

It must be noted that the lysine content in the starter feed in group 1 is 11% below the declared content. However, the declared content in this diet was higher than in the other diets. Analyses of lysine revealed an 8% lysine deficiency in group 1 compared with the highest value of the three other diets. The starter feed only constitutes a limited part of the feed in the entire period, and this deficiency is therefore not believed to affect the outcome of the trial.

Production results

The production results are shown in table 2 and selected results are illustrated in figures 1-3.

The pigs in group 2 had a significantly lower daily gain compared with the pigs in the other groups for the entire trial period (7-30 kg) as shown in figure 1. The pigs in group 3, given the highest inclusion of benzoic acid, had the highest feed intake.

Results showed no significant differences in feed conversion per kg gain between groups 1, 2 and 4 and groups 2, 3 and 4. The only difference was observed between group 1 and group 3 where the pigs in group 3 had a significantly higher feed conversion per kg gain, as shown in figure 2.

The production value (PV) for the entire growth period is illustrated in figure 3 in which it is clear that the production value was significantly lower in group 2 (low copper, no benzoic acid) than in the other three groups. Data revealed no significant differences between groups 1, 3 and 4.

Table 2. Production results and production value per pig place/day.

Group	1	2	3	4	P value
Benzoic acid, %	0	0	1	0,5	
Copper, ppm	150	20	20	20	
7 to 9.5 kg:					
Daily gain, g	166 a	129 b	162 a	167 a	<0.0001
Feed intake, FUgp /pig/day	0.25 a	0.22 b	0.24 a	0.24 a	<0.0001
FCR/kg gain	1.53 a	1.78 b	1.53 a	1.50 a	<0.0001
9.5 to 30 kg:					
Daily gain, g	616 a	593 b	631 a	615 a	0.0009
Feed intake, FUgp /pig/day	1.01 b	0.96 c	1.05 a	1.02 b	<0.0001
FCR/kg gain	1.64 bc	1.64 c	1.68 a	1.66 ab	<0.0001
Entire trial period, 7 to 30 kg:					
Mortality, %	0.35	0.54	0.27	0.27	0.813
Daily gain, g	485 a	460 b	495 a	486 a	<0.0001
Feed intake, FUgp /pig/day	0.79 b	0.75 c	0.82 a	0.80 b	<0.0001
FCR/kg gain	1.63 b	1.64 ab	1.66 a	1.64 ab	0.0022
Copper supplied per finished pig, g	5.2	0.7	0.7	0.7	
Production value (PV), DKK/pig place/day					
PV: 7-9.5 kg	0.20 a	0.07 b	0.21 a	0.22 a	<0.0001
PV: 9.5-30 kg	2.03 ab	1.97 b	2.04 a	2.01 ab	0.040
PV: 7-30 kg	1.49 a	1.41 b	1.50 a	1.48 a	<0.0001
PV index	100	95	101	100	

Different superscripts denote significant differences ($P < 0.05$).

The least certain difference in index was estimated at 3.3 index points.

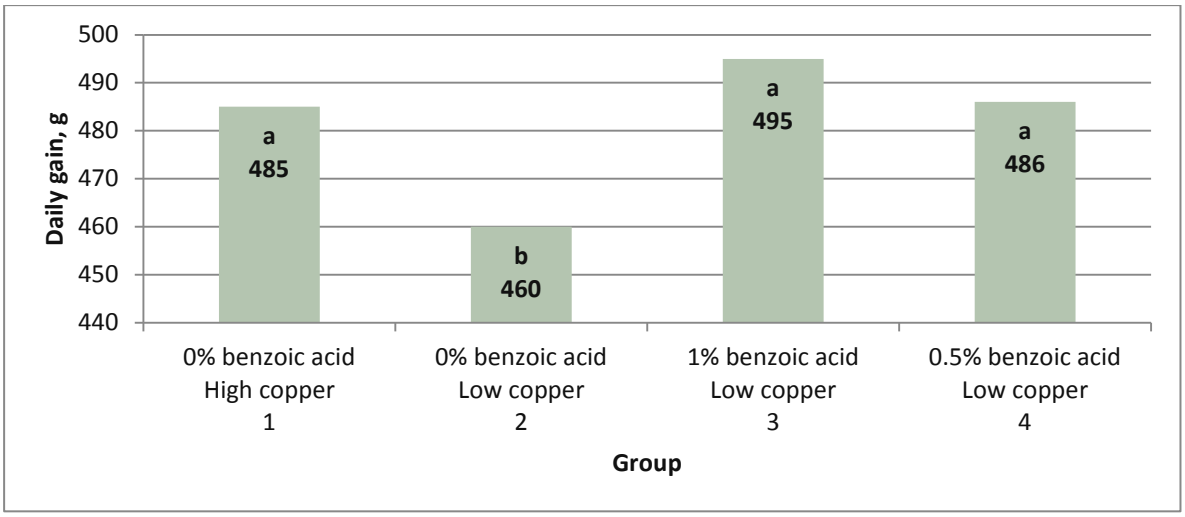

Figure 1. Daily gain, g, in the period 7-30 kg

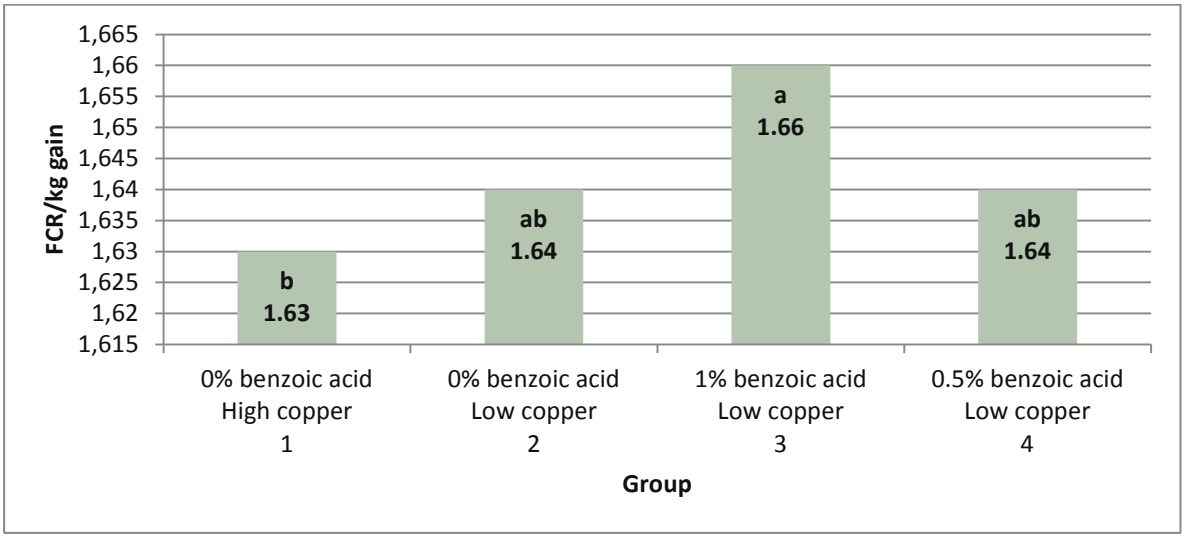

Figure 2. Feed conversion ratio in feed units (FUGp) per kg gain, 7-30 kg

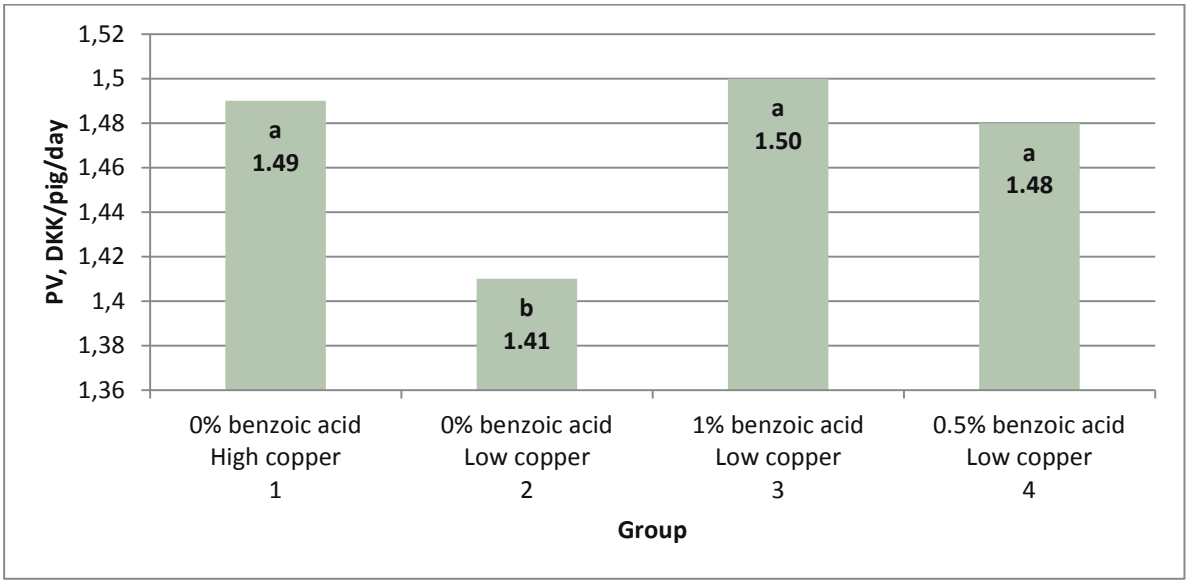

Figure 3. Production value (PV) in DKK per pig/day, 7-30 kg

Health

Mortality rates did not differ between the groups. There were no significant differences in the number of pens that received group-treatment.

However, the frequency of treatments for diarrhoea was significantly higher in group 2 (no benzoic acid, low copper) than in group 3 (1% benzoic acid, low copper), as shown in table 3.

Table 3. Treatments for disease in the period 7-30 kg.

Group	1	2	3	4	P value
Benzoic acid, %	0	0	1	0,5	
Copper, ppm	150	20	20	20	
Pens	70	56	56	56	
% pens where group-treatment was administered	83	93	86	83	0.255
% days one pig was treated for diarrhoea	1.5 ab	2.0 b	1.0 a	1.4 ab	<0.0001

Different superscripts denote significant differences ($P < 0.05$).

Conclusion

The production value was identical for the pigs in groups 1, 3 and 4 given either a high level of copper (analysed content of 120 ppm) or 0.5% or 1% benzoic acid in their feed.

The pigs in group 2 given a low content of copper of around 40 ppm and no benzoic acid had a significantly poorer production value than the pigs in the other groups.

The number of treatments for diarrhoea, measured as per cent days individual pigs were treated, was significantly higher in group 2 than the other three groups. The lowest frequency of treatments was observed in group 3 where the feed contained 1.0% benzoic acid. The difference between group 2 and group 3 was significant.

Overall, this trial demonstrates that it is possible to lower the content of copper to 20-30 ppm without adversely affecting pig performance or without an increase in diarrhoea outbreaks provided minimum 0.5% benzoic acid is also added to the feed.

References

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Appendix 1

Group 1

Table 4. Analysed and declared nutrient values in the diets used in group 1

	Starter diet, 7-9.5 kg		Weaner diet, 9.5-30 kg	
Ingredient	**Analysed**	**Declared**	**Analysed**	**Declared**
Crude protein, %	20.7 (8)	20.9	18.8 (9)	18.4
Fat, %	4.3 (8)	4.3	3.9 (9)	3.9
Ash, %	5.1 (8)	6.0	5.4 (9)	6.0
Water, %	10.3 (8)	14.0	11.8 (9)	14.0
EDOM pigs, %*	92.3 (8)	-	89.8 (9)	-
$EDOM_i$, %**	87.4 (2)	-	83.0 (9)	-
Feed units per 100 kg	119.8 (2)	121	110.9 (9)	109
Phytase activity, FTU kg	1,376.1 (8)	1,000	2,117.1 (9)	1,000
Calcium, g/kg	8.3 (8)	7.8	8.8 (9)	8.7
Phosphorus, g/kg	6.6 (8)	6.8	5.6 (9)	5.4
Copper, mg/kg [1]	121.5 (8)	170.0	120.8 (9)	170.0
Zinc, mg/kg [2]	2,329.9 (8)	2,500	220.1 (9)	100
Benzoic acid, mg/kg	-	0.0	18.1 (1)	0.0
Lysine, g/kg	15.3 (7)	17.2	12.8 (9)	12.8
Methionine, g/kg	4.4 (7)	4.9	3.8 (9)	4.0
Met + cys, g/kg	3.2 (7)	-	3.1 (9)	-
Threonine, g/kg	8.9 (7)	-	7.9 (9)	-
Tryptophan, g/kg	-	-	2.7 (9)	-
Valine, g/kg	10.4 (2)	-	8.8 (9)	-

Number of analyses shown in paranthesis

[1] Declared as copper sulphate, pentahydrate

[2] Declared as zinc oxide

* EDOM = Enzyme Digestible Organic Matter

** EDOMi = Enzyme Digestible Organic Matter at ileum

Group 2

Table 5. Analysed and declared nutrient values in the diets used in group 2

	Starter diet 7-9.5 kg		Weaner diet 9.5-30 kg	
Ingredient	**Analysed**	**Declared**	**Analysed**	**Declared**
Crude protein, %	20.8 (6)	20.9	19.1 (9)	18.4
Fat, %	4.3 (6)	4.3	3.9 (9)	3.8
Ash, %	5.0 (6)	5.9	5.3 (9)	5.9
Water, %	9.9 (6)	14.0	11.8 (9)	14.0
EDOM pigs, %*	92.5 (6)	-	90.4 (9)	-
$EDOM_i$, %**	87.8 (2)	-	83.4 (9)	-
Feed units per 100 kg	121.5 (2)	121	111.4 (9)	109
Phytase activity, FTU kg	1,284.3 (6)	1,000	1,658.4 (9)	1,000
Calcium, g/kg	9.2 (6)	7.8	9.0 (9)	8.7
Phosphorus, g/kg	6.6 (6)	6.8	5.6 (9)	5.4
Copper, mg/kg [1]	44.3 (6)	20.0	39.3 (9)	20.0
Zinc, mg/kg [2]	2,171.3 (6)	2,500	186.2 (9)	100
Benzoic acid, mg/kg	-	0.0	9.6 (1)	0.0
Lysine, g/kg	16.1 (6)	16.7	13.1 (9)	12.8
Methionine, g/kg	4.4 (6)	4.9	4.0 (9)	4.0
Met + cys, g/kg	3.2 (6)	-	3.0 (9)	-
Threonine, g/kg	9.4 (6)	-	8.1 (9)	-
Tryptophan, g/kg	2.9 (2)		2.8 (9)	
Valine, g/kg	10.9 (2)	-	8.7 (9)	-

Number of analyses shown in parenthesis

[1] Declared as copper sulphate, pentahydrate

[2] Declared as zinc oxide

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Group 3

Table 6. Analysed and declared nutrient values in the diets used in group 3

	Starter diet 7-9.5 kg		Weaner diet 9.5-30 kg	
Ingredient	**Analysed**	**Declared**	**Analysed**	**Declared**
Crude protein, %	21.4 (8)	20.9	18.8 (9)	18.4
Fat, %	4.2 (8)	4.3	4.0 (9)	3.9
Ash, %	5.0 (8)	5.9	5.4 (9)	5.9
Water, %	10.0 (8)	14.0	11.5 (9)	14.0
EDOM pig, %*	92.6 (8)	-	89.3 (9)	-
$EDOM_i$, %**	88.7 (2)	-	83.3 (9)	-
Feed units per 100 kg	122.4 (2)	121	111.6 (9)	109
Phytase activity, FTU kg	1,163.0 (6)	1,000	1,639.9 (9)	1,000
Calcium, g/kg	9.5 (6)	7.80	9.4 (9)	8.7
Phosphorus, g/kg	6.8 (6)	6.80	5.4 (9)	5.4
Copper, mg/kg [1]	29.0 (6)	20.0	26.6 (9)	20.0
Zinc, mg/kg [2]	3,156.0 (6)	2,500	183.4 (9)	100
Benzoic acid, mg/kg	8,523.3 (6)	10,000	8,941.7 (6)	10,000
Lysine, g/kg	16.7 (8)	16.8	12.8 (9)	12.8
Methionine, g/kg	4.8 (8)	4.9	3.9 (9)	4.0
Met + cys, g/kg	3.3 (8)	-	3.1 (9)	-
Threonine, g/kg	9.8 (8)	-	8.0 (9)	-
Tryptophan, g/kg	-		2.7 (9)	
Valine, g/kg	11.5 (2)	-	8.6 (9)	-

Number of analyses shown in parenthesis

[1] Declared as copper sulphate, pentahydrate

[2] Declared as zinc oxide

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Group 4

Table 7. Analysed and declared nutrient values in the diets used in group 4

	Starter diet 7- 9.5 kg		Weaner diet 9.5- 30 kg	
Ingredient	**Analysed**	**Declared**	**Analysed**	**Declared**
Crude protein, %	21.2 (7)	20.9	18.8 (9)	18.4
Fat, %	4.3 (7)	4.3	4.0 (9)	3.8
Ash, %	5.0 (7)	5.9	5.5 (9)	5.9
Water, %	10.1 (7)	14.0	11.8 (9)	14.0
EDOM pigs, %*	92.4 (8)	-	90.1 (9)	-
$EDOM_i$, %**	87.8 (2)	-	83.4 (9)	-
Feed units per 100 kg	120.5 (1)	121	111.5 (9)	109
Phytase activity, FTU kg	1,019.7 (6)	1,000	1,513.4 (9)	1,000
Calcium, g/kg	9.2 (6)	7.80	9.2 (9)	8.7
Phosphorus, g/kg	6.8 (6)	6.80	5.5 (9)	5.4
Copper, mg/kg [1]	29.8 (6)	20.0	26.0 (9)	20.0
Zinc, mg/kg [2]	2,455.2 (6)	2,500	204.3 (9)	100
Benzoic acid, mg/kg	4,453.3 (6)	5,000	4,580.0 (5)	5,000
Lysine, g/kg	16.5 (7)	16.7	13.0 (9)	12.8
Methionine, g/kg	4.6 (7)	4.9	3.9 (9)	4.0
Met + cys, g/kg	3.3 (7)	-	3.1 (9)	-
Threonine, g/kg	9.6 (7)	-	8.1 (9)	-
Tryptophan, g/kg	3.1 (2)		2.7 (9)	
Valine, g/kg	10.9 (1)	-	8.7 (9)	-

Number of analyses shown in paranthesis

[1] Declared as copper sulphate, pentahydrate

[2] Declared as zinc oxide

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