BENZOIC ACID AS REPLACEMENT FOR COPPER IN FEED FOR WEANED PIGS

TRIAL REPORT NO. 1057

A low content of copper in feed for weaned pigs lowers performance, but this is offset by the addition of 1% benzoic acid.

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Abstract

Weaned pigs fed a diet containing 1% benzoic acid had the same high productivity as the pigs fed a diet with a high content of copper (150 mg Cu/kg) or 1% benzoic acid in combination with a high content of copper.

However, the pigs given 20 mg Cu/kg (low content) had a significantly poorer productivity than the pigs in the other three groups. This demonstrates that benzoic acid can replace a high content of copper, and this applied to all three growth intervals 7-9 kg, 7-20 kg and 7-30 kg.

The addition of 2500 ppm zinc to the feed the first two weeks post-weaning did not prevent the drop in productivity when the pigs were fed a diet with a low copper content. The productivity of the pigs fed a high content of copper was not further affected by the addition of 1% benzoic acid.

Pigs fed a diet with a low content of copper had a lower production value. More group treatments for diarrhoea were administered among these pigs and the average treatment period per pigs was longer in this group.

The trial was conducted at experimental station Grønhøj and comprised four groups given varying levels of copper and benzoic acid.

Background

Research shows that the addition of 90-175 ppm copper to pig feed improves gain and feed intake significantly among weaned pigs in the weight interval 5-25 kg, whereas the feed conversion ratio improves only slightly or remains unaffected [1], [4]. However, some results indicate that the effect of copper is neutralized when 2,500 ppm zinc is added to the feed just after weaning [2].

According to current EU legislation, pig feed used up to week 12 post-weaning can contain maximum 170 mg Cu/kg feed. In Denmark, veterinarians are furthermore allowed to prescribe the addition of 2,500 ppm zinc to the feed for up to 14 days post-weaning for treatment of post-weaning diarrhoea. Heavy metals, such as copper and zinc, may accumulate in soil during the spreading of slurry, and it is therefore highly desirable to find alternative additives that may allow a reduction in the use of copper and zinc oxide in pig feed.

Copper has an antibacterial effect in pigs' intestines which is also believed to be the cause of the improved feed conversion and gain seen in pigs given feed containing 90 ppm copper and more [1]. Other products, such as organic acids, may also have an antibacterial effect and could therefore be an alternative to copper in feed for weaned pigs.

The addition of 0.5% and 1% benzoic acid to finisher feed was previously seen to significantly increase the production value because gain as well as FCR improved [3]. A trial made by Pig Research Centre also revealed an increase in productivity when 0.5% benzoic acid was added to feed for weaned pigs [5].

The aim of this trial was to investigate the effect on productivity of lowering the content of copper from 150 to 20 ppm in feed for weaned pigs in the period 7–9 kg when, at the same time, 2,500 ppm zinc or 2,500 ppm zinc in combination with 1% benzoic acid was added to the feed. The effect of lowering the zinc content from 150 to 20 ppm in the period 9-20 kg while at the same time adding 1% benzoic acid was also investigated.

It was also analysed whether the addition of 1% benzoic acid to a diet with a high content of copper would further improve productivity.

Materials and method

Feed and feeding

The trial was conducted at experimental station Grønhøj with weaned pigs purchased from an external supplier. The pigs were transferred to the trial at an average weight of roughly 7 kg and accommodated in pens designed as traditional pens for weaned pigs with one feeder and one drinking bowl in each pen.

The trial included three diets in the growth period 7 to 30 kg (table 2).

The feed for the pigs in the four groups contained varying content of benzoic acid and copper from weaning and until the pigs weighed 20 kg (table 2). It was decided to stop using benzoic acid at 20 kg rather than 30 kg as benzoic acid is a fairly expensive product and in practice it would therefore not be used for pigs above 20 kg.

In the period 20-30 kg the pigs were all fed the same diet containing 150 ppm copper and 100 ppm zinc per kg feed.

Until the first intermediate weighing at roughly 9 kg, the pigs were fed a starter diet containing 2,500 ppm zinc supplied from a feed cart. The feeders were subsequently manually filled to half capacity and the automatic Spotmix feeding system was activated. The pigs then gradually switched from the first weaner diet to the second. After the second intermediate weighing at roughly 20 kg, the pigs were fed a mix of the two weaner diets according to the scheme outlined in table 1.

Table 1. Gradual transition from weaner diet 1 to weaner diet 2

Day after second intermediate weighing	% of weaner diet 9-20 kg	% of weaner diet 20-30 kg
Day 1	33%	67%
Day 2	50%	50%
Day 3	67%	33%
Day 4	0%	100%

The content of copper and benzoic acid in each diet is shown in table 2.

The diets were formulated to comply with the current nutrient standards for weaned pigs in the weight intervals 7-9 kg, 9-15 kg and 15-30 kg with the aim of all diets being identical in terms of nutrient content and differing only in the content of copper and benzoic acid. The feed was pelleted and was produced at Danish Agro's facilities in Sjølund.

Feed samples were routinely collected during the production using the automatic sampling equipment available at the production facilities. In order to obtain a representative sample, one sample was collected from each mix charge and these samples were subsequently pooled into one sample for each diet.

A total of nine diets were used in this trial. The diets used from 20 to 30 kg in all four groups were identical in nutrient content and were therefore pooled into one sample. Each pooled sample was split into a series of samples according to the TOS principles and forwarded for analysis at the Eurofins Steins Laboratory.

The content of copper, benzoic acid, zinc and phytase in the diets was verified by analysing the feed. The diets were also analysed for energy, lysine, methionine, threonine, tryptophan, valine, calcium and phosphorus to confirm that the content of these nutrients did not vary, as variations may affect the outcome of the trial (appendix 1).

Coloured microgrits were added to all diets to be able visually to confirm that each group was given the right diet.

Table 2. Content of copper, zinc and benzoic acid in this trial (ppm per kg).

	Group 1	Group 2	Group 3	Group 4
7-9 kg	150 Cu 2,500 Zn	20 Cu 2,500 Zn	150 Cu 2,500 Zn 1% benzoic acid	20 Cu 2,500 Zn 1% benzoic acid
9-20 kg	150 Cu 100 Zn	20 Cu 100 Zn	150 Cu 100 Zn 1% benzoic acid	20 Cu 100 Zn 1% benzoic acid
20-30 kg	150 Cu 100 Zn	150 Cu 100 Zn	150 Cu 100 Zn	150 Cu 100 Zn

Recordings

The trial comprised roughly 670 pigs in each of the four groups and 58 replicates.

The following recordings were all made at pen level:

- start and end weight used to determine daily gain
- feed intake
- treatment for disease
- dead and culled pigs.

Calculations and statistics

The production results were pooled in a production value, PV, calculated on the basis of:

- value of gain
- feed costs
- productive days.

Feed costs were calculated by using the feed prices of the last five years and the value of 1 kg gain.

This 2×2 factor trial included the two factors “benzoic acid” with the levels “benzoic acid” and “no benzoic acid” and “copper” with the levels “high” or “low”. Feed conversion ratio, feed intake and daily gain were used for calculating the production value. These three key figures constituted the primary trial parametres.

The variables: ”feed intake per day”, ”feed conversion ratio per kg gain”, ”daily gain”, ”production value per pig” and ”production value per pen” were analysed as a 2-factor trial with two levels for each of the factors ”benzoic acid” and ”copper”. Interaction was observed between the two factors. The above variables were subject to analysis in proc mixed in SAS.

The variables ”dead”, ”pen treated” and ”treatment days” were subject to logistic regression in proc glimmixed in SAS.

Six comparisons in pairs were made between the four groups, and the results were subject to Bonferroni correction.

Data from nine pens were excluded from the analysis results due to recording errors.

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 of copper.

The feed used in the period 7-9 kg in group 2 generally had a lower content of protein, amino acids and phosphorus. The lysine content was 6.5% lower than the average content of the other three diets. The feed used in the period 9-20 kg in group 2 had a lower content of lysine and protein (lysine content 3% lower than the average content of the other three diets) while for the remaining amino acids the highest content was found in the feed for group 2.

By applying the trial-based functions that form the basis of determining the amino acid standards, this amino acid deficiency would lead to a loss in daily gain of roughly 5 g and a reduction in feed

conversion ratio of approx. 0.02 feed units/kg gain in the period 7-20 kg. The effect drops slightly in the entire period 7-30 kg.

The outcome of this trial is therefore generally not affected by these differences in nutrient content.

The diets containing benzoic acid were subject to chemical analyses which verified the expected content of benzoic acid.

Production results

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

In the period 7–9 kg, a low content of copper (20 ppm, group 2) resulted in a significantly lower gain and a poorer feed efficiency compared with a high content of copper (150 ppm).

Analyses showed that the daily gain among the pigs in group 4 given feed with a low content of copper and 1% benzoic acid corresponded to the daily gain obtained with a high content of copper. The productivity of the pigs given 1% benzoic acid combined with a high content of copper (group 3) was identical to that of pigs in the control group given a high content of copper.

Overall, the trial demonstrates that a high content of copper can be replaced by 1% benzoic acid. According to this trial, the production results improve with the addition of 150 ppm copper versus 20 ppm copper regardless of whether 2,500 ppm zinc was already added to the feed. This contradicts the tendencies observed in some international studies [2], but is in alignment with a previous trial made by Pig Research Centre [4].

The addition of 1% benzoic acid to feed that has a high content of copper did not further impact gain.

In the periods 7-20 kg and 7-30 kg the impact on daily gain and FCR was identical with the effects observed in all groups in the period 7- 9 kg.

The production value (PV) for the entire growth period 7–30 kg is shown in table 3 and figure 3. PV is significantly lower in group 2 (low copper, no benzoic acid) than in the other three groups.

Table 3. Production results, production value and mortality

Group	1	2	3	4	P value
Benzoic acid, %	0	0	1	1	
Copper, ppm	150	20	150	20	
Period 7-9 kg:					
Mortality, %	0.6 *a*	1.1 *a*	1.5 *a*	1.4 *a*	*0.34*
Daily gain, g	168 *a*	125 *b*	167 *a*	175 *a*	*<0.0001*
Feed intake, FUgp per pig/day	0.27 *b*	0.24 *c*	0.26 *b*	0.29 *a*	*<0.0001*
FCR per kg gain	1.64 *a*	1.97 *b*	1.61 *a*	1.71 *a*	*0.0006*
Period 7-20 kg:					
Mortality, %	3.4 *a*	3.5 *a*	4.5 *a*	2.9 *a*	*0.24*
Daily gain, g	356 *b*	298 *c*	376 *a*	373 *a*	*<0.0001*
Feed intake, FUgp per pig/day	0.58 *b*	0.52 *c*	0.61 *a*	0.61 *a*	*<0.0001*
FCR per kg gain	*1.63 a*	*1.73 b*	*1.63 a*	*1.65 a*	*<0.0001*
Period 7-30 kg:					
Mortality, %	4.1a	4.7 a	6.3 a	4.5 a	0.19
Daily gain, g	461 a	420 b	473 a	471 a	<0.0001
Feed intake, FUgp per pig/day	0.78 b	0.72 c	0.80 ab	0.80 a	<0.0001
FCR per kg gain	1.68 a	1.73 b	1.69 a	1.69 a	0.007
Copper supplied per finished pig, g	5.6	2.7	5.8	2.8	
Economy:					
PV 7-9 kg	0.22 a	0.03 b	0.21 a	0.19 a	<0.0001
PV 7-20 kg	1.01 b	0.78 c	1.06 a	1.02 ab	<0.0001
PV 7-30 kg	1.33 a	1.19 b	1.38 a	1.35 a	0.0002

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

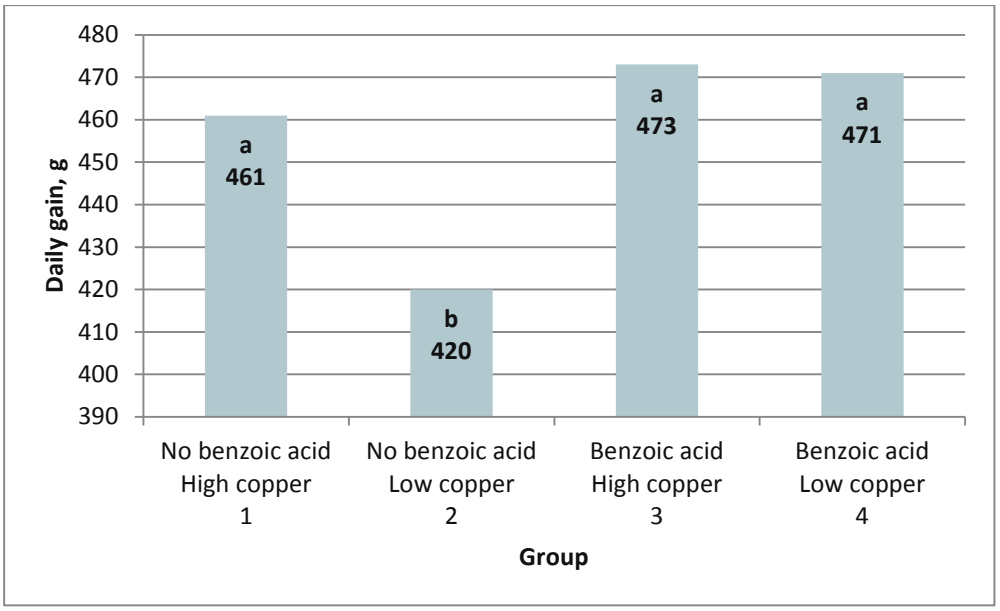

Figure 1. Daily gain, 7–30 kg

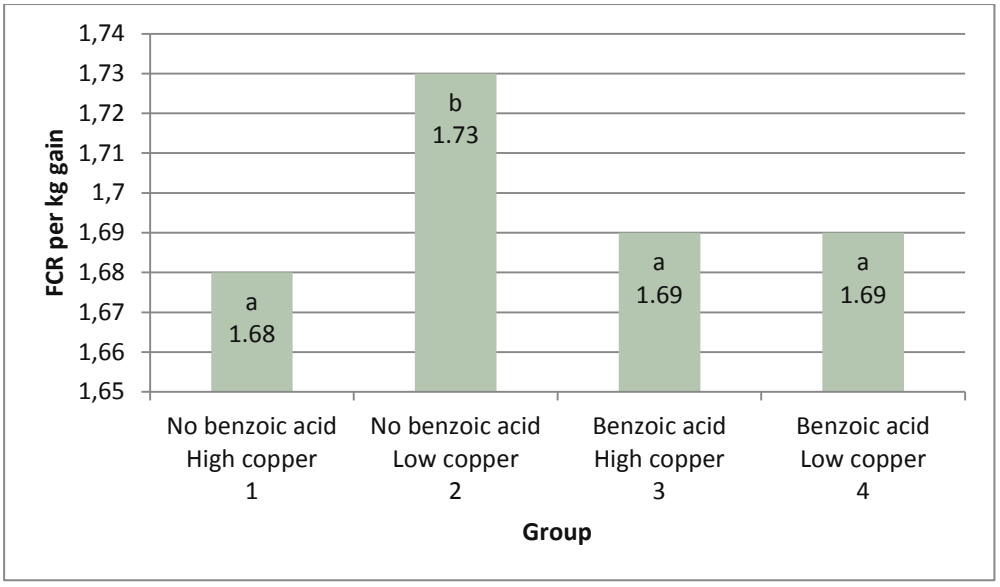

Figure 2. Feed efficiency, 7-30 kg

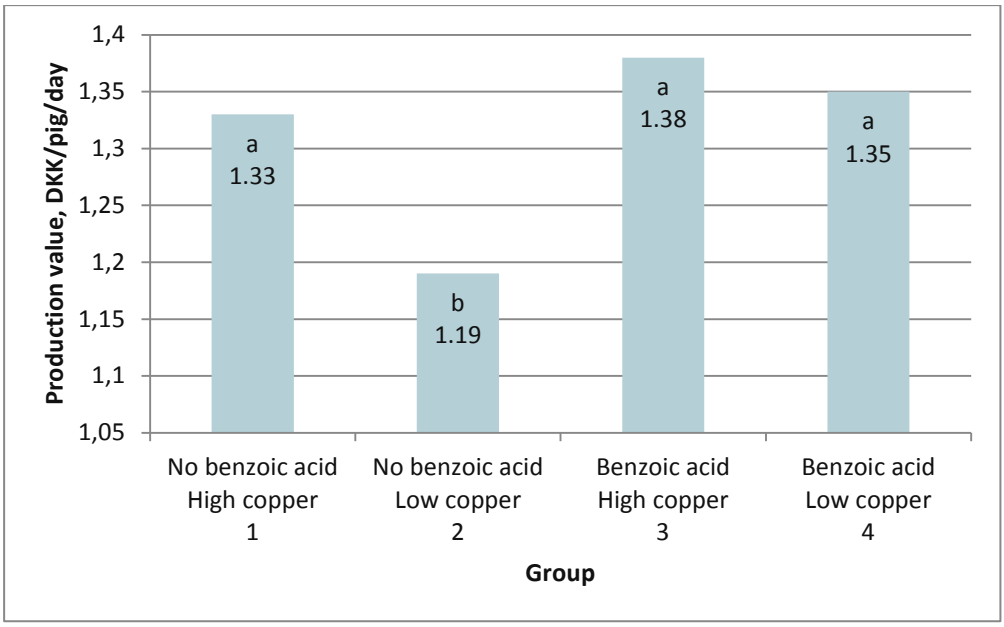

Figure 3. Production value, 7-30 kg.

Health

Analyses did not reveal any differences in mortality between the four groups.

The lowest number of group-treatments was administered in group 3 where the pigs were fed a high content of copper combined with 1% benzoic acid. Significantly more group-treatments were administered in group 1 (no benzoic acid, high copper) compared with the other groups (figure 4).

The effect on health of different diets can also be determined by comparing the percentage of days spent on treatments in each of the four groups. In group 2, with no benzoic acid and a low content of copper, the treatment period was 2-3 times longer than in the remaining groups. This difference is significant (figure 5).

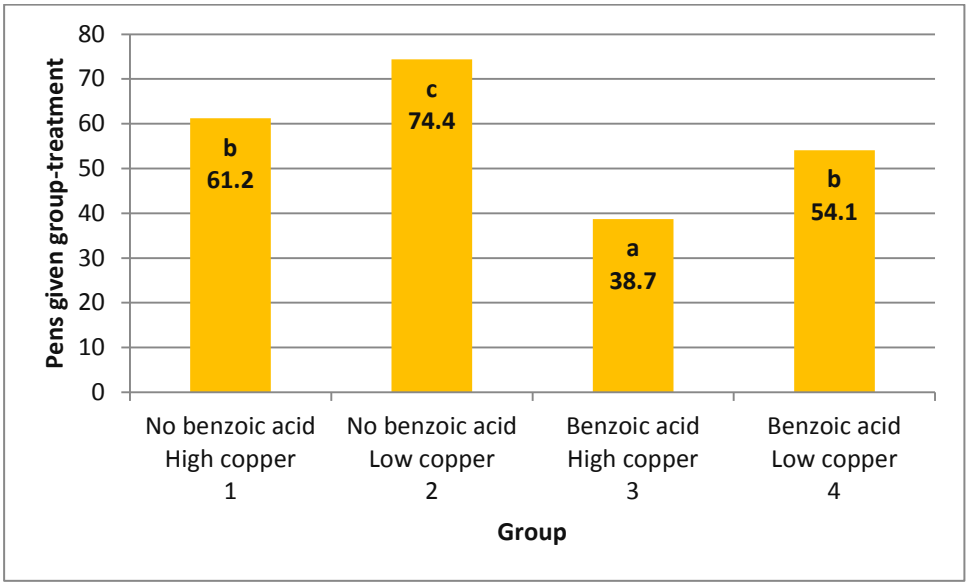

Figure 4. Pens where group-treatment was administered, 7-30 kg, %.

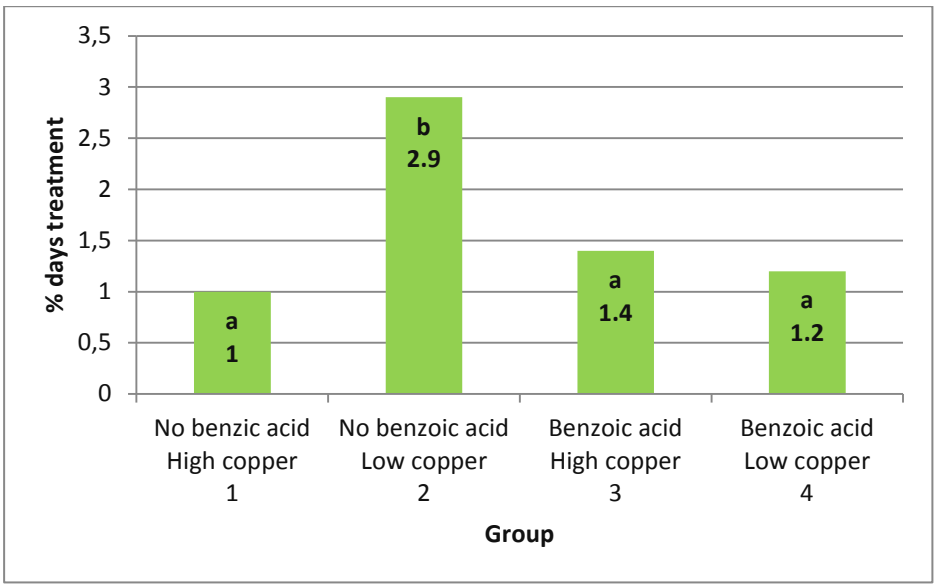

Figure 5. % days when the pigs in the group were treated (7-30 kg).

Conclusion

Weaned pigs fed a diet with a low content of copper (20 mg Cu/kg) and no benzoic acid had a lower gain and poorer FCR than the pigs fed a diet containing either a high content of copper (150 mg Cu/kg), 1% benzoic acid or a combination of the two. This applied to the three growth intervals 7-9 kg, 7-20 kg and 7-30 kg.

The combination of 1% benzoic acid and 150 ppm copper did not lead to a greater increase in productivity either one of the additives alone.

A high inclusion of zinc in the feed used from 7 to 9 kg did not prevent the drop in productivity triggered by a low content of copper in the feed.

References

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Trial no.1302

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Appendix 1

Analysed nutrient content

Feed from 7 to 9 kg

	Group no.			
Ingredient	**1**	**2**	**3**	**4**
[1]Crude protein, %	18.3	17.6	18.5	17.9
[1]Fat, %	4.7	4.7	4.7	4.7
[1]Ash, %	4.9	4.6	4.9	4.8
[1]Water, %	10.6	10.9	10.6	11.1
[1]EDOM, %*	92.3	92.0	92.4	92.2
[1]EDOMi, %**	87.9	87.7	88.1	88.4
[1]FUgp, per 100 kg	121.9	121.9	122.5	122.1
Phytase activity, FTU kg	[2]1,818	[2]1,870	[2]1,308	[3]522.5
[1]Calcium, g/kg	8.08	7.96	8.18	8.09
[1]Phosphorus, g/kg	6.00	5.47	5.56	6.29
[1]Copper, mg/kg	128.5	25.25	136.0	27.00
[1]Zinc, mg/kg	2,371	2,015	2,582	2,655
[1]Lysine, g/kg	14.35	13.63	14.73	14.65
[1]Methionine, g/kg	4.78	4.37	4.71	4.70
[1]Cystine, g/kg	3.18	3.11	3.18	3.18
[1]Met + cys, g/kg	7.96	7.49	7.89	7.88
[1]Threonine, g/kg	9.50	8.76	9.55	9.36
[2]Tryptophan, g/kg	3.02	2.65	3.00	2.79
[2]Valine, g/kg	9.59	9.26	9.61	9.46
[4]Benzoic acid, g/kg			7,590	7,970

1) Average of 4 analyses. 2) Average of 3 analyses. 3) Average of 2 analyses. 4) One analysis

* EDOM = Enzyme Digestible Organic Matter

** EDOMi = Enzyme Digestible Organic Matter at ileum

Feed from 9 to 20 kg

	Group no.			
Ingredient	**1**	**2**	**3**	**4**
Crude protein, %	18.3	18.1	18.3	18.5
Fat, %	4.3	4.4	4.3	4.4
Ash, %	5.1	4.9	5.1	5.0
Water, %	12.2	12.2	12.2	12.2
EDOM, %*	90.7	90.5	90.6	90.6
$EDOM_i$, %**	83.9	82.5	82.8	82.3
FUgp, per 100 kg	113.0	111.9	111.7	111.5
Phytase activity, FTU kg	2,559	2,870	2,179	2,318
Calcium, g/kg	8.14	7.90	8.24	8.25
Phosphorus, g/kg	5.41	5.37	5.68	5.48
Copper, mg/kg	127.0	24.75	140.3	29.25
Zinc, mg/kg	173.8	184.8	163.0	217.0
Lysine, g/kg	13.23	12.65	12.95	12.93
Methionine, g/kg	3.91	3.86	3.83	3.88
Cystine, g/kg	3.17	3.20	3.13	3.20
Met + cys, g/kg	7.08	7.06	6.96	7.08
Threonine, g/kg	8.41	8.14	8.28	8.36
Tryptophan, g/kg	2.74	2.75	2.65	2.72
Valine, g/kg	8.87	8.55	8.67	8.72
Benzoic acid, g/kg			9,025	9,015

Average of 4 analyses, with the exception of tryptophan and benzoic acid, which are averages of 2 analyses.

* EDOM = Enzyme Digestible Organic Matter

** EDOMi = Enzyme Digestible Organic Matter at ileum

Feed from 20 to 30 kg

The average content shown here covers all four groups as the nutrient content of the four groups was identical in the period 20-30 kg.

Ingredient	Result
Crude protein, %	19.3
Fat, %	4.4
Ash, %	5.4
Water, %	12.4
EDOM, %*	90.4
$EDOM_i$, %**	81.9
FUgp, per 100 kg	110.0
Phytase activity, FTU kg	2,922
Calcium, g/kg	8.13
Phosphorus, g/kg	5.38
Copper, mg/kg	137.9
Zinc, mg/kg	189.8
Lysine, g/kg	13.37
Methionine, g/kg	4.07
Cystine, g/kg	3.25
Met + cys, g/kg	7.32
Threonine, g/kg	8.38
Tryptophan, g/kg	2.64
Valine, g/kg	8.83

Average of 10 analyses, with the exception of phytase activity and valine, which are averages of 6 analyses, and tryptophan, which is an average of 4 analyses.

* EDOM = Enzyme Digestible Organic Matter

** EDOMi = Enzyme Digestible Organic Matter at ileum

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