Chicory for weaners

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The addition of 15% chicory or 7.5% chicory + 0.5% benzoic acid increased weaner productivity compared with feed with and without 7.5% chicory. No effect was found on health. With the current chicory prices, this is not profitable.

Abstract

The bacteria in the large intestine that ferment fibre increase when pigs are fed dried chicory root or other ingredients containing long-chained fibre/carbohydrates. Research has shown chicory to have a positive effect on parasites and Lawsonia (Roepsdorf et al., 2005, & Jensen, 2007). One of the most important methods for reducing pathogenic bacteria in pigs' gastro-intestinal tract is a high concentration of organic acids together with a low pH in the stomach and intestines. Organic acids can either be added to the feed where the primary effect is then found in the stomach, or they are produced naturally in the gastro-intestinal tract (hind gut). A naturally high concentration of organic acids in the large intestine can be obtained by increasing the fermentation of carbohydrates in the large intestine. When organic acids is combined with the addition of chicory to pig feed, the expected effect is a reduction of pathogenic bacteria in the stomach and small intestine caused by the acid products and in the large intestine through fermentation of chicory.

The trial comprised four groups given the following diets in the period 7-28 kg:

Group	**1**	**2**	**3**	**4**
Chicory, %	0	7.5	15	7.5
Benzoic acid, %	-	-	-	0.5

The diet for the newly weaned piglets did not contain zinc oxide in high doses.

The addition of 15% chicory or 7.5% chicory in combination with 0.5% benzoic acid significantly increased the production value compared with the control diet without chicory and the diet containing 7.5% chicory only. The addition of chicory alone or combined with benzoic acid did not affect the pigs' health in terms of treatments for diarrhoea compared with control. No differences were found in the population of Lawsonia bacteria in faeces between control, the pigs given 15% chicory or the pigs given 7.5% chicory and 0.5% benzoic acid.

Dried chicory root is fairly expensive (DKK 6.50-7.50 per kg in 2009/10), and it is therefore not profitable to add 15% chicory to weaner feed. If the price drops to DKK 3.50 per kg, the production economy will be identical between control and the diet with 7.5% chicory and 0.5% benzoic acid. An inclusion of 7.5% chicory did not affect health or productivity. It is therefore not assumed that inclusion rates below 7.5% will have a positive effect on health or productivity among weaners.

Background

The bacterial balance in pigs' intestines shifts when they are fed diets containing chicory or ingredients containing fermentable carbohydrates. Dried chicory root has a dry matter content of approx. 50% inulin (fructan), approx. 15% sucrose and 1% fructose. Inulin ferments in the large intestine, whereas sucrose and fructose are digested in the small intestine. The effect of adding a high dosage of fermentable fibre will probably be neutralized if the pigs are fed the diet for a longer period of time as the bacterial flora will then stabilise (Pluske, 2008, pers. communication). Organic acids will form in the intestines as a result of the modified bacterial balance. Organic acids inhibit coliform bacteria, which may be the reason why some pig producers experience a positive effect of adding chicory to weaner feed. However, Danish research has not confirmed this effect in trials with inulin extracted from chicory. It should be noted, though, that these trials concerned fairly low inclusion rates (0.03% and 1.5%, respectively) and were designed exclusively to document effects on productivity (Maribo, 1999; Olsen & Maribo, 1999). Murdoch University in Australia studied the addition of inulin and benzoic acid to feed for weaners inoculated with diarrhoea-inducing coli

bacteria, and the results demonstrated a reduction in diarrhoea and a limited effect on productivity by adding 0, 4 or 8% inulin to weaner feed (corresponds to 7% and 16% chicory). The results also showed a positive effect on productivity of adding 0.5% benzoic acid to the feed (Danka, 2010).

Research has shown chicory to have a positive effect on parasites and Lawsonia (Roepsdorf et al., 2005, and Jensen, 2007). One method for reducing pathogenic bacteria in pigs' gastro-intestinal tract through feeding is a high concentration of organic acids and a low pH in the stomach and intestines. Organic acids are either added to the feed or form naturally in the gastro-intestinal tract. Normally, the addition of organic acids to pig feed is found in the first segment of the small intestine and not further down the alimentary tract. A naturally high concentration of organic acids can be created, for instance, by increasing fermentation in the large intestine. If the effect of using organic acids is combined with chicory in pig feed, a reduction is expected of pathogenic bacteria in the stomach as well as the small intestine through the acids, and in the large intestine through fermentation of chicory.

Gross margin increases by approx. DKK 1-3 per pig in the growth period 7-30 kg if mortality is reduced by 10% and treatments for diarrhoea by 25% provided that one day of treatment costs DKK 1 per pig per day.

Weaner trials demonstrated positive effects on productivity and a 50% reduction in the number of treatments for diarrhoea when 2% benzoic acid was added to the feed the first two weeks post-weaning. Analyses of the gastro-intestinal tract revealed that benzoic significantly reduced the prevalence of anaerobic bacteria and yeast in the small intestine and the numeric population of coliform bacteria. Benzoic acid was found in stomach as well as small intestine (Maribo, 2000). Subsequently, the addition of 0.5% benzoic acid was investigated, and results demonstrated the same effect on productivity, but not on diarrhoea. This may be attributed to the fact that the prevalence of diarrhoea was very low (1.1 treatment days per pig) in that trial (Maribo, 2003).

In this trial, chicory alone and in combination with benzoic acid was studied in weaner feed. This combination was chosen to obtain an effect on the prevalence of pathogenic bacteria in the stomach and small intestine (of benzoic acid) and in the large intestine (of chicory). This should cover the entire alimentary tract.

The aim is to document if feeding with chicory in different inclusion rates and in combination with benzoic acid has a positive effect on health and productivity of weaners.

Materials and method

The trial was conducted at the weaner facility at Pig Research Centre's Experimental Station Grønhøj. The pens had 1/3 slatted floor; 2/3 solid floor and cover. The pigs were approx. five weeks old and weighed averagely 7.4 kg at trial start. At intermediate weighing two weeks later, they weighed 8.8 kg, and by the end of the trial their weight averaged 28.3 kg. The trial comprised four groups, 65 replicates (pens) per group and 684 pigs per treatment.

Table 1. Trial design

Group	1	2	3	4
Chicory, %	0	7.5	15	7.5
Benzoic acid, %	-	-	-	0.5

Feeding

All pigs were fed ad lib in dry feeders. After ten days, the piglet diet was gradually replaced over 4-5 days by the weaner diet. Zinc oxide in high doses to prevent diarrhoea was not added to the piglet diet.

The diets were formulated to have the same nutrient content. The content of the first five amino acids was 5% above standard and the diets contained 10% more calcium and phosphorus than stated in the standards (Jørgensen & Tybirk, 2008) to ensure that variations in ingredients did not affect the results. The nutrient content of chicory was analysed before the diets were formulated. Nutrient content of chicory as well as of the diets is shown in Appendices 1 and 2. The feed was produced at Aarhusegnens Andel.

Lawsonia

Blood samples (serology) were screened for antibodies and the results demonstrated Lawsonia in the herd. In the last week before slaughter, faecal samples were taken from the rectum of 32 pigs picked randomly from 32 pens in groups 1 and 3 and from 26 pens in group 4. The samples were frozen and submitted for analysis of Lawsonia bacteria with the PCR analysis method (the Technical University of Denmark).

Statistical analyses

Daily gain and feed conversion ratio for each pen were used for calculating the productivity per pig (PV) at the same price per analysed FUgp for all groups.

PV/pig = sales price – purchase price – feed costs – various costs

The production value was calculated with the below factors.

Average price of the last 5 years (September 1, 2004 – September 1, 2009):

- 7 kg pigs: DKK 199 per pig, +/- DKK 8.82 per kg
- 30 kg pigs: DKK 335 per pig, -DKK 4.87 (15-30 kg)/+ DKK 5.03 (30-40 kg) per kg.
- Feed price (average of 5 years): Piglet feed DKK 2.87 per FUgp; weaner feed DKK 1.63 per FUgp
- Various costs: DKK 20
- Value of daily gain: DKK 5.94 per kg
- Price of chicory from Dancikorie: DKK 7.50 per kg incl. manufacturer's profit.

The trial was designed as a comparison between four groups. Production value, disease recordings and mortality were analysed as primary parameters. Continuous data was described with a generalised linear model with group as systematic effects, weight at transfer to the trial as co-variate, and block as random effect. The discrete data (mortality and treatment) was described with logistic regression with treatment as explaining variable. The results are shown as adjusted average for each group. Data was checked for normal distribution and prevalence of outliers to ensure that no pens deviated significantly from the others. In analyses with Lawsonia as explaining variable, treatment groups 1 and 3 were included as systematic effect. All analyses were made in Proc Mixed in SAS with block as random effect. All statistical analyses employed the logarithm of Lawsonia concentration. The influence of Lawsonia bacteria in faeces on daily gain, feed conversion ratio, dead and culled pigs was also analysed.

Statistically significant differences were stated at 5% level. Six comparisons in pairs were made which is why Bonferroni correction was employed.

Results and discussion

Health

The addition of chicory to the feed did not affect the frequency of diarrhoea treatments. On average, the pigs were treated for diarrhoea for 2.4 days. No differences were observed in the percentage of dead and culled pigs; mortality averaged 1.5% and 0.5% were destroyed. 15% of the pigs were moved to a hospital pen, primarily in the weaner period (cf. table 2). The high percentage of culled pigs is attributed to a high prevalence of Lawsonia after intermediate weighing; Lawsonia bacteria in faeces averaged 10^7, which indicates that the pigs' health was affected by it (table 3).

Table 2. Health

Group	1	2	3	4
Chicory, %	0	7.5	15	7.5
Benzoic acid, %	-	-	-	0.5
Treatments for diarrhoea, days/pig	3.2	2.1	2.2	2.0
Dead and destroyed, %	1.8	1.9	1.0	1.7
Dead, destroyed, placed in hospital pen, %	15.0	17.2	14.9	13.7

No significant differences were found between groups 1, 3 and 4 in the number of Lawsonia bacteria in faeces. The pigs were evenly distributed on the categories: no or low degree of infection / moderate infection / high degree of infection (cf. table 3). In order to detect an effect on health, the population of Lawsonia bacteria must be reduced by a factor 10^3 corresponding to 1,000 times fewer bacteria as a result of the treatment (pers. communication, Tim K. Jensen, 2010).

Table 3. Effect of chicory on the prevalence of Lawsonia in the last part of the weaner period.

Group	**1**	**3**	**4**
Chicory, %	0	15	7.5
Benzoic acid, %	0	0	0.5
Samples, pen	64 (32)	64 (32)	52 (26)
Lawsonia bacteria per g faeces	6.88×10^7	3.13×10^7	1.2×10^7
Pigs with no or low infection, $<10^4$/g faeces	9	10	8
Pigs with moderate infection, $<10^6$/g faeces	19	22	18
Pigs with massive infection, $>10^6$/g faeces	36	32	26

Feed

The amino acid content of the piglet diet was below the standard. The largest deviation from the calculated content was found for methionine (-10%), and phenylalanine and tyrosine (-11%): when converted to g digestible per FUgp this corresponds to a deficiency of 2% for both amino acids compared with the standard. The valine content was calculated at 5% below standard. Deviations compared with the standards and between the groups were small and are therefore not assumed to affect the conclusion of this trial. The analysed nutrient content in the weaner diet corresponded with the calculated values. In all groups, the content of zinc was significantly above the calculated content (Appendix 3). Dried chicory root contains 52% fructan (inulin); 13% sucrose and 1% fructose in dry matter (Appendices 1 and 2). The level of sucrose and fructan (inulin) increased in the feed with increasing inclusion of chicory. The diet containing 15% chicory had an inulin (fructan) content that was 4.4 and 8.5 times higher in piglet feed and weaner feed, respectively, compared with the control diets. The sum of sugars (glucose, fructose, sucrose and fructan) was 4.4 and 3.6 times higher in piglet and weaner diets, respectively, when 15% chicory was added to the feed compared with the control groups (Appendix 3).

Production value

With an equal feed price for all groups, the pigs fed 15% chicory or 7.5% chicory combined with 0.5% benzoic acid had a significantly higher production value than the control pigs and the pigs given only 7.5% chicory. This is attributed to a significantly higher daily gain and a better feed conversion ratio overall and in the weaner period. Daily gain was very low the first 14 days post-weaning, which resulted in a poor feed conversion ratio. There were large variations between the batches (cf. table 4).

As no significant effect was found on the production value of adding 7.5% chicory to the feed, it is not profitable to reduce the inclusion rate further as the effect on productivity is expected to drop linear with decreasing inclusion of chicory.

If the actual feed price (2009/2010) is used in the calculation, the production values are identical in the group given 7.5% chicory and 0.5% benzoic acid and the control group provided that chicory costs approx. DKK 3.50 per kg. With a price of DKK 6.50 or 7.50 per kg chicory, it is not profitable to add 7.5% or 15% chicory to the feed (cf. table 5).

Table 4. Productivity in weaners fed diets with chicory and benzoic acid

Group	1. Control	2. 7.5% chicory	3. 15% chicory	4. 7.5% chicory + 0.5% benzoic acid
Immediate pre-weaning period – 10 days post-weaning (7.4-8.8 kg)				
Daily gain, g/day	139	135	141	151
Feed intake, FUgp/day	0.27	0.26	0.26	0.27
FCR, FUgp/kg	2.31	2.44	2.04	2.32
Weaner period – last four wks (8.8-28.3 kg)				
Daily gain, g/day	506[a]	519[a]	551[b]	570[b]
Feed intake, FUgp/day	0.93[a]	0.92[a]	0.94[a]	0.99[b]
FCR, FUgp/kg	1.82[a]	1.76[b]	1.70[c]	1.72[bc]
The entire trial period (7.4-28.3 kg)				
Daily gain, g/day	422[a]	429[a]	457[b]	473[b]
Feed intake, FUgp/day	0.78[a]	0.77[a]	0.79[a]	0.83[b]
FCR, FUgp/kg	1.84[a]	1.77[b]	1.71[c]	1.73[bc]

a,b,c: Values with different superscripts are significantly different ($p<0.05$)

Table 5. Production value (PV) based on identical feed prices, and current production value including the price of chicory and the feed.

Group	1. Control	2. 7.5% chicory	3. 15% chicory	4. 7.5% chicory + 0.5% benzoic acid
Production value, DKK/pigs	56.83[a]	60.71[a]	65.70[b]	67.31[b]
Index	100	106	114	118
Index PV, incl. feed price chicory: DKK 3.50/kg	100	91	84	99
Index PV, incl. feed price chicory: DKK 6.50/kg	100	75	52	83
Index PV, incl. feed price chicory: DKK 7.50/kg	100	70	41	77

a,b: Values with different superscripts are significantly different ($p<0.05$)

Conclusion

If the prices of the diets are identical, the addition of 15% dried chicory root or 7.5% dried chicory root combined with 0.5% benzoic acid significantly increased the production value compared with control and the diet including only 7.5% chicory. The addition of chicory alone or in combination with benzoic acid did not affect the pigs' health. No differences were detected in the population of Lawsonia bacteria in faeces between the control pigs, the pigs given 15% chicory or the pigs given 7.5% chicory and 0.5% benzoic acid.

With the current feed prices (2009/2010) and a chicory price of DKK 6.50-7.50 per kg, it is not profitable to add 15% chicory to weaner feed. If chicory drops to DKK 3.50 per kg, the production economy will be identical between the control pigs and the pigs given 7.5% chicory + 0.5% benzoic acid. Inclusion rates lower than 7.5% chicory affected neither health nor productivity. It is therefore assumed that lower inclusion rates will not have a positive impact on weaner health and productivity.

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Appendix 1. Nutrient content in chicory – average of six analyses.

FUgp	**125.2**
Crude protein	5.5
Crude fat	0.4
Water	5.2
Ash	5.0
EFOSi	88.8
Glucose, %	0.2
Fructose, %	1.3
Sucrose, %	14.7
Fructan (inulin), %	54.4

Glucose, fructose, sucrose and fructan are determined on the basis of two analyses.

Appendix 2. Composition of diets

	Piglet diet (first 2 wks post-weaning)				Weaner diet			
	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 1**	**Group 2**	**Group 3**	**Group 4**
Chicory	0	7.5	15	7.5	0	7.5	15	7.5
Benzoic acid	0	0	0	0.5	0	0	0	0.5
Barley	20.00	20.00	20.00	20.00	15.00	15.00	15.00	15.00
Wheat	45.53	37.11	28.07	36.64	54.55	45.96	37.54	44.99
HP300	11.96	11.55	13.21	10.55	-	-	-	-
Potato protein	4.00	3.14	2.76	4.00	2.98	2.67	2.56	2.63
Dehulled soybean meal	3.00	3.00	3.00	3.00	16.60	18.47	20.00	20.00
Milk	6.00	6.00	6.00	6.00	-	-	-	-
Fishmeal	4.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00
Feed lime	1.01	0.78	0.55	0.77	1.80	1.57	1.33	1.56
Mono CaP	1.29	1.30	1.31	1.31	0.77	0.79	0.82	0.80
Salt	0.21	0.20	0.19	0.20	0.29	0.28	0.27	0.28
Molasses	1.00	1.00	1.00	1.00	1.50	1.50	1.50	1.50
Fat Scanfedt S	3.18	3.00	3.00	3.15	2.36	2.14	1.90	2.38
Lysine	0.46	0.44	0.41	0.42	0.42	0.40	0.36	0.39
Methionine	0.12	0.13	0.15	0.13	0.10	0.10	0.11	0.10
Threonine	0.13	0.14	0.14	0.13	0.10	0.10	0.09	0.10
Tryptophan	0.32	0.31	0.31	0.32	0.23	0.22	0.21	0.22
Vitamins/minerals	0.38	0.38	0.38	0.38	0.29	0.29	0.29	0.29

Appendix 3. Calculated and analysed nutrient content of piglet diet.

Group	1. Control		2. 7.5% chicory		3. 15% chicory		4. 7.5% chicory + 0.5% benzoic acid	
	Calc.	Analysis[1]	Calc.	Analysis[1]	Calc.	Analysis[1]	Calc.	Analysis[1]
FUgp/100 kg	120	119	120	118	120	117	120	119
Crude protein, %	21.3	20.1	21.4	21.3	21.5	21.5	21.4	21.1
Lysine, g/kg	15.1	14.0	15.2	14.9	15.2	15.0	15.4	15.1
Methionine, g/kg	4.9	4.4	5.0	4.6	5.1	4.7	5.0	4.9
Meth+cyst., g/kg	8.3	7.9	8.3	8.0	8.4	8.1	8.3	8.2
Threonine, g/kg	9.5	8.9	9.6	9.6	9.7	9.5	9.6	9.7
Isoleucine, g/kg	9.0	8.5	9.1	9.0	9.1	9.5	9.1	9.4
Leucine, g/kg	16.1	14.7	16.2	15.7	16.4	16.1	16.3	15.9
Histidine, g/kg	5.1	5.1	5.2	5.4	5.3	5.2	5.2	5.2
Phenylalanine, g/kg	10.2	9.3	10.2	9.9	10.3	10.0	10.2	10.1
Phenyl+tyrosine, g/kg	18.0	16.0	18.1	17.3	18.3	17.4	18.1	17.5
Valine, g/kg	10.7	10.0	10.8	10.4	10.9	10.9	10.8	10.9
Calcium, g/kg[2]	8.6	10.4	8.6	8.9	8.6	8.9	8.6	9.7
Total P, g/kg[2]	7.5	7.6	7.4	7.8	7.4	7.9	7.4	8.0
Zinc, mg/kg[2]	164	280	163	221	132	226	163	203

1) Analysed content is based on 6 analyses of FUgp and crude protein and 3 analyses of amino acids.

2) Analysed content is based on 2 analyses.

Diet	% of DM	Glucose, % of DM	Fructose, % of DM	Sucrose, % of DM	Fructose, 5 of DM	Total
Group 1. Piglet	91.88	0.18	0.16	1.44	0.96	2.74
Group 2. Piglet	91.88	0.17	0.23	2.15	4.03	6.58
Group 3. Piglet	92.07	0.18	0.33	3.12	8.39	12.01
Group 4. Piglet	92.05	0.16	0.26	2.31	4.63	7.36
Group 1. Weaner	91.69	0.17	0.18	2.29	1.31	3.96
Group 2. Weaner	91.77	0.16	0.27	3.28	4.83	8.54
Group 3. Weaner	92.12	0.17	0.39	4.23	9.58	14.36
Group 4. Weaner	92.06	0.17	0.29	3.27	5.52	9.25

Appendix 3 (cont.). Calculated and analysed nutrient content of weaner diet.

Group	1. Control		2. 7.5% chicory		3. 15% chicory		4. 7.5% chicory + 0.5% benzoic acid	
	Calc.	Analysis[1]	Calc.	Analysis[1]	Calc.	Analysis[1]	Calc.	Analysis[1]
FUgp/100 kg	114	117	114	113	114	112	114	114
Crude protein, %	20.5	20.1	20.6	20.8	20.8	21.0	20.6	21.0
Lysine, g/kg	13.8	13.9	13.9	14.4	14.0	14.3	13.9	14.4
Methionine, g/kg	4.3	4.0	4.3	4.3	4.4	4.3	4.3	4.3
Meth+cyst., g/kg	7.7	7.5	7.6	7.8	7.7	7.7	7.6	7.8
Threonine, g/kg	8.5	8.3	8.6	8.9	8.7	8.9	8.6	9.0
Isoleucine, g/kg	8.4	8.8	8.5	9.1	8.7	8.9	8.5	9.3
Leucine, g/kg	15.0	15.0	15.2	15.3	15.5	15.4	15.2	15.7
Histidine, g/kg	4.9	4.9	5.0	5.2	5.1	5.3	5.0	5.5
Phenylalanine, g/kg	9.7	9.6	9.8	9.9	9.9	9.7	9.8	10.0
Phenyl+tyrosine, g/kg	17.0	16.7	17.1	17.1	17.5	16.9	17.2	17.2
Valine, g/kg	9.7	10.2	9.9	10.6	10.2	10.3	9.9	10.9
Calcium, g/kg[2]	10.0	11.6	10.0	10.7	10.0	9.4	10.0	10.2
Total P, g/kg[2]	6.1	6.4	6.1	6.5	6.1	6.2	6.1	6.6
Zinc, mg/kg[2]	262	296	260	252	259	185	260	197

1) Analysed content is based on 8 analyses of FUgp and crude protein and 4 analyses of amino acids.

2) Analysed content is based on 4 analyses.