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Final report
Delacon IED (IPPC)

Scientific study no. 3594

Investigation of a feed additive regarding emission reduction and performance with consideration of the IED (IPPC) guideline

Untersuchung eines Futtermittelzusatzes im Hinblick auf Emissionsminderung und Leistungsdaten unter Berücksichtigung der IED-(IPPC-)Richtlinie

Project manager:
Ing. Eduard Zentner, AREC Raumberg-Gumpenstein

Project assistants:
Ing. Irene Mösenbacher-Molterer, Gregor Huber, Mag. Elisabeth Finotti, Dipl.Tzt. Dr. Johann Gasteiner, Christian Bachler, Manfred Mayer, Sigrid Brettschuh, Bernhard Rudorfer, Ing. Anton Schauer, Roland Kitzer, Ing. Josef Kaufmann, Barbara Steiner,

Project partners:
DI Martin Veit, DELACON Biotechnik GmbH,
Weissenwolffstraße 14, 4221 Steyregg, Austria

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CONTENTS

Summary

The aim of this trial was to evaluate the effect of the phytogenic feed additive Fresta® F Plus (FF+) on performance and ammonia emissions and concentrations at animal level.

From April until June 2011, a total of 32 female (Large White × Landrace) × Pietrain hybrids were distributed by weight to two treatment groups. Pigs were housed in two identical barns with two pens with fully slatted floors, for 8 fattening pigs from 30 to 110 kg live weight. During the experiment, the control group was fed the basal diet while the treatment group received the basal diet plus 150 ppm of the phytogenic feed additive (Delacon Biotechnik GmbH, Austria) for 78 days. Body weight was recorded individually weekly, while feed intake was recorded daily per pen. Temperature, humidity and ammonia concentrations were continuously measured outside and in the barns. Ammonia and carbon dioxide concentrations were measured continuously with the photo-acoustic field gas monitor INNOVA 1412 (Lumasense Technologies), at 3 measurement points per barn and for emissions in the chimneys. The ventilation rates were recorded with measurement ventilators. For the evaluation of odor concentrations and emissions an olfactometer (Mannebeck, Germany) was used. Samples for odor measurements were taken 5 times in the exhaust chimneys during the trial. Slurry was analyzed mainly for nitrogen and ammonia nitrogen.

Temperature, humidity and ventilation rates were at the same level in both barns. Ammonia concentrations were significantly reduced by 21 % in the treatment group, while daily feed intake and daily weight gain increased by 7.4 % and 8.4 %, respectively. Ammonia emissions were reduced by 19.3 % or 210 g ammonia and odor emissions by 32.6% or 64 million odor units per fattening pig from 30 to 100 kg. Total nitrogen (3.01%) and ammonia nitrogen (1.23) in the slurry was reduced in the FF+ group. Due to improved performance parameters the application of this feed additive is leading to a profit of 0.78 € per fattening pig.

The current study proves that phytogenic feed additives containing saponins which inhibit the urease activity reduce ammonia and odor emissions as well as concentrations in the barn while providing economical benefits to the farmer.

Therefore the tested feed additive “Fresta® F plus” is in any case suitable for reducing odor and ammonia emissions as well as the resulting nuisance.

Introduction

In the context of a trial with growing-finishing pigs the feed additive “Fresta® F Plus“ (Delacon Biotechnik GmbH, Austria), which has already been tested in a prior trial, was investigated. In comparison to the last trial the measuring techniques used this time are more accurate and measurement ventilators were installed. In this connection the focus especially lies on representative measuring results at continuous measurements, quality control and other measuring procedures for reference in order to calibrate with respect to CEN-standards etc. Hence, the acceptance of the results all over Europe is the focal point and the product should also be able to be utilized as reduction method by farms ranging with the IED (IPPC) guideline.

In the trial 2010 a reduction of odor and noxious gas concentration in growing-finishing pigs was shown. The olfactory measurements showed a strong reduction of the odor units in the test group. The concentration of ammonia was significantly decreased by 32% ($P<0.0001$). Thus, the tested additive is suitable to induce an improvement of the climate in stables and therefore a positive effect in terms of animal health and well-beeing.

The objective of the current trial was the investigation of emissions and concentrations in the animals´ area with the focus on a win-win situation for animals and environment. The project was carried out with respect to the IED (IPPC) guideline (guideline 2010/75EU of the European Parliament and the Council from 24th of November, 2010 in terms of industrial emissions – integrated prevention and reduction of environmental pollution – new version), in order to receive data acknowledged all over Europe.

Material und Methods

Test groups

From April until June 2011, a total of 32 female (Large White × Landrace) × Pietrain hybrids were housed in two identical barns. The animals´ origin was organized with the VLV Upper Austria (federation of agricultural refinement producers). Both barns were separated into two pens with fully slatted floors, each for 8 fattening pigs from 30 to 110 kg live weight. Animals were distributed by equal weight into two treatment groups. Average weight at housing (2011-03-31) and start of measurement period are shown in Table 1 and 2. During an adaptation phase from housing until trial start (2011-04-11), the control group was fed the basal diets with placebo while the treatment group received the basal diet plus 150 ppm of the phytogenic feed additive Fresta® F Plus (FF+), developed by Delacon Biotechnik GmbH, Austria.

Table 1: Body weight of the animals at housing

	Control		FF+	
Average weight in kg	32.31		32.26	
SD	2.19		2.05	
	Pen 1	Pen 2	Pen 1	Pen 2
Average weight in kg	32.05	32.58	31.95	32.58
SD	2.23	2.26	2.03	2.17

Table 2: Body weights at trial start

	Control		FF+	
Average weight in kg	37.9		39.0	
SD	2.86		2.89	
	Pen 1	Pen 2	Pen 1	Pen 2
Average weight in kg	37.34	38.46	39.53	38.49

SD	3.53	3.22	3.51	2.09

Trial facility

The multi-purpose-housings of the AREC include two special barns for trials with fattening pigs. The conception allows a variable configuration, whereby there are completely equal pens for 4 x 8 = 32 finishing pigs (16 animals per barn) ranging from 30 – 110 kg live weight.

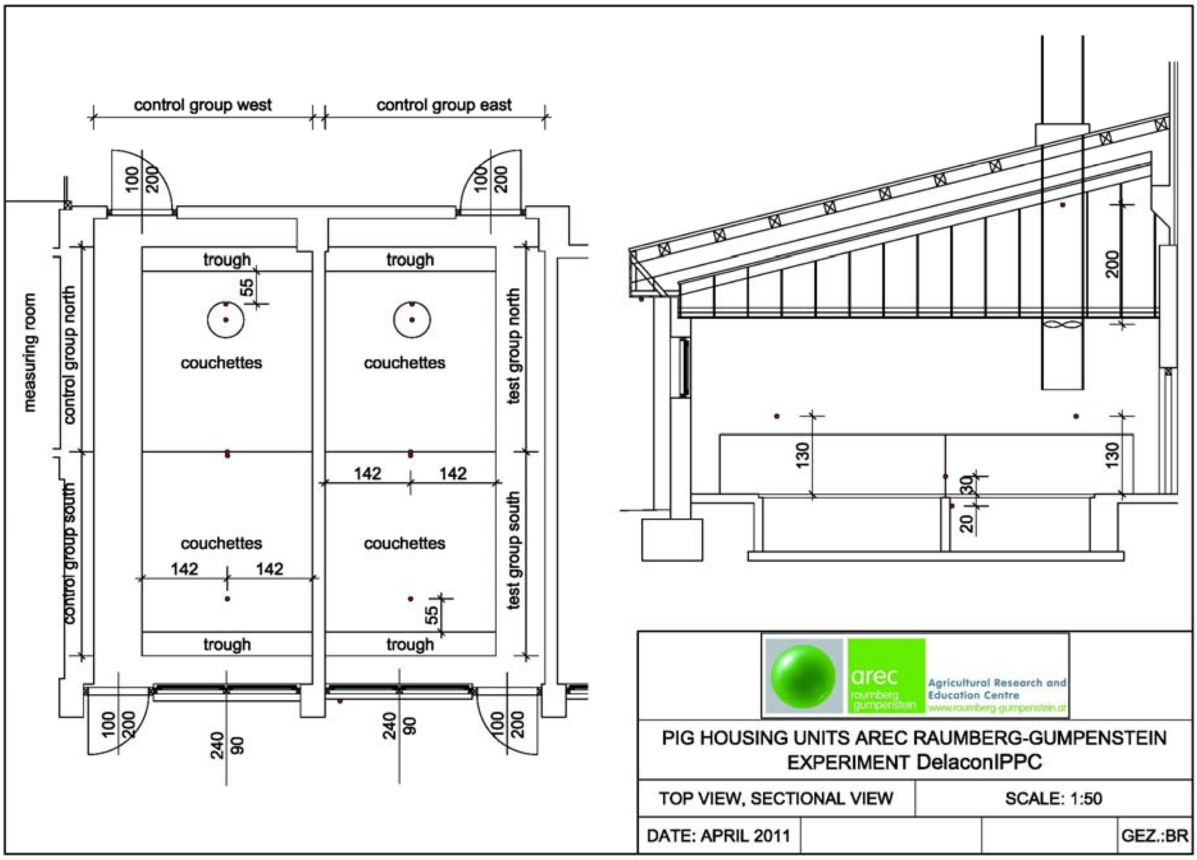

Figure 1: Draft of the test units and position of the monitoring points in the housings (red dots)

The pigs were housed on fully-slatted floor, which had been renewed before the trial´s begin. Furthermore, there were feeding racks in every pen, which were daily filled with straw in order to provide manipulable material. Before the beginning of the trial period the barns were cleaned and disinfected again and the slurry pit was emptied and cleaned.

Ventilation

For ventilation a porous ceiling with 5 cm coating for insulation was built in; the incoming air gets into the animal area via the roof. The exhaust air was controlled electronically and extracted over a vent stack. An electronic heating secures to be able to comply with the demand of the animals in terms of temperature, especially at the beginning of the fattening period. Additionally, the barns were pre-heated before the housing of the animals. Ventilation and heating were controlled in parallel in the barns.

The ventilation rate was calculated by means of measuring ventilators, which were controlled and serviced on request in the course of the weekly weighing. Measurements took place in an interval of 10 minutes.

Tested feed additive

Phytogenic feed additives

Phytogenic feed additives are mixtures consisting of plant raw materials and carriers. Selected essential oils as well as herbs and spices are used. Because of their high potential in problem solving and consumer acceptance this new generation of additives has a fixed place in the present feed industry, especially after the prohibition of the antibiotic growth promoters.

Manufacturer´s data

"Fresta® F Plus" is a premixture consisting of the EU registered zootechnical additive "Fresta F" plus saponins. It is a standardized and qualitatively high-value combination of partly micro-encapsulated essential ethereal oils (caraway and lemon), herbs, spices, carrier substances and saponins. A minimum content of 0.35% carvone is guaranteed.

The natural potential of the phytogenic ingredients of "Fresta® F Plus" is used to optimize digestion and nutrient utilization. The herbal active components verifiably stimulate the metabolism and digestion and increase the slaughter performance. The saponins used were tested in terms of their inhibition of urease in order to prohibit the release of ammonia.

Verification of the additives in feed

In order to be able to verify/control the use of feed additives in feed for reduction of ammonia, the following methods are provided for "Fresta® F Plus":

1) GC/MS

A GC/MS-procedure, which was especially developed for Delacon and is acknowledged by the EFSA (European Food Safety Authority), is used for the determination of carvone – the lead active substance of "Fresta® F Plus". Carvone is not only used for qualitative characterisation but also quantitatively determined. Carvone, analysed by GC-MS, is traceable through premixtures and to final feeds. The detection limit for this analysis lies at 0.1 µg/g.

2) Micro tracer

Micro tracers are metallic particles being coated with a food colorant. 1 g micro tracer contains an exactly defined number of such coated particles. In order to mark a product, a specified amount of micro tracer is homogenously mixed into the product.

Products are either marked with a micro tracer on customer´s request or in case of feeding trials in order to control the correct addition of the additive (e.g. "Fresta F Plus") to the finished feed. If the number of metallic particles being found in the finished feed strongly deviates from the expected/calculated amount, one can conclude that a mistake had occurred when mixing of "Fresta® F Plus" into the finished feed.

Delacon uses an exclusive micro tracer, that makes it possible to confirm the presence of a Delacon-product only by the qualitative proof of the tracer. Also a carry-over can therefore easily be proven.

Feeding management

Feed and water was available ad libitum during the whole fattening period. As of 5th of April the control group received the grower feed with placebo and the test group grower feed with the feed additive "Fresta®

F Plus“. The shift to the finisher feed with placebo or with “FF+” took place at 16th of May 2011, at an average live-weight of 65kg.

Each morning and in the evening the feed was offered; it was weighed before and the rest of feed was weighed at the next before the next feeding.

Health

At delivery, of the piglets clinical evidence was provided by the veterinarian of the AREC. During the test period the animals were controlled weekly by the veterinarian and daily by the responsible persons.

Measurement equipment

In both barns temperature and air humidity were measured by means of thermistor and humidistat, which was doubly assured by a second measuring unit in the centre of the barns, 110cm above the floor. Additionally, the external conditions as well as the values in the attic were measured. The assessment was continuous,; the mean value of each 10 minutes was saved on a Saveris-datalogger.

During the whole test period the gases being mentioned in *table 3* were continuously assessed by means of the Multi Gas Monitoring System – INNOVA 1412 (Luma Sense Technologies). The recording interval was set on 15 minutes. Before the housing of the animals the concentrations in the barns were measured in order to ensure comparability.

Figure 2: Multi Gas Monitoring System – INNOVA 1412 (Luma Sense Technologies)

The following parameters were assessed in the supply air and outside as well as in each barn at the following 5 measuring points (*figure 1*):

- North side in a height of 130 cm (animal level)
- In the centre in a height of 30 cm (animal level)
- Centre – 20 cm below the slatted floor (animal level)
- South side in a height of 130 cm
- Vent stack

Table 3: Measured gases by INNOVA 1412

No.	Gas	Chemical formula	Unit
1	Ammonia	NH_3	ppm; mg/m³
2	Carbon dioxide	CO_2	ppm; mg/m³

Measurements of reference-data were carried out with Dräger X-am 7000-measuring instruments, in order to control the values on the one hand and on the other hand to provide a certain data safety in case of an eventual breakdown of the continuous measuring techniques.

Olfactometric evaluation

Olfactometric examinations were carried out at the AREC in order to be able to give definite evidence concerning the original questioning in the tests, namely the reduction of odor.

Olfactometry is a measuring method being related to causes and effects and analyses the effect of odor on humans. Odor arises from a numerous chemical substances, the synergy of which in terms of their efficiency on the human nose can be quite different depending on the kind of material and on the amount of the respective gas mixture. An analysis of the total odorous substances of a sample taken from the air is hardly possible because of the huge number of distinct components. The determination of the leading components can deliver a correlation to odor concentration and odor intensity only with an identical composition of the samples. Even with a quantitative determination of all ingredients of a sample the impression of odor cannot be described.

Measurement of the odor threshold

Each sample was analysed by 2 teams with 4 probands each. An olfactometer of the company Mannebeck, production series TO8 was used for analysis. As for the measuring method the measurement of the odor threshold (determination of the odor´s concentration) was selected. The results of the measurements of odor concentration are indicated in odor units per m³ (OU/ m³) with all appendant statistical values.

Definition: „1 OU is the amount of odorous substances, which in 1 m³ of air just cause an olfactory sensibility at 50% of humans."

Figure 3: Probands at the Olfactometer TO8

The concentration of odor of the exhaust gas-sample to be measured is determined by dilution with synthetic air up to the odor threshold. For this purpose a continuous odor-less air flow is mixed up with a strong-odoring gas flow to be dosed by means of a flow meter in increasing concentration. Via nose-masks this mixture is offered for assessment to a group of test persons. For determination of the individual odor threshold each of the probands has to make a yes-/no-decision (it smells/doesn´t smell). The positive decision is transferred by keypress to a special programme for evaluation.

Electronic Nose – PEN 2

PEN 2 (Portable Electronic Nose – portable chemical sensor) of the company WMA Airsense Analysentechnik GmbH in Schwerin, is a rapid and robust identification system for gases and gas-mixtures. The proof of the gases is achieved by an arrangement of 10 different gas-sensors. Gaseous compounds are classified on the basis of the pattern being produced by the sensors and are recognized after one training step. The instrument obtains a simple and quick decision “good” or “bad”, “yes” or “no” with different software for the recognition of the patterns – depending on the training by the user.

Table 4: Description of the sensors of an electronic nose

Ser.no.	Sensor-name	General description	Reference
1	W1C aromatic	Aromatic component	**Toluol, 10 ppm**
2	W5S large spectrum	Highly sensitive, large spectrum, high-sensitive concerning nitrogen oxide and ozone, very sensitive on negative signal	**NO_2, 1 ppm**
3	W3C aromatic	Ammonia, utilization as sensor for aromatic components	**Benzol, 10 ppm**
4	W6S hydrogen	Mainly hydrogen, optionally breathing gas	**H_2, 100 ppm**
5	W5C aromatic-aliphatic	Aliphatic hydrocarbon, aromatic components, low pool-component	**propane, 1 ppm**
6	W1S large spectrum for methane	Sensitive for methane (environment) with ca. 10 ppm, large spectrum, similar to no. 8	**CH_4, 100 ppm**
7	W1A organic sulfur	Reacts on sulfur-components (H_2S, 0.1 ppm), on the other hand sensitive in terms of terpenes and organic sulphur components, which are essential for the odor (limes, pyrazine)	**H_2S, 1 ppm**
8	W2S large spectrum alcohols	For alcohols, partially aromatic components with large spectrum	**CO, 100 ppm**
9	W2W sulfur – chlorine	Aromatic components, organic sulfur components	**H_2S, 1 ppm**
10	W3S methane-aliphatic	Reacts on high concentrations > 100 ppm, sometimes very sensitive (methane)	**CH_4, 10 ppm**

The advantage in contrast to the human nose is to be seen in that such a system works impartially and does not tire. The signal is quantifiable and has an electronic shape. In comparison to the classical analysis in lab it is essentially cheaper and faster and enables utilization for the mass. It is possible to integrate it in automatic procedures and measuring systems or in alarm systems, as well. However, there is still sort of a problem with the long-term stability. The sensors can be contaminated by and by or be jammed, maybe by fat particles. So sensitivity and selectivity can change over time. Thus, they have regularly to be calibrated.

Processing of measurement

For the measurement with the electronic nose one sample-sac was filled for each sampling date. In terms of the gas composition it was to determine by means of a test measurement, how (on which canal) to adjust the dilution in order to avoid a too strong straining and therefore a higher wear-out failure of the sensors.

Subsequently all odor-samples of the pig-stabling´s air were measured by means of the electronic nose and analysed by the appendant software. The recorded patterns can be compared with the previous saved patterns of known substances. With the appendant software it is possible to extract from the signals two characteristic parameters, which are registered in an xy-diagramme and can reflect the “location” of the odor. This procedure is named Principal Components Analysis (PCA). Different odors reassemble in different sectors, which are partially clearly delimited from each other, but partially they also overlap.

Analysis

Climate in the barns

The assessed barn climate parameters were transferred from the data logger into the computer, brought into an excel-file and statistically analysed. Starting from the values, which had been assessed in 10 minutes-intervals the following was calculated: daily mean of 24 hours and daily maxima and minima. In order to elucidate the daily progression, especially in the animal area, temperature profiles were made by means of the 10-minutes-values for typical or extreme periods.

Primarily, the contents of carrier gas and noxious gas were measured with the goal to determine the barn-air´s concentration of noxious gases at animal level, especially in terms of ammonia (NH_3). Weekly, when the gas values had been read out, the daily mean, daily maximum and minimum were ascertained.

Statistical analysis

For the data daily weight gain and feed conversion the SAS proc glm was used. Treatment and barn were integrated as fix variables and the starting weight was taken as co-variable. The measuring points in the animal area were subsumed and the treatment´s effect on the ammonia concentration was tested by means of SAS proc glm as well.

Calculation of emissions

Ventilation rates and concentrations in the exhaust duct were raised in order to calculate the emissions. The data for the correction to biomass weight gain rely on the weighing data.

Feed analysis

The feed for grower- and finishing period were analysed by means of the Weender analysis in the labs of the AREC Raumberg-Gumpenstein. There could not be determined any deviations from the manufacturer´s data.

Slurry analysis

Slurry samples were taken at the end of grower- and finishing period always and were analysed in terms of the following parameters: dry substance, ash, nitrogen, ammonia nitrogen, pH-value, Ca, Mg, K, P, Na, Mn, Fe, Cu and Zn.

Results

In order to obtain a better comparability results are shown for growing period (day 1 to 35), finishing period (day 36 to 78) and for the total trial period (day 1 to 78).

Barn climate data

By means of permanent measurements all relevant climate data were assessed over the whole fattening period. Special regard was laid on the absolute comparability of control- and test barn. All periods of time, for which there was no absolute comparability given because of the weighing (these took place on Monday morning always), were removed for the general evaluation.

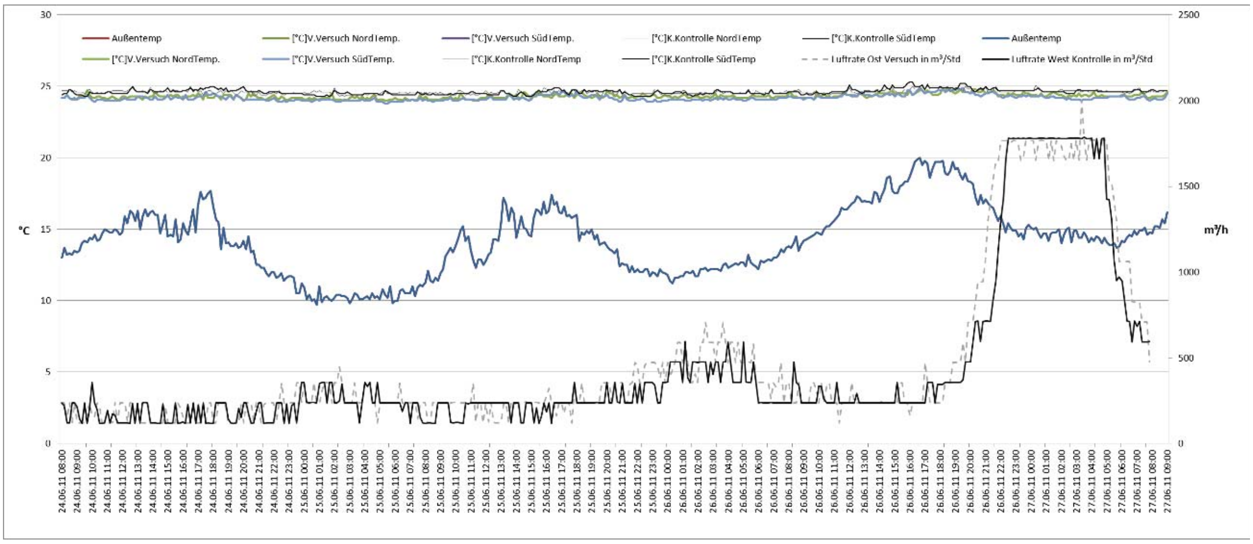

Figure 4: Processing of temperature in °C, ventilation rates in m³/h from 24-06-2011 until 27-06-2011

Figure 4 shows the equal temperature in the control and test barn beside large variations in temperature outside. According to DIN 18910 (1992), the relative humidity in animal housings without a heating system should lie in a range from 60-80 %. For housings with a heating system values from 40-70 % humidity are recommended (BEA, 2004). *Table 5* contains the most important parameters in comparison.

Table 5: Mean values of temperature and rel. humidity

	Temperature (°C)		Humidity (%)		Temperature (°C)	Humidity (%)
	Control	FF+	Control	FF+	Outside	Outside
Growing period (day 1-35)	24.6	24.5	60.7	59.8	11.5	65.3
Finishing period (day 36-78)	24.9	24.9	56.8	55.2	16.4	71.9
Total (day 1-78)	24.7	24.7	58.2	57.5	13.9	68.6

Noxious gases

Ammonia concentration

Table 6 shows all LS mean values from 3 measuring points at animal level in growing and finishing period as well as the difference between the treatments. In the test barn (FF+) an average of 17.5 ppm NH_3 and in the control barn 22.3 ppm NH_3 was measured, which is a reduction by 21.5%. This reduction of the ammonia concentration also means an improvement for the well-being and health of the animals.

Table 6: LS Means of ammonia concentration (ppm) in the animal area and reduction (%)

	Grower	Finisher	Total
Control	29.5	15.2	22.3
FF+	23.4	11.8	17.5
Reduction in %	20.9	22.3	21.5
p-value	0.0112	0.0065	0.005
SEM	0.9786	0.4608	0.6215
R^2		0.88	

Figure 5 illustrates the results with an ammonia concentration reduction of 20.9 % in the grower-period and 22.3 % in the finisher-period compared to the control barn – therefore an overall reduction potential of 21.5 % resulted through the feed additive "Fresta® F Plus". The daily feed intake and the daily weight gain were 7.4 % and accordingly 8.4 % higher. Therefore, an increased nitrogen uptake resulted in the treated groups, which explains the somewhat smaller reduction of the ammonia concentration – compared to the previous results.

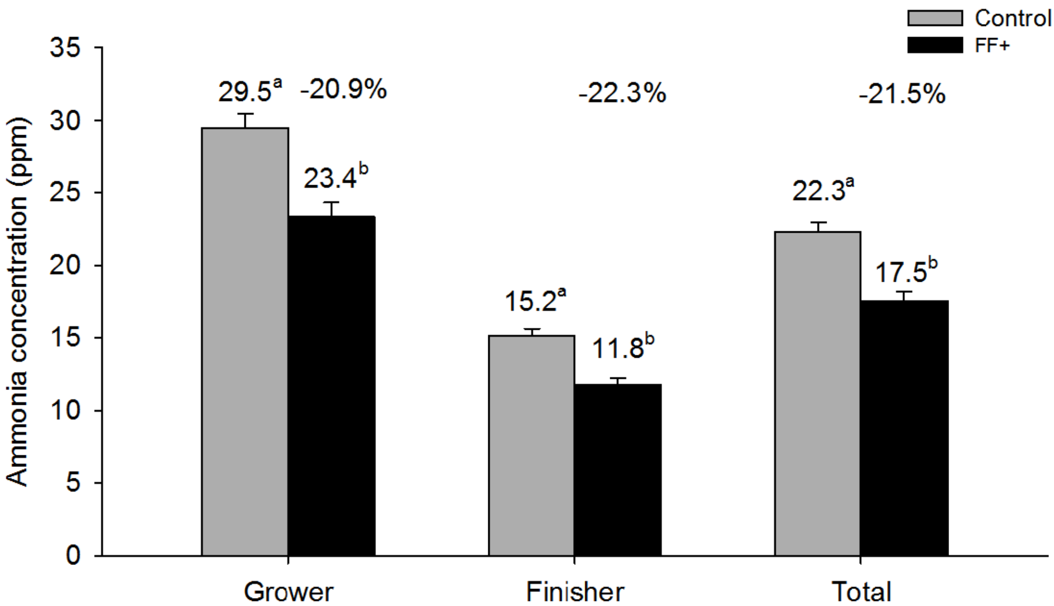

Figure 5: LSMeans of the ammonia concentration (ppm) in the animal area and differences (%)

In *table 7* the large difference between ammonia concentration in the animal area and 20 cm beneath the slatted floor is shown.

Table 7: Mean values of ammonia concentration (ppm) at animal level and 20 cm beneath the slatted floor as measured by INNOVA 1412

	Control		FF+	
	Animal area	Beneath slatted floor	Animal area	Beneath slatted floor
Growing				
Mean	29.2	64.9	26.14	55.3
SD	8.7	30.4	10.6	31.2
Finishing				
Mean	16.1	46.7	12.3	36.8
SD	6.14	30.0	6.16	23.3
Total				
Mean	21.2	53.8	17.7	44.0
SD	9.65	31.4	10.6	28.1

Comparing the continuously assessed values of the new measuring technique with the regularly accomplished manual measurements (carried out by means of the Dräger X-am 7000 in order to ensure the results in case of a possible breakdown of the equipment), only very small deviations were detected. In the test barn a mean value of 17.2 ppm was achieved (standard dev. 12.52), in the control barn the mean value was at 20.76 ppm (st.dev. 10.04). This assures the results from previous trials, which were exclusively carried out with the Dräger devices.

Carbon dioxide

As a metabolism product of the animals´ respiration carbon dioxide is to be found in all housings. Small amounts of carbon dioxide have their origin in the degradation of excrements, urine and rests of feed. An increased concentration of carbon dioxide, however, indicates insufficient ventilation. The level of carbon dioxide concentration in the barn is determined by the animals´ age, their performance and their number as well as by their activity (UNRATH, 2004). According to MOTHES (1977) the highest concentrations of carbon dioxide in barns are to be found at ground level as well as at the ceiling. The author´s explanation for this fact is that carbon dioxide is water-soluble at different temperatures. Different concentrations of carbon dioxide in the daily processing are therefore to be ascribed to increased metabolism after eating.

Table 8: Mean values of the carbon dioxide concentration (ppm) in the animal area and 20 cm beneath the slatted floor

	Control		FF+	
	Animal area	Beneath slatted floor	Animal area	Beneath slatted floor
Growing period				
Mean value	3,391	3,841	3,260	3,613
SD	1,063	1,051	999	1,228
Finishing period				
Mean value	1,805	1,934	1,936	2,908
SD	685	1,276	792	784
Total				
Mean value	2,422	2,676	2,451	3,183
SD	1,151	1,513	1,090	1,039

Ventilation rate

The ventilation rates accounted for 329 – 454 m³/h. In the growing period lower ventilation rates were measured, because there were lower outside temperatures at that time. However, the nearly identical values of the stables reflect a good comparability in terms of stable climate again.

Table 9: Ventilation rate of both stables

	Unit	Control	FF+
Ventilation rate grower	m³/h	332	329
Ventilation rate finisher	m³/h	554	550
Ventilation rate total	m³/h	454	451

Olfactory examinations

The samplings and evaluations for the olfactory examinations, electronic nose included, took place on 4th and 11th May as well as on 3rd, 14th and 27th of June, 2011. The sampling on 27th of June was carried out one day before the end of the trial before slaughtering of the first animals.

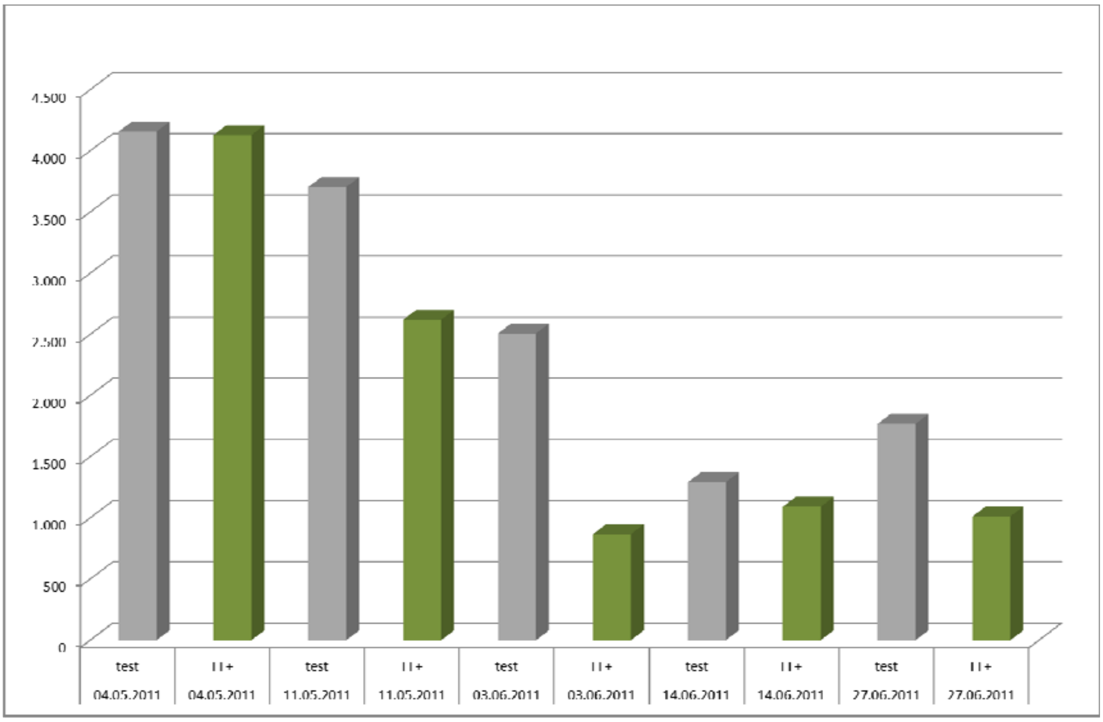

Figure 6: Odor threshold values (OU/m³) in comparison

In the present trial the measurements showed an average reduction of 27.6 % concerning the odor units. Generally, the assessed data – lying between 670 and 5,363 OU/m³ – are to be judged as being in a range, which is usual for practice.

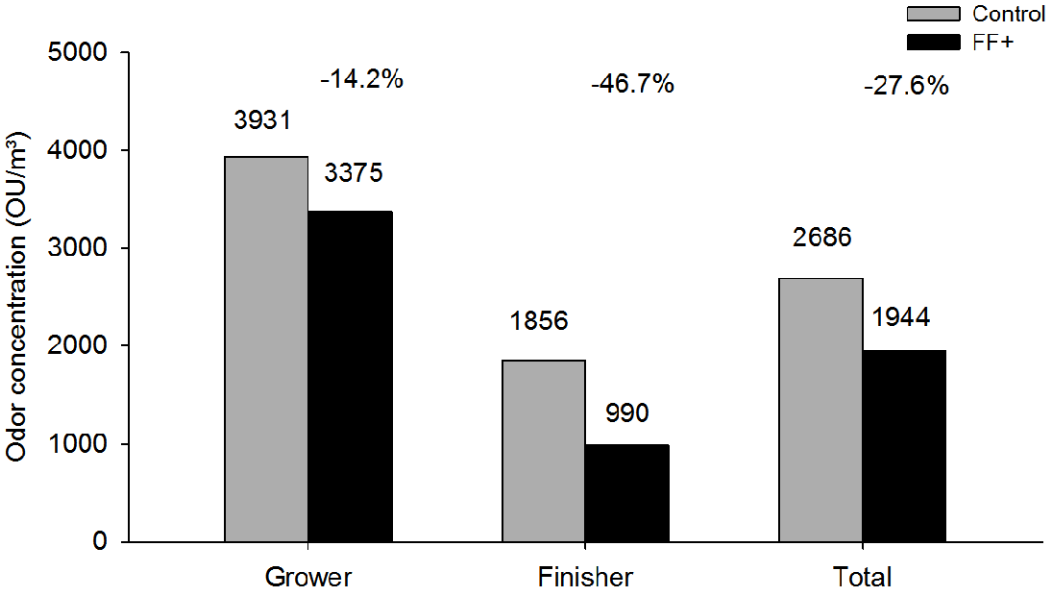

Figure 7: Odor concentrations (OU/m³) in growing, finishing and in total as well as differences in %

In order to find out a correlation between odor and ammonia, the mean values for both compartments were contrasted in *table 10*. Regarding the reduction potentials in the respective fattening period and accordingly in the total view, it will soon be clear that indeed we can speak of a distinctive correlation between odor and ammonia.

Table 10: Odor units (OU/m³) and ammonia concentrations (ppm) in the air samples and differences (%)

		OU/m³	Difference OU (%)	NH_3 in ppm	Difference NH_3 (%)
Growing	Control	3,931		25.0	
	FF+	3,375	-14.16	22.0	-13.75
Finishing	Control	1,856		20.0	
	FF+	990	-46.69	14.0	-29.79
Total	Control	2,686		22.1	
	FF+	1,943	-27.64	17.1	-22.45

Electronic nose PEN 2

In the following figures the results of the odor-tests carried out with the electronic nose PEN 2 are presented. The listing of 10 gas-sensors (*table 4*) gives an overview on the composition of odor.

PCA-Analysis

The control- and FF+ data from all measurements were subsumed in a figure (classes: control and test FF+) – evaluation on the 1st and 2nd principal axis. It is important that results of different samples of one class lie closely together. The analysis of the main components (Principal Component Analysis – PCA-analysis) can deliver a very good differentiation of the different classes. This means, the air composition of the stable "FF+" changed through the utilization of the feed additive, whereby odor intensity/strongness were similar in both compartments, though (distribution of the data points on the abscissa).

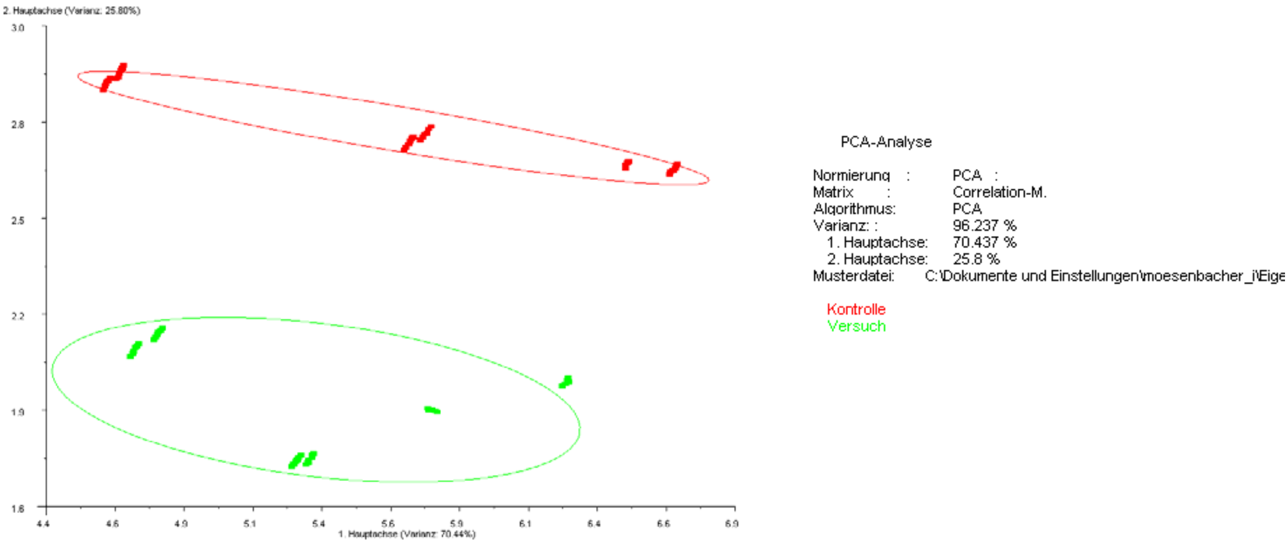

Figure 8: PCA-analysis

For the evaluation of the distinct measuring files always one sample of the test and of the control stablewas chosen, in order to demonstrate the measuring data of odor composition in a circle diagram. During the processing of one measurement (50 sec.) for both samples higher resistance values arose at the sensors 8 and 9.

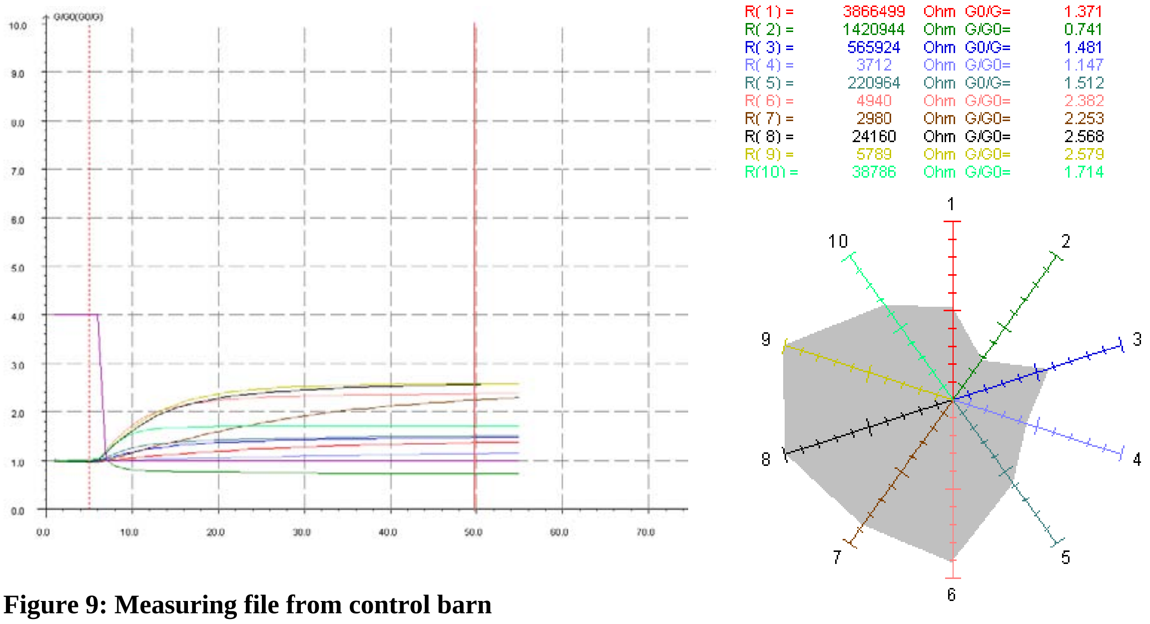

Figure 9: Measuring file from control barn

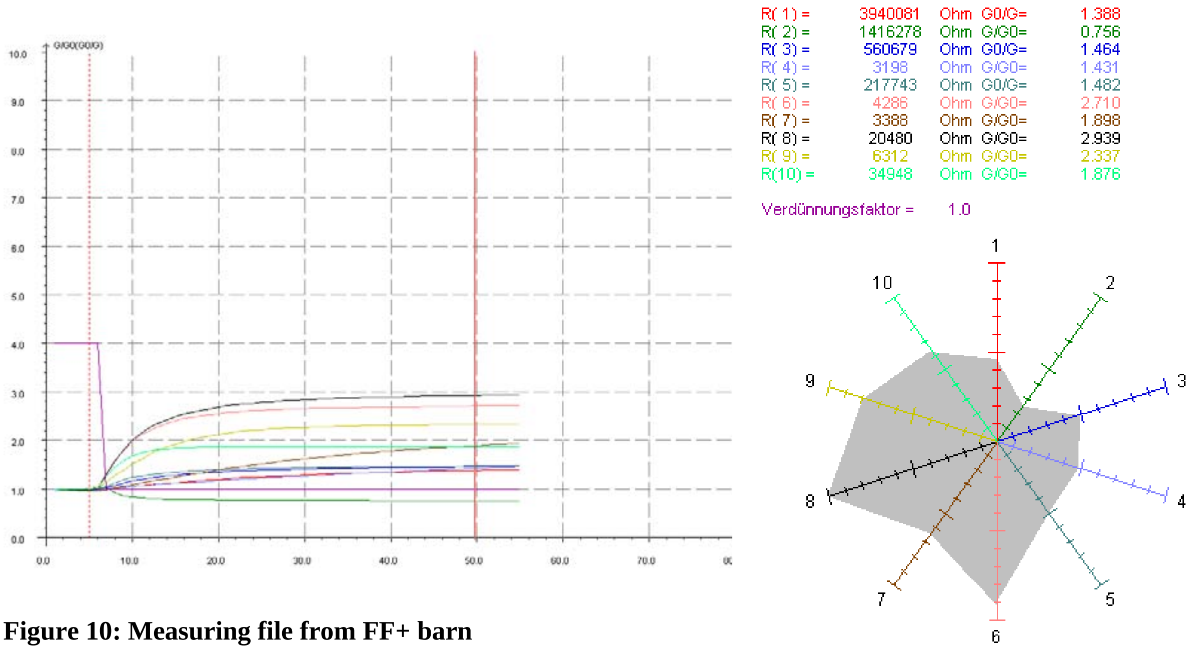

Figure 10: Measuring file from FF+ barn

Feed composition

The feed mixtures were produced from the same raw material batches for both groups. Formulations from the trial of the year 2010 were used.

Table 11: Composition and analysed content data from grower and finishing feed

Raw material	Unit	Grower	Finisher
Wheat	%	33.930	36.425
Corn	%	18.000	17.800
Barley	%	16.500	17.500
Soya HP	%	14.000	9.000
Rape extract bruised grain	%	5.000	6.500
Wheat bran	%	3.000	3.000
Molasses	%	2.000	2.000
Soya oil	%	1.000	1.000
Carbonic feeding lime	%	1.200	1.300
Mono-calcium phosphate	%	0.100	0.100
Salt (NaCl)	%	0.500	0.500
Amino acids & premix	%	4.570	4.675
FF+VM and placebo, resp.	%	0.200	0.200
Parameter	**Unit**	**Grower**	**Finisher**
Crude protein	%	20.70	18.71
Crude fibre	%	3.27	3.32
Crude fat	%	3.83	3.53
Ca	%	0.83	0.87
P	%	0.50	0.52
Na	%	0.24	0.24

Water consumption

The water consumption was recorded as well. The differences (in l) are shown in *table 12*. In the FF+ group a total of 13,220 l water was determined. In contrast there was a water consumption of 11,390 l in the control group. The higher water consumption can be explained by the increased feed intake and accordingly the increased weight gain of the test group.

Table 12: Processing of the water consumption in l

Assessment date	Test FF+	Control	Difference
18-04-2011	880	760	120
26-04-2011	2,070	1,660	410
02-05-2011	3,000	2,370	630
09-05-2011	4,210	3,270	940
16-05-2011	5,520	4,300	1,220
23-05-2011	6,800	5,330	1,470
30-05-2011	8,310	6,550	1,760
06-06-2011	9,510	7,680	1,830
14-06-2011	10,860	8,990	1,870
28-06-2011	13,220	11,390	1,830

On 25th of May, 2011, a failure occurred at the water pipe in the stabletest FF+, which was immediately repaired and correctly pictured in *table 12*.

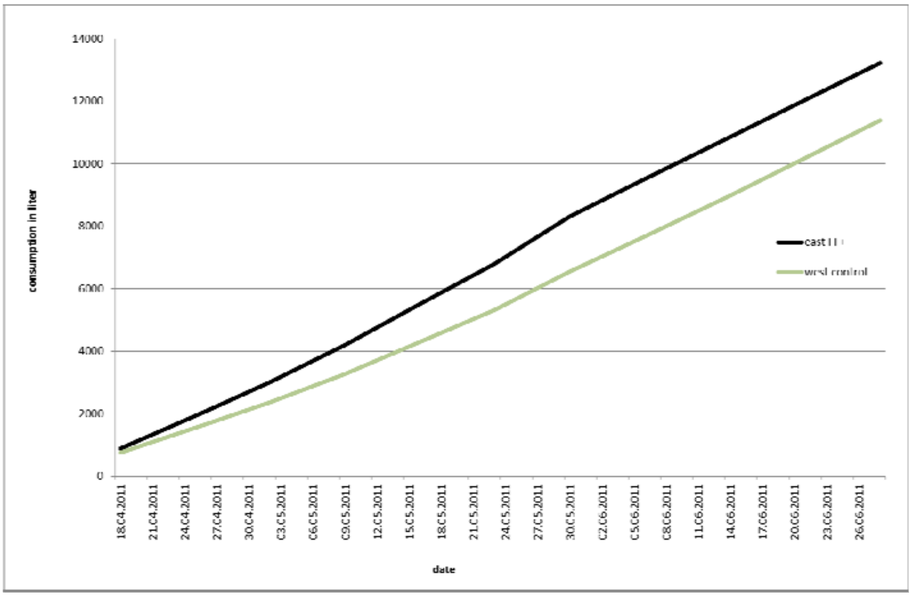

Figure 11: Contrasting of the water consumption under influence of the feed additive FF+

Performance parameters

The feed intake in kg per animal was higher in the FF+ group by 1.09 kg on average. Besides a higher ammonia concentration this also explains the larger water consumption of the test group.

Table 13: Mean values and standard deviation of the daily feed intake (kg) per pen with 8 animals each

	Control		Test FF+	
	Pen 1	Pen 2	Pen 1	Pen 2
Growing				
Mean	12.74	13.81	14.3	14.27
SD	1.67	2.04	2.08	2.03
Finishing				
Mean	16.20	17.18	17.97	17.73
SD	2.22	2.37	2.40	2.06
Total				
Mean	14.62	15.65	16.3	16.16
SD	2.64	2.78	2.93	2.63

Comparing the performance data of the two groups, the growing period shows a significantly higher feed intake because of the feed additive. For the whole fattening period the animals of the FF+ group had a higher weight gain of 64 g per animal and day compared to the control group. These are 8.6 % more. With 9 g per animal and day the feed intake only increased by 5.8 % . This implies an improved feed conversion in the FF+ group. In the growing period feed conversion by FF+ was about 4 % higher than in the control group.

Table 14: LSMeans of the daily weight gain (g/animal), mean values of feed intake (kg/animal) and feed conversion (kg/kg)

	Daily weight gain g		Feed intake* kg		Feed conversion kg/kg	
	Control	FF+	Control	FF+	Control	FF+
Growing						
LSMean	742	823	1.66	1.79	2.27	2.18
SEM	21	22			0.070	0.072
p-value	0.013				0.378	
Finishing						
LSMean	751	801	2.08	2.18	2.73	2.74
SEM	18	19			0.065	0.067
p-value	0.069				0.880	
Total						
LSMean	747	811	1.89	2.00	2.52	2.48
SEM	16	17			0.054	0.056
p-value	0.011				0.637	

Analysis of slurry

At the end of the trial (1st slaughtering) samples of the slurry were taken of each stable and finally evaluated in the lab.

Table 15: Amounts of slurry and nitrogen contents in total and per kg body weight gain

Treatment	Amount inl	N total (kg)	NH4-N (kg)	N/kg weight gain (g)	NH4-N/kg weight gain (g)
Trial FF+	11,491	37.6	25.9	37.8	26.0
Control	9,828	36.4	24.6	39.0	26.4

Because of the already mentioned failure of the water pipe in the FF+ stable (25th of May, 2011) 1,663 l water came into the slurry area. This is also apparent regarding the dry matter content of the sample, which had been taken at the end of the trial. In order to get a better comparability the slurry amounts were corrected by this difference quantity. According to the higher feed intake the total nitrogen and ammonia nitrogen are higher in the FF+ group. Calculations on total nitrogen and ammonia nitrogen quantities per kg body weight gain show a reduction of 3.01% and 1.23%.

Table 16: Results of the analysis of slurry per kg fresh weight (sampling date)

	Treatment	DM	Ash	Ca	Mg	K	P	N	NH_4-N	pH
Grower	**FF+**	32.25	8.64	0.95	0.58	2.16	0.59	2.51	1.98	7.15
	Control	31.18	9.79	0.92	0.51	2.42	0.55	3.22	2.40	7.13
Finisher	**FF+**	32.30	10.06	0.95	0.60	2.06	0.68	3.27	2.25	7.05
	Control	42.30	12.03	1.09	0.69	2.52	0.77	3.70	2.50	6.87

Emissions

Ventilation rates and concentrations in the exhaust duct delivered the base for the calculation of the emissions. In order to achieve comparable results, g per kg body weight gain was chosen as reference value for all emission parameter. Odor emissions were additionally converted into the unit OU/s*GVE (odor units per second and livestock unit), to allow the comparison with international data.

Ammonia emissions

Figure 12 shows the reduction in terms of ammonia emissions, which could be achieved by means of FF+. Regarding the whole fattening period ammonia emissions decreased on average by 19.34 % in the FF+ group, in the finishing period the reduction was at 24 % in compared to the control group.

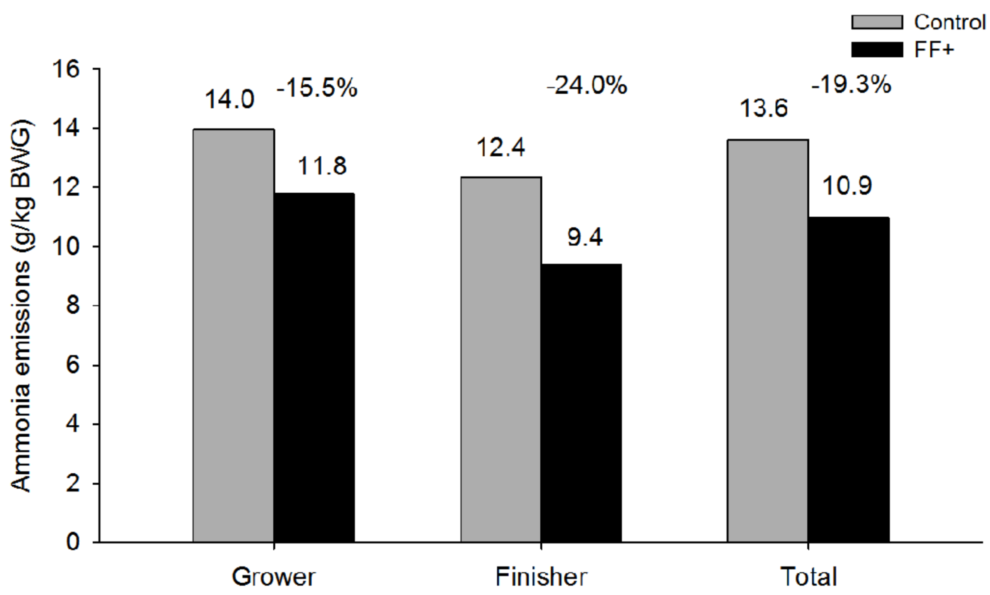

Figure 12: Ammonia emissions (g/kg body weight gain) and reduction (%) by FF+

After further discussions and a comparison of the ammonia emission in g/fattening place/year it is shown that the values from the test housings are 630 g/fattening place lower (*table 17*). The general data comply with international values, e.g. 3 kg NH_3/fattening place/year (DÖHLER et al., 2002).

Table 17: Ammonia emissions per kg weight gain, per animal (80 kg increase), per fattening place and reductions

	Control	FF+	Diff. %
Emission grower g/kg weight gain	13.97	11.80	- 15.52
Emission finisher g/kg weight gain	12.35	9.39	- 24.02
Emission total g/kg weight gain	13.61	10.98	- 19.34
Emission g/animal 30-110 kg	1,089	878	- 210g
Emission kg/fattening place/year	**3.26**	**2.63**	**- 631g**

In Austria reference values exist in the context of the PRTR-guideline (intensive husbandry and aquaculture), whereby the national assessment framework (KTBL 2006) shows the range of NH_3-emissions, which are caused by the type of the housing system (covering), kind of ventilation, average room temperature, ventilation rate, N/P-reduced feeding, phase-feeding and the storage period of manure in the housings. Regarding the situation in the housings, emission factors of fattening pigs achieve values of ca. 1 kg up to ca. 5.5 kg NH_3/animal unit and year.

Austria registers ammonia emissions on a level of 63,000 t per year caused by livestock husbandry. This corresponds to 86 % of the total emission (source: Federal Office for Environment – UMWELTBUNDESAMT, 2009). About 27 % of this value is to be assigned to pig husbandry. Regarding the potential of emission reduction concerning the total of the national situation, it is shown that the feed additive “Fresta® F Plus“ could provide the economization of about 2,700 t per year.

Carbon dioxide emissions

Causing emissions of 527 up to 660 kg per animal unit and year carbon dioxide (as typical process gas, lesser as noxious gas) is an important trace gas in pig husbandry. However, as a direct main product in the process chain of the organism "pig" it is not to be avoided (HÖLSCHER, 2006). In the present trial the carbon dioxide emissions could be lowered onto 494 kg CO_2/animal unit/year.

Table 18: Carbon dioxide emissions per kg increase, per animal (80 kg weight gain), per fattening place and reductions

	Control	FF+	Diff. %
Emission grower g/kg weight gain	2,279	2,023	- 11.25
Emission finisher g/kg weight gain	2,005	1,958	- 2.32
Emission total g/kg weight gain	2,216	2,059	- 7.07
Emission g/animal 30-110 kg	177	164	- 12 g
Emission g/fattening place/year	**532**	**494**	**- 38 g**

Regarding the whole trial the average reduction ratio lay at -7 % (*figure 13*). The highest reduction of carbon dioxide emissions was assessed in the grower period, showing a reduction of -11.3 %.

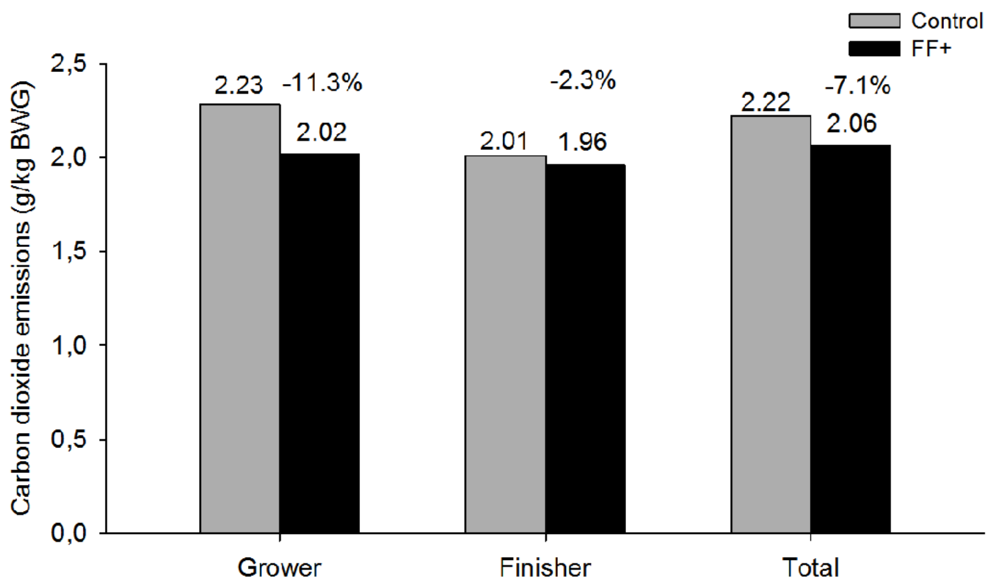

Figure 13: Carbon dioxide emissions (g/kg weight gain) and reduction (%) by means of Fresta F+

Odor emissions

As a link to the ammonia and carbon dioxide data the values of odor emissions per kg weight gain were indicated as well. Here a result of 2.45 MOU (millions odor units) per kg weight gain in the control stablecomes about in contrast to 1.65 MOU in the stableFF+ (*table 19*).

Table 19: Odor emissions (MOU/kg weight gain) and reduction (%)

	Control	FF+	Diff. %
Growing period MOU/kg weight gain	2.64	2.09	-20.70
Finishing period MOU/kg weight gain	2.05	1.02	-50.05
Total MOU/kg weight gain	2.45	1.65	-32.62
Emission MOU/animal 30-110 kg	196	132	- 64 MOU
Emission MOU/fattening place/year	**588**	**396**	**- 219 MOU**

Calculated in percentages these are reduction values of -20.7 % in the grower period and -50 % in the finishing period caused by the product "Fresta® F Plus" – as total reduction over the whole trial arises a result of -32.6 %, referring to the odor units per kg live weight gain (*figure 14*).

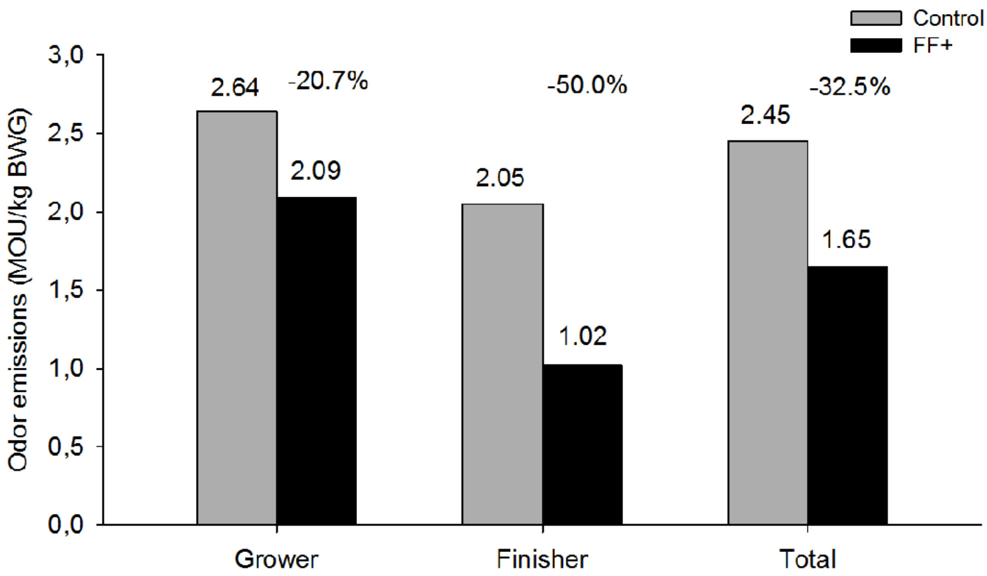

Figure 14: Odor emissions (MOU/kg body weight gain) and reduction (%)

In order to be able to compare the odor emissions on the basis of internationally provided data, additionally, the conversion of the values into the unit OU/s*GVE (odor unit per second and livestock unit) took place.

This unit of measure predominates in the ambit of odors and accordingly primarily serves as data basis for the accomplishment of atmospheric dispersion modelling in connection with odor emission factors (conventional values). As a rule these factors are not calculated and/or estimated, because a few years back the data base in the ambit of odor (above all the measurement of emissions by means of olfactometry) was relatively small, yet.

According to the VDI-guideline 3894-IE (2009) for fattening pigs up to 120 kg (liquid manure/manure) conventional values of 50 OU $s^{-1}GV^{-1}$ are assumed. The references concerning odor emissions in pig fattening, however, reach from 25-1,100 OU $s^{-1}GV^{-1}$ (GALLMANN, 2011), so the presently measured values at the AREC can be said to lie in an absolutely acceptable range. During the trial at the AREC

Raumberg-Gumpenstein emission mass flow rates of 141.26 OU $s^{-1}GV^{-1}$ arose in the control stableand 101.41 OU $s^{-1}GV^{-1}$ in the test FF+ stable– here the reduction lies at -28.21 %.

Table 20: Data of odor emissions in OU/s*GVE

	Control	FF+	Diff %
Growing period OU/s*GVE	151.05	128.50	14.93
Finishing period OU/s*GVE	119.01	62.99	47.07
Total OU/s*GVE	**141.26**	**101.41**	**28.21**

Economical calculation

As having done for the calculation of the emissions, as well, the weight gain per fattening pig was corrected onto 80 kg (fattening from 30 up to 110 kg) for the calculation of profitability on the basis of the available test data. Per fattening pig accrued feed costs of 64.59 € in the control group and 63.81 € in the FF+ group; this yields a profit of 78 cent per fattening pig. Regarding the assessed ammonia reduction of 210 g per fattening pig, 4.76 fattening pigs are fed for 1 kg ammonia reduction. Therefore arises a gain of 3.73 €.

Table 21: Calculation of profitability for fattening pigs with 80 kg standardised weight gain

	Control	FF+
Feed costs (€/t)	320	323
Feed conversion growing period (kg/kg)	2.27	2.18
Feed conversion finishing period (kg/kg)	2.73	2.74
Weight gain grower (kg)	36.0	38.7
Weight gain finisher (kg)	44.0	41.3
Weight gain in total (kg)	80	80
Feed costs grower (€/kg weight gain)	0.726	0.704
Feed costs finisher (€/kg weight gain)	0.874	0.885
Feed costs in total (€/kg weight gain)	0.807	0.798
Ammonia emissions (g/kg weight gain)	13.6	11.0
Costs per animal (€)		-0.78
Costs per fattening comp. and year (€)		-2.35
Costs/kg ammonia reduction (€)		-3.73

Conclusion

The feed additive “Fresta® F Plus“ (Delacon, Austria) was tested on reduction of noxious gas and odor emissions in pig fattening in the trial facilities of the AREC Raumberg-Gumpenstein. The effect of product on concentrations had already been shown in a former trial in the year 2010. In the current trial the emission parameters could be calculated for the first time, because beside the contents of gas also the ventilation rates had been recorded. One goal was the examination of the previous results with the aid of modern measuring techniques and the integration of the feed additive into the BAT-list. This question is to be answered with Yes due to the available results. The tested feed additive “Fresta® F Plus“, which causes a reduction of emissions of ammonia and odor and therefore improves stable climate as also concentrations in the barns can be achieved, should in future be able to be utilized as reduction measure by farms, which belong to the IED (IPPC)guideline because of their size. The utilization, however, is also recommended for every other structural farm size in pig-fattening.

By using the tested feed additive no extra cost accrue for the reduction of ammonia and odor because of the improved feed conversion. In the current trial an improved profitability of 2.35 Euro/fattening place/year was calculated. The feed additive “Fresta® F Plus“ reduces the content of ammonia in the air of housings, and therefore improves the whole stable climate. This positive effect can be seen in relation to a more stable animal health and, above all, verifiably in relation to a reduction of emissions and nuisance as well.

The tested feed additive is to be valued as emission reducing technique in pig-fattening and is therefore an alternative for exhaust air treatment.

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