Danish Agriculture & Food Council
Pig Research Centre

VERA TEST REPORT

JH Forsuring NH4+

Jørgen Hyldgaard Staldservice A/S

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PUBLISHED:	31 MARCH 2014
REVISED	28 APRIL 2016

Foreword

This report describes the results of the VERA test of the "JH Forsuring NH4+" acidification system (version 1) from the company Jørgen Hyldgaard Staldservice A/S at two farms with finishing pig facilities. The VERA test was performed in accordance with the Test Protocol for Livestock Housing and Management Systems (Version 2, 2011-29-08). The test at location A was performed between November 2010 and November 2011. This test started before the initiation of the VERA programme, and therefore supplementary measurements in compliance with the Test Protocol were performed between 9 June 2012 and 1 May 2013. The test at location B was performed between 16 April 2012 and 15 April 2013. Both tests were performed in accordance with the Pig Research Centre's quality assurance system – ISO 9001:2008 and as a DANAK accredited laboratory according to ISO/IEC 17025 – TEST Reg. no. 524.

Producer of the "JH Forsuring NH4+" acidification system:

Jørgen Hyldgaard Staldservice A/S
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Denmark

The tests were performed at:

Test location A	Test location B
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7500 Holstebro	6971 Spjald
Denmark	Denmark

Test organisation:

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31 March 2014 | Anders Riis

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Introduction

In recent years, there has been a growing interest in reducing odour and ammonia emissions from pig production facilities in Denmark and other European countries. This has resulted in several companies developing technologies for odour and ammonia reduction from pig units. One of these is the Danish company Jørgen Hyldgaard Staldservice A/S, which has developed the “JH Forsuring NH4+” acidification system.

A previous study of an acidification system from the company Staring Maskinfabrik A/S in 2002-03 showed a 70% reduction in ammonia emissions from a finishing pig house [1]. In this system, acidification of the slurry was supplemented by aeration of the slurry. This system is currently marketed by the Danish company Infarm A/S.

Daily treatment of the manure by the “JH Forsuring NH4+” acidification system from Jørgen Hyldgaard Staldservice A/S is performed by flushing the manure to a process tank where sulphuric acid (96%) is added under continuous stirring. When the pH reaches 5.5, a small amount of the manure is pumped to a storage tank. The rest of manure is then pumped back to the facility. Compared with the system from Infarm A/S, no aeration takes place in the system from Jørgen Hyldgaard Staldservice A/S.

The international measurement protocols for environmental technology (VERA) must ensure that the test is performed identically in different countries so that the results can be transferred between countries. The aim of the present VERA test was to document the operational reliability and the ammonia and odour reduction efficiency during an entire year at two farms with finishing pigs using the “JH Forsuring NH4+” acidification system from Jørgen Hyldgaard Staldservice A/S. The test on each farm was performed as a case-control study. The system’s ability to reduce dust was not evaluated in this test, since no effect was expected.

Materials and Methods

The “JH Forsuring NH4+” acidification system from Jørgen Hyldgaard Staldservice A/S was installed at two farms with finishing pig units (locations A and B).

Test location A: The finishing pig house consisted of six identical units. Each unit consisted of 12 pens and a total of 192 pig places. Each unit was 14.7 m long and 11.4 m wide. The walls in the unit were 2.6 m high, and the ceiling had a 20 degree roof pitch. Each pen was 5.2 m long and 2.25 m wide. The floor consisted of 1/3 drained floor and 2/3 slatted flooring (see Figure A1 in the appendix). The pigs were fed restricted liquid feed. Between each batch of finishers, the finishing pig unit was cleaned, disinfected and dried before new pigs entered the unit. The unit had a system for vacuum flushing of the slurry. The slurry channel was 60 cm

deep. The ventilation system consisted of wall inlets and two exhaust outlets in each unit. During the first test period at location A, two units were used as experimental units and two units were used as control units:
Unit 1: Control
Unit 2: Control
Unit 3: Experimental
Unit 4: Experimental
Unit 5: No experiments
Unit 6: No experiments

Pigs weighing 30 kg entered the control and experimental units two by two, so the number and weight of the animals were identical in units 1 and 3 and in units 2 and 4.

During the second test period at location A, one unit was used as an experimental unit and one unit was used as a control unit:
Unit 2: Control
Unit 3: Experimental

The number and weight of the animals were identical in units 2 and 3 during the second test period. The management in both the control and experimental units was similar. However, in the experimental units, the manure was treated daily with sulphuric acid. In the control units, the manure in the slurry channels was emptied to storage when necessary.

The “JH Forsuring NH4+” acidification system at location A consisted of a process tank that can contain a volume of 400 m^3 of manure. In the process tank, two pH electrodes are automatically rinsed with water before the manure enters the process tank. The manure from the experimental units is flushed into a pump well through 315 mm tubes. From the pump well, the manure is pumped to the process tank. Stirring of the manure in the process tank begins, and back-flushing of the tube system underneath the pig house takes place. After 10-20 minutes of stirring, sulphuric acid (96%) is added to the manure under continuous stirring in the process tank. The sulphuric acid is kept in an acid tank containing a volume of 42 tons of sulphuric acid. After 30-60 minutes, the stirring stops and the pH has now reached a level of 5.5. Depending on the time when the daily acidification is set to run, manure is pumped to a storage tank until a preset minimum level in the process tank is reached. The rest of the manure is then pumped back to the slurry channels in the experimental units through 160 mm tubes. The process is automatically controlled by valves placed in the tubes. All processes such as stirring, pumping, addition of sulphuric acid and measurement of pH values are controlled automatically via a control unit, and the values are logged. The logged values are uploaded to a web server, which enables the farmer or technician to monitor and verify that the installation is running as intended.

Figure 1. The “JH Forsuring NH4+” acidification system at location A.

Test location B: Test location B consisted of two pig houses, each divided into two units (see Figure 2). Units 1 and 3 were 37 m long, 13 m wide, had a wall height of 2.6 m and consisted of 32 pens and a total of 640 pig places. Units 2 and 4 were 42 m long and 13 m wide, had a wall height of 2.6 m and consisted of 36 pens and a total of 720 pig places. Each pen was 6.0 m long and 2.2 m wide. The floor consisted of 4.0 m slatted flooring and 2.0 m drained flooring (see Figure A2 in the appendix). The pigs were fed restricted liquid feed. Between each batch of finishers, the finishing pig unit was cleaned, disinfected and dried before new pigs entered the unit. The units had a system for vacuum flushing of the slurry. The slurry channel was 50 cm deep. The ventilation system consisted of an air inlet through a diffuse ceiling and five exhaust outlets in each unit. A supplementary air inlet was placed above each pen, four meters from the wall side. The supplementary air inlet was set to open when the temperature inside the pig unit exceeded the set point temperature by three degrees Celcius.

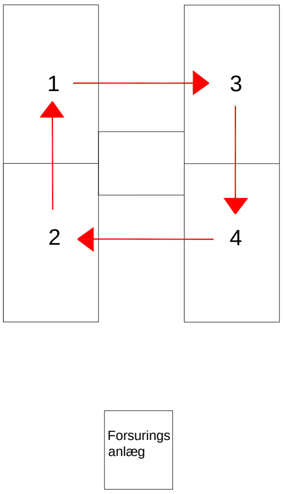

Figure 2. The site plan for the two pig houses at location B, each of which is divided into two units. The red arrows indicate the entry strategy of the pigs.

To align the average weight between the control and experimental groups, two experimental units and two control units were used. The 30 kg pigs entered the units in the following order, with a one-week interval between them:

- 1st entry: unit 1 – experimental
- 2nd entry: unit 3 – control
- 3rd entry: unit 4 – control
- 4th entry: unit 2 – experimental

The management in both the control and experimental units was similar. However, in the experimental units, the manure was treated daily with sulphuric acid. In the control units, the manure in the slurry channels was emptied to storage when necessary.

The "JH Forsuring NH4+" acidification system at location B was identical to the system at location A (Figure 2). However, the process tank could contain a volume of 315 m^3 of manure at location A.

Figure 2. The "JH Forsuring NH4+" acidification system at location B.

Data recording

Test periods

For both locations, the farm was visited by a technician from the Pig Research Centre every second week during the test period. Besides the recordings of the performance of the "JH Forsuring NH4+" acidification systems every second week, measurement days were carried out during the year in order to investigate the ammonia and odour reduction efficiency (see the test periods below).

An agreement was made between the herd owner and the Pig Research Centre that Jørgen Hyldgaard Staldservice A/S should regularly check the performance of the "JH Forsuring NH4+" acidification systems at both locations. If a system failure occurred, then the Pig Research Centre would be contacted. Time spent on service and maintenance was recorded in a logbook during the test period.

Test location A:

The test at location A was performed between November 2010 and November 2011. During this test period at location A, four batches of finishers were produced in each of the four participating finishing pig units, corresponding to a total of 3,048 finishers (31.1 – 109.3 kg). The ammonia emission from the four batches of pigs was measured continuously using electrochemical sensors. However, these measurements were started before the initiation of the VERA programme, and therefore supplementary ammonia emission measurements in compliance with the Test Protocol were performed on 32 days between 9 June 2012 and 1 May 2013. During the first test period, odour measurements were taken on eight days between 13 July 2010 and 12 October 2010 in the summer period. Since two control units and two experimental units were used during the first test period, only two only odour samples were collected in each unit on each measurement day. To fulfil the Test Protocol, odour measurements were taken on five days in the autumn, winter and spring of the second test period between 31 October 2012 and 1 May 2013. In the second test period, only one control unit and one experimental unit were used, and therefore three odour samples were collected in each unit on each measurement day. The consumption of sulphuric acid at location A was recorded during the first test period. The service and maintenance costs were recorded during both test periods.

Test location B:

The test at location B was performed between 16 April 2012 and 15 April 2013. During this test period at location B, four batches of finishers were produced in each of the four finishing units, corresponding to a total of 10,600 finishers (34.5 – 107.4 kg). Measurements of the ammonia emission in compliance with the Test Protocol were performed on 48 days between 16 April 2012 and 7 February 2013. Odour measurements were taken on nine days in the summer period and on five days during the rest of the year. On ten measurement days, odour samples were taken in two control units and two experimental units, and therefore only two only odour samples were collected in each unit on each measurement day. On four measurement days during the summer period, odour samples were taken in one control and one experimental unit, with three odour samples in each unit. The consumption of sulphuric acid and electricity and the service and maintenance costs were recorded between 16 April 2012 and 15 April 2013. The feed composition and feed consumption are listed in Tables A1 and A2, respectively.

Primary measurements

Ammonia measurements

During the year, the ammonia concentration was measured on a continuous basis using an INNOVA 1412 photoacoustic gas analyser. Air was supplied via an INNOVA 1309 Multipoint Sampler. Data from the gas analyser were logged using software Type 7850, and there were ten repeated measurements per channel before switching between measurement points. Only the last measurement per channel was used in the data treatment. A number of 15 to 23 measurements per day went into the calculation of the daily mean values. The ammonia concentration was measured in the exhaust air from both the control and experimental units and in the outdoor air. The measured concentration of ammonia in the outdoor air was close to the detection limit of the method used and therefore no correction of background was done. Throughout the measurement periods, control measurements of the ammonia concentration were taken using Kitagawa gas detector tube 105SD.

Odour measurements

The odour measurements were taken by collecting a representative volume of air in the exhaust air from both the control and experimental units in accordance with Danish Standard [2]. On each measurement day, two air samples were taken from the exhaust air in each unit. The air samples were taken by inserting a Teflon™ tube at each measuring point and connecting it to a 30 L nalophan bag. The individual bag was in an air-tight box. A vacuum was created in the box using a pump, and the bag was filled with air from the measuring point. The bags were filled over a period of approximately 30 minutes. The first batch of air samples was taken between 11 a.m. and 12 p.m., the second batch of air samples was taken at 12.30 p.m., and the third batch of air samples was taken at 14.00 p.m. on each measurement day. All air samples from each measurement day were sent to the odour laboratory at LUFA Nord-West in Germany and were analysed the following day in accordance with Danish Standard [2].

Conditional measurements

Hydrogen Sulphide

During the collection of the air samples for determination of the odour concentration, the concentrations of hydrogen sulphide were measured at the same measuring points in the exhaust air. Four measurements were taken consecutively. The first measurement was discarded each time, and an average was calculated on the basis of the last three measurements. The hydrogen sulphide concentrations were measured using a Jerome 631-XE hydrogen sulphide analyser (Arizona Instrument LLC).

Airflow rate

At location A, the airflow rate was recorded with a Fancom wing anemometer (Fancom AT(M), unit 80) placed in each of the two exhaust outlets in each unit. The airflow rate was logged every five minutes. At location B, the airflow rate was recorded by the Dynamic Air system (SKOV A/S) and was logged every five minutes. Once during the test period, the airflow rate measured by the Dynamic Air system was verified with a calibrated Fancom wing anemometer fitted to each of the five exhaust outlets in each unit (see Figure A3-A6 in the appendix).

Temperature and relative humidity

The temperature and the relative humidity of the air were measured at the measuring points after the collection of each air sample for determination of the odour concentration. The temperature and relative humidity of the external air were measured before the collection of the first air sample and after the collection of the last air sample. The temperature and relative humidity were measured with a TSI VelociCalc 9555 air velocity meter.

Number of animals and weight

The number of animals and the weight of the animals were recorded in the finishing units each time the farms were visited.

Electricity and acid consumption

The electricity consumption was recorded with an electricity meter and acid consumption of the “JH Forsuring NH4+” acidification system was measured at each location during the test periods.

Manure measurements

On each measurement day with odour measurements, the height of the manure in the slurry channels was measured, and a sample from the slurry channel in both the control and experimental units was collected. The sample was collected by pumping one litre of manure from the slurry channel. The pH was measured in each sample before it was frozen immediately after being taken. The samples were sent to Eurofins Steins (Holstebro) and were analysed for content of total N, ammonia + ammonium-N, dry matter, pH, total sulphur, total carbon, phosphorus and potassium. The measurement uncertainty of the applied measurement methods is shown in Table A3 in the appendix.

Statistics and calculations

The ammonia concentrations and emissions measured with INNOVA were analysed by an analysis of variance using the MIXED procedure in SAS (Version 9.3) taking into account the repeated measurements per day. The odour concentrations and emissions were logarithmically transformed and analysed by an analysis of variance using the MIXED procedure in SAS taking into account the repeated measurements per day.

Ammonia

For a given time, the ammonia emission was calculated based on the ammonia concentration, the airflow rate and the number of pigs in the unit using the following formula:

g NH_3-N/hour/animal = (M x V x Q x P) / (R x T x N x 1,000)

where:

M: Molar weight of N, 14.007 g/mol

V: Concentration, ppm = mL/m^3

Q: Airflow rate, m^3/hour

P: Pressure, 1 atm.

R: Gas constant, 0.0821 litre x atm/(mol x K)

T: Temperature in Kelvin

N: Number of pigs in the unit

Odour

The odour emission per 1,000 kg animal was calculated based on the analysed odour concentration, the airflow rate and the number of pigs in the finishing unit using the following formula:

OU_E/s per 1,000 kg animal = (L x Q x 1,000) / (N x W x 3,600)

where:

L: Odour concentration, OU_E/m^3

Q: Airflow rate, m^3/hour

N: Number of pigs in the unit

W: Average weight of the pigs in the unit, kg

The hydrogen sulphide emission was calculated based on the hydrogen sulphide concentration, the airflow rate and the number of pigs in the unit using the following formula:

mg H_2S/hour/animal = (M x V x Q x P) / (R x T x N)

where:

M: Molar weight of H_2S, 34.076 g/mol

V: Concentration, ppm = mL/m^3

Q: Airflow rate, m^3/hour

P: Pressure, 1 atm.

R: Gas constant, 0.0821 litre x atm/(mol x K)

T: Temperature in Kelvin

N: Number of pigs in the unit

Results

Ammonia

Measurements of the ammonia concentrations at location A were performed during one year between November 2010 and November 2011. During this period, the use of the “JH Forsuring NH4+” acidification system in the experimental units resulted in a 71% lower ammonia emission compared with the control units

[3]. However, during this period, the ammonia reduction efficiency was measured continuously with an electrochemical sensor that was not in compliance with the VERA Test Protocol. Consequently, supplementary measurements were performed at location A with the INNOVA 1412 photoacoustic gas analyser on 32 days divided into periods between 9 June 2012 and 1 May 2013. Figure 4 shows the daily means of the ammonia emissions from the experimental and control units at location A. Table 1 shows the average ammonia concentration and emission from the experimental and control units during the measurement period. The use of the “JH Forsuring NH4+” acidification system in the experimental unit resulted in a 63% lower ammonia emission compared with the control unit at location A.

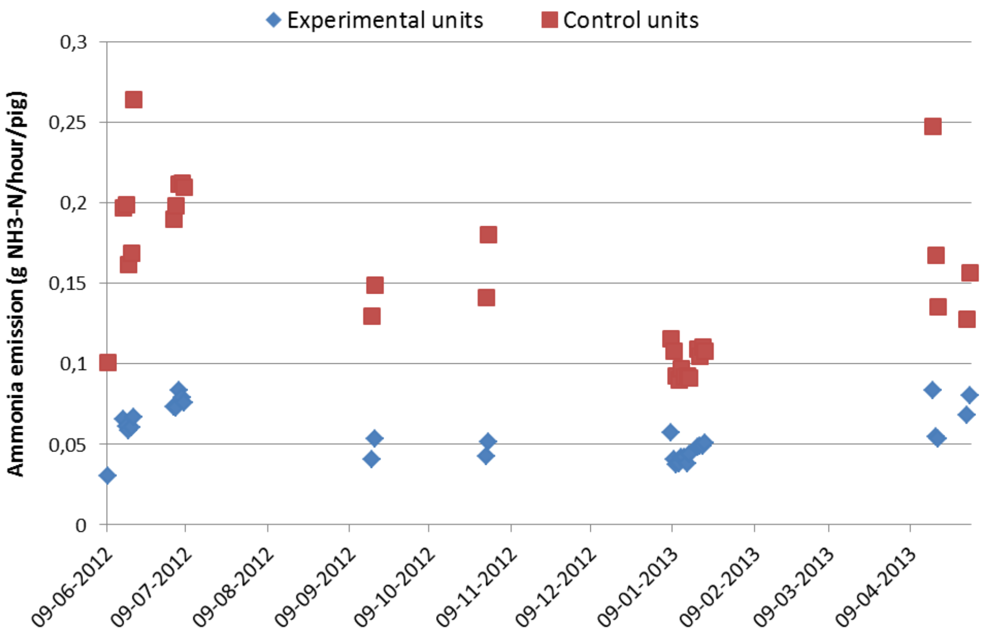

Figure 4. Ammonia emissions measured with INNOVA in the exhaust air from the control and experimental units at test location A on 32 days between 9 June 2012 and 1 May 2013. Each mark represents a daily mean.

Table 1. The ammonia concentrations and emissions measured with INNOVA in the exhaust air from the control and experimental units at test location A on 32 days between 9 June 2012 and 1 May 2013. The 95% confidence interval is given in brackets.

Location A	Ammonia concentration (ppm)		Ammonia emission (g NH_3-N/hour/pig)
	Mean	Median	
N	32	32	32
Control unit	7.9 (7.0 – 8.8)	7.4	0.15 (0.14 – 0.16)
Experimental unit	2.8 (1.9 – 3.7)	2.6	0.056*** (0.043 – 0.069)

*** Statistically significant difference, P<0.001 relative to the ammonia emission from the control unit.

Measurements of the ammonia concentrations and emissions were performed at location B with the INNOVA 1412 photoacoustic gas analyser on 48 days divided into periods between 16 April 2012 and 7 February 2013. Figure 5 shows the daily means of the ammonia emissions from the experimental and control units at location B. Table 2 shows the average ammonia concentrations and emissions from the experimental and control units during the measurement period. The use of the “JH Forsuring NH4+” acidification system in the experimental units resulted in a 66% lower ammonia emission compared with the control units at location B. The ammonia emissions from the two control units and the two experimental units are shown separately in Figure A7 in the appendix.

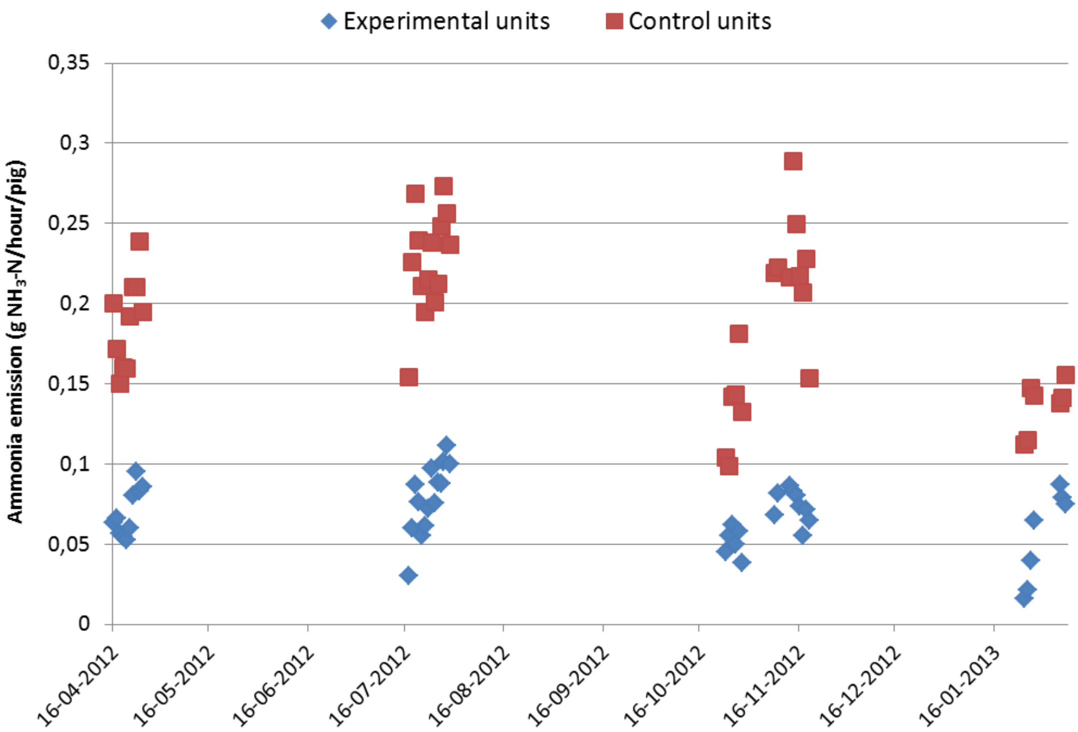

Figure 5. Ammonia emissions measured with INNOVA in the exhaust air from the control and experimental units at test location B on 48 days between 16 April 2012 and 7 February 2013. Each mark represents a daily mean.

Table 2. The ammonia concentrations and emissions measured with INNOVA in the exhaust air from the control and experimental units at test location B on 48 days between 16 April 2012 and 7 February 2013. The 95% confidence interval is given in brackets.

Location A	Ammonia concentration (ppm)		Ammonia emission (g NH_3-N/hour/pig)
	Mean	Median	
N	48	48	48
Control units	8.6 (8.2 – 9.1)	9.0	0.20 (0.19 – 0.21)
Experimental units	3.2 (2.7 – 3.6)	2.9	0.068*** (0.060 – 0.077)

*** Statistically significant difference, P<0.001 relative to the ammonia emission from the control units.

At both locations, the average ammonia emissions from the experimental units in this study were 65% lower than those from the control units. The difference in the ammonia emissions between the experimental and control units in this study was lower than the difference found in an earlier study [1]. However, since 2004 the ammonia emissions from finishing pig facilities in Denmark have generally decreased due to an improved genetic feed conversion rate and also due to feed optimisation with lower nitrogen content of the feed. This has resulted in a lower nitrogen content of the manure, which has been reduced by 10.4% between 2004 and 2013 based on the standard figures for nitrogen content of manure [5],[6]. This could explain why the percentage difference in the ammonia emissions between experimental and control units decreased in recent studies compared with the studies conducted in 2004. Therefore, estimating the effect of the "JH Forsuring NH4+" acidification system as a reduction percentage in the ammonia emissions between experimental and control units is a questionable parameter over time.

Odour

Figure 4 shows the odour emissions measured at test location A. Table 3 shows the average odour concentrations and emissions for test location A. During the year, the use of the "JH Forsuring NH4+" acidification system in the experimental unit resulted in a 29% lower odour emission compared with the control unit at location A (P<0.001). However, on days with an outdoor temperature of more than 16 °C, the average odour emission from the experimental units was 26% lower compared with the control unit (P<0.001). The odour measurements during the year were taken at an average outdoor temperature of 13.4 °C (95% confidence interval: 8.5 – 18.3 °C) and a relative humidity of 69 % (95% confidence interval: 66 – 72). The odour emissions from each control unit and each experimental unit on the measurement days at location A are shown separately in Figure A8 in the appendix.

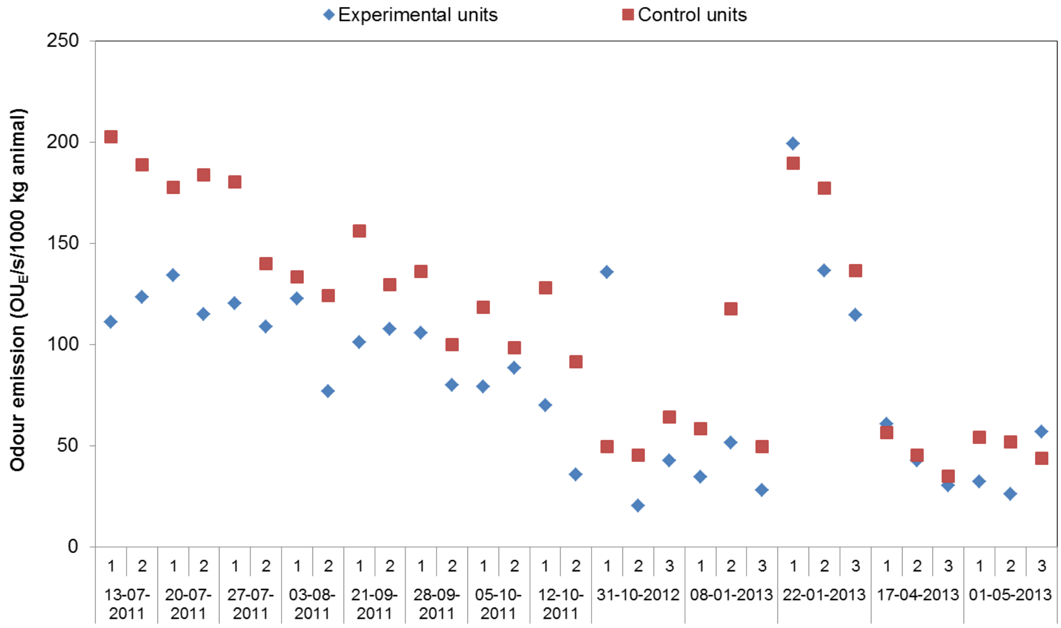

Figure 6. Odour emissions measured in the exhaust air from the control and experimental units at test location A on 8 days between 13 July 2011 and 12 October 2011 and on 5 days between 31 October 2012 and 1 May 2013.

Table 3. The odour concentrations and emissions measured in the exhaust air from the control and experimental units at test location A. The 95% confidence interval is given in brackets.

Location A	Odour concentration (ppm)	Odour emission (OU_E/s/1000 kg animal)	
	Average during the year	Summer measurements[1]	Average during the year
N	47	20	47
Control units	429 (301 – 612)	80 (63 – 102)	97 (77 – 122)
Experimental units	335 (235 – 478)	59*** (46 – 74)	69*** (55 – 86)

*** Statistically significant difference, P<0.001 relative to the odour emission from the control units.

[1] Measurements on days with an outdoor temperature of more than 16 °C.

Figure 7 shows the odour emissions measured at test location B. Table 4 shows the average odour concentrations and emissions for test location B. The odour emission from the experimental units at location B was not reduced significantly compared with the control units by using the “JH Forsuring NH4+” acidification system during the year, although the odour emission from the experimental units was numerically lower compared with the control units. Also on days with an outdoor temperature of more than

16 °C, the odour emission from the experimental units was not significantly different compared with the control units. The odour measurements at location B during the year were taken at an average outdoor temperature of 18.1 °C (95% confidence interval: 2.0 – 29.3 °C) and a relative humidity of 65% (95% confidence interval: 51 – 79). The odour emissions from each of the two control units and the two experimental units at location B are shown separately in Figure A9 in the appendix.

Although the results showed a significantly lower odour emission from the experimental units at location A and a numerically lower emission from the experimental units at location B, it can be concluded that the treatment of manure in the experimental units does affect the odour emission to a certain extent. However, an increased hydrogen sulphide concentration and also other odour compounds are observed around the "JH Forsuring NH4+" acidification system when it is treating the manure.

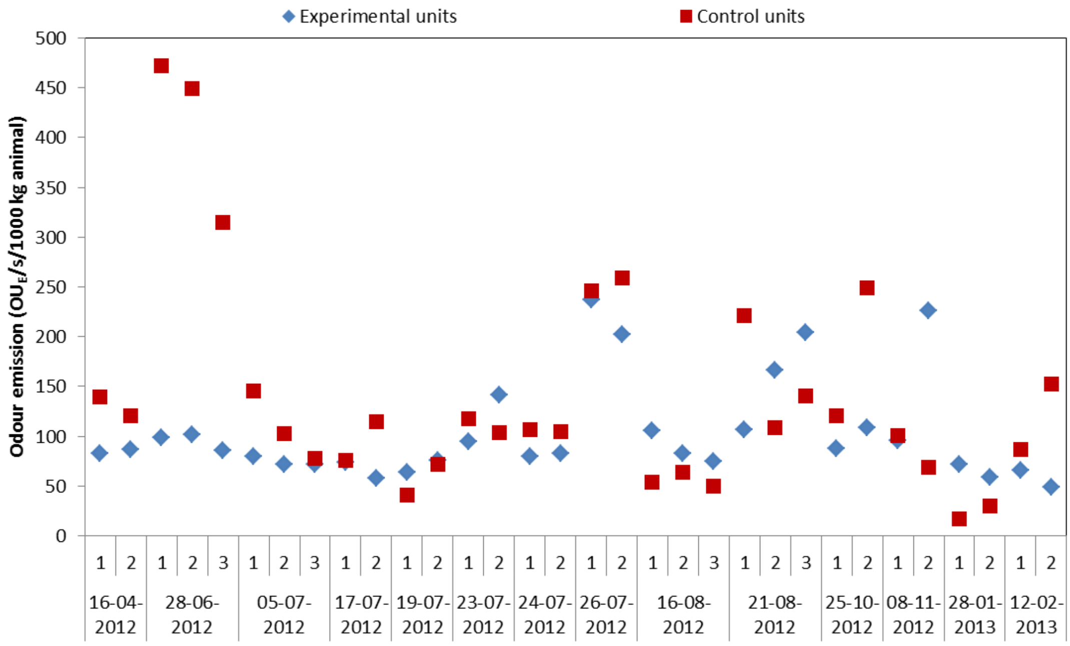

Figure 7. Odour emissions measured in the exhaust air from the control and experimental units at test location B on nine days in the summer period and on five days during the rest of the year.

Table 4. The odour concentrations and emissions measured in the exhaust air from the control and experimental units at test location B. The 95% confidence interval is given in brackets.

Location B	Odour concentration (ppm)	Odour emission (OU_E/s/1000 kg animal)	
	Average during the year	Summer measurements[1]	Average during the year
N	52	32	52
Control units	366 (273 – 491)	112 (83 – 150)	99 (79 – 125)
Experimental units	366 (273 – 490)	98[NS] (73 – 131)	92[NS] (73 – 116)

[NS] No significant difference, P>0.05 relative to the odour emission from the control units.

[1] Measurements on days with an outdoor temperature of more than 16 °C.

Hydrogen sulphide

The hydrogen sulphide concentration was measured in the same spot when each odour measurement was taken. Table 5 shows the average hydrogen sulphide concentration and emission during the test period at test location A. The use of the “JH Forsuring NH4+” acidification system resulted in a significantly lower hydrogen sulphide emission compared with the control units. On average, the hydrogen sulphide emission from the experimental unit was 67% lower compared with the control unit. Table 6 shows the average hydrogen sulphide concentration and emission during the test period at test location B. Also at test location B, the hydrogen sulphide emission from the experimental units was significantly lower compared with the control units, corresponding to 90%. As previously mentioned, an increased hydrogen sulphide concentration was observed when the daily flushing of the manure took place during treatment of the manure. However, each treatment of the manure took place in less than one hour, and therefore the time with the increased hydrogen sulphide emission from the experimental units is limited compared with the relatively long period with the low hydrogen sulphide emission.

Table 5. The hydrogen sulphide concentrations and emissions measured in the exhaust air from the control and experimental units at test location A on days with odour measurements on 8 days between 13 July 2011 and 12 October 2011 and on 5 days between 31 October 2012 and 1 May 2013. The 95% confidence interval is given in brackets.

Location A	Hydrogen sulphide concentration (ppm)	Hydrogen sulphide emission (mg H_2S/hour/pig)
N	47	47
Control units	0.76 (0.60 – 0.91)	57 (49 – 64)
Experimental units	0.32*** (0.16 – 0.47)	19*** (11 – 26)

*** Statistically significant difference, P<0.001 relative to the ammonia emission from the control units.

Table 6. The hydrogen sulphide concentrations and emissions measured in the exhaust air from the control and experimental units at test location B on days with odour measurements on nine days in the summer period and on five days during the rest of the year. The 95% confidence interval is given in brackets.

Location B	Hydrogen sulphide concentration (ppm)	Hydrogen sulphide emission (mg H_2S/hour/pig)
N	52	52
Control units	0.53 (0.43 – 0.63)	43 (38 – 47)
Experimental units	0.060*** (~0 – 0.16)	4.5*** (0.12 – 8.9)

*** Statistically significant difference, P<0.001 relative to the ammonia emission from the control units.

Conditional measurement parameters

Ventilation rate, carbon dioxide and temperature

During the one-year test period, conditional measurements of ventilation rate, carbon dioxide and temperatures were monitored at both locations when continuous measurements for ammonia emission were taken (Table 7). There was no significant difference in the ventilation rate, carbon dioxide concentration or temperature in the control units compared with the experimental units at both locations A and B.

Table 7. Average values of conditional air-related measurements during the test period at locations A and B. The 95% confidence interval is given in brackets.

	Location A		Location B	
	Control units	Experimental units	Control units	Experimental units
Ventilation rate (m^3/hour)	8,470 (6,459 – 10,482)	8,304 (6,293 – 10,316)	31,771 (28,167 – 35,375)	30,245 (26,644 – 33,847)
Carbon dioxide (ppm)	2,062 (1,721 – 2,403)	2,188 (1,847 – 2,529)	1,723 (1,600 – 1,846)	1,784 (1,661 – 1,907)
Temperature (°C)	19.5 (18.9 – 20.0)	19.7 (19.1 – 20.2)	20.2 (19.9 – 20.6)	20.3 (19.9 – 20.6)
Outdoor temperature (°C)	11.7 (-0.5 – 23.6)		12.6 (-2.2 – 30.7)	

Table 8 shows the average number and weight of the animals on the measurement days. There was no significant difference in either the number or the weight of the animals between the control and experimental units at locations A and B. The floor space per animal and the air volume per animal at maximum ventilation are also shown in Table 8. There was no difference in these parameters between the control and experimental units, although the levels were numerically higher for both the control and experimental units at location A compared with location B.

In the experimental units, the height of the manure was controlled by the “JH Forsuring NH4+” acidification system. The average height of the manure in the experimental units was 31 cm at location A compared with 25 cm at location B. The average height of the manure in the control units was also higher at location A compared with location B. However, the difference between locations A and B can be explained by the total depth of the slurry channels, which was 60 cm at location A and 50 cm at location B. It also means that the average age of the manure in the control units was higher in location A than in location B. This could be part of the reason why a significant odour reduction was seen at location A and not at location B.

At both locations A and B, no accumulation of manure was recorded in the slurry channels. Therefore, the daily use of the “JH Forsuring NH4+” acidification system did not negatively affect the performance of the slurry channel system.

Table 8. Average number and weight of animals, floor space per animal, air volume per animal and height of manure in the slurry channels during the test period at locations A and B. Mean and standard deviations are shown in the table.

	Location A		Location B	
	Control units	Experimental units	Control units	Experimental units
Number of animals	190 ± 5	191 ± 5	666 ± 33	674 ± 66
Weight of animals (kg)	76 ± 18	76 ± 18	66 ± 9.6	66 ± 18
Floor space per animal (m^2)	0.74	0.74	0.67	0.67
Air volume per animal at maximum ventilation (m^3/hour)	119	118	99[1]	102[1]
Height of manure in slurry channels (cm)	36 ± 15	31 ± 6.7	26 ± 8.3	25 ± 2.3

[1] With supplemental air inlets open

Table 9 shows the manure composition of samples taken during the test periods at locations A and B. For location A, the results shown are samples taken during the second test period between 9 June 2012 and 1 May 2013. However, results of the manure composition during the first test period are shown in Pedersen & Albrechtsen (2012) [4].

For both locations, the acidification of the slurry resulted in a lower pH value compared with the control units. At location B, the pH of the manure in the experimental units was 0.2 pH units lower compared with the experimental unit at location A. This difference could be due to different set points in the control of the “JH Forsuring NH4+” acidification system. However, this difference resulted in a slightly higher content of nitrogen in the manure at location B compared with location A. As expected, the content of sulphur in the manure in the experimental units was significantly increased by treating the manure with sulphuric acid, compared with the control units.

In general, it is difficult to take representative samples of the manure from the slurry channels, especially dry matter and components related to dry matter. The highest variation was found in dry matter and other components in samples taken in the control units compared with the experimental units. This difference could be explained by the daily treatment of the manure in the experimental units. Daily treatment of the manure made it more homogenous than the untreated manure, and therefore more representative samples were collected from the experimental units. However, the dry matter content and also other components of the manure in the control unit were unrealistically low at location A when compared to the results of the first test period [4]. Therefore, the ratio of C to N was not calculated for the control units at location A.

Table 9. Analyses of manure content during the test period at locations A and B. The samples from location A were taken in the second test period between 9 June 2012 and 1 May 2013.

	Location A		Location B	
	Control units	Experimental units	Control units	Experimental units
N	8	8	26	26
pH	7.4 ± 0.12	5.7 ± 0.23	7.1 ± 0.30	5.5 ± 0.38
DM (%)	2.2 ± 0.75	4.2 ± 0.81	3.6 ± 2.1	4.8 ± 1.0
Organic DM (% of DM)	28 ± 5.2	25 ± 5.0	33 ± 5.8	29 ± 4.0
Total N (kg/ton)	3.0 ± 0.78	4.0 ± 0.52	3.9 ± 0.89	4.5 ± 0.47
Ammonia N (kg/ton)	2.5 ± 0.59	2.8 ± 0.31	2.9 ± 0.43	3.0 ± 0.22
Total P (kg/ton)	0.28 ± 0.14	1.0 ± 0.20	0.68 ± 0.55	0.95 ± 0.25
Total K (kg/ton)	3.4 ± 0.67	3.3 ± 0.11	3.4 ± 0.30	3.0 ± 0.64
Total S (kg/ton)	0.18 ± 0.064	2.9 ± 0.32	0.31 ± 0.44	2.9 ± 0.90
C:N	-	3:1	3:1	3:1

Operating costs

The operating costs of using the acidification system comprise costs for electricity, acid and service and maintenance costs. Table 10 shows the consumption costs during the test period for test locations A and B. The consumption of sulphuric acid was 7.1 kg per produced pig at location A and 5.8 kg per produced pig at location B. The larger amount of sulphuric acid used at location A could be due to the larger amount of manure treated each day. The total electricity consumption for the acidification system amounted to 1.5 kWh per produced pig in test location B.

Table 10. Consumption of sulphuric acid and electricity during the test period at locations A and B.

	Location A		Location B	
	Total consumption	Consumption per produced pig	Total consumption	Consumption per produced pig
Sulphuric acid (kg)	13,396	7.1	30,605	5.8
Electricity (kWh)	-	-	8,701	1.5

It was agreed that Jørgen Hyldgaard Staldservice A/S would perform the supervision of the acidification system and all service visits at test locations A and B. Tables 11 and 12 show the dates for the service visits during the test period at locations A and B, respectively. On three days during the test period, repair work was carried out on the acidification system by Jørgen Hyldgaard Staldservice A/S at location A. At location B on five days during the test period, repair work was carried out on the acidification system by Jørgen Hyldgaard Staldservice A/S. At location B, the total time used for all of the visits was eight hours. Since the "JH Forsuring NH4+" acidification system only runs once a day, none of the problems was so serious that the acidification systems were inoperative, except on four days during the summer time at location A. However, during these four days a high ammonia reduction was still measured in the experimental unit. The calculated uptime for the "JH Forsuring NH4+" acidification system was 99% during the first test period at location A and 100% during the test period at location B and the second test period at location A.

Table 11. Service visits and repairs on the acidification system during the test period at location A.

Date	**Problem/replacement**	**Action/time**
04-05-2011	Alarm for problem with one valve	Repaired
02-06-2011 to 06-06-2011	The acidification system was stopped due to errors	Repaired
27-09-2012 to 03-10-2012	The acidification system was stopped due to an empty acid tank	The acidification system was started again 03-10-2012

Table 12. Service visits and repairs on the acidification system during the test period at location B.

Date	Problem/replacement	Action/time
20-04-2012	Error in one of the valves – did not close properly	Repaired – 2 hrs
28-04-2012	Alarm for problem with three valves	Repaired – 2 hrs
30-04-2012	Alarm for problem with two valves	Repaired – 1½ hrs
09-10-2012	Control problems	Repaired – 2 hrs
20-12-2012	Alarm for problem with one valve	Repaired – 1½ hrs
05-03-13 to 07-03-2013	The acidification system was manually stopped because all storage capacity for manure was occupied.	The acidification system was started again 07-03-2013

Other issues

The present VERA test was performed on two different finishing pig farms, and the results therefore reflect the effect of the “JH Forsuring NH4+” acidification system in this type of unit. It is assessed that the acidification system could also be used for other types of pig units with good effect. It is also assessed that the acidification system could be used for other categories of animals, e.g. dairy cattle, where the effect has been documented in another VERA test.

Information on safety risks related to checking and maintaining the “JH Forsuring NH4+” acidification system can be found in the safety regulations contained in the system’s technical user instructions from Jørgen Hyldgaard Staldservice A/S.

For facilities where the manure is acidified no corrosion in the manure channels should be expected if the concrete has a quality corresponding to a moderate environmental class (DS/EN 206 +DS 2426) [7].

Conclusion

On average during the year, daily treatment of the manure with a “JH Forsuring NH4+” acidification system resulted in a 65% reduction in ammonia emissions from a finishing pig facility with drained floor. The ammonia emission from the experimental units was 63% lower compared with the control units at location A. The use of the “JH Forsuring NH4+” acidification system in the experimental units resulted in a 66% lower ammonia emission compared with the control units at location B. However, since 2004, ammonia emissions from finishing pig facilities in Denmark have generally decreased due to an improved genetic feed conversion rate and also due to feed optimisation with a lower nitrogen content of the feed. This has resulted in a lower nitrogen content of the manure, which has been reduced by 10.4% between 2004 and 2013 based on the standard figures of nitrogen content of manure. This could explain why the percentage difference in the ammonia emissions between experimental and control units has decreased in recent studies compared with studies conducted in 2004.

During the year, the use of the “JH Forsuring NH4+” acidification system in the experimental unit resulted in a 29% lower odour emission compared with the control unit at location A. However, on days with an outdoor temperature of more than 16 °C, the average odour emission from the experimental units was 26% lower compared with the control unit. However, at location B the odour emission was not reduced significantly, although the odour emission from the experimental units was numerically lower compared with the control units. Although the results from location A showed a significantly lower odour emission from the experimental units and a numerically lower emission from the experimental units at location B, it can be concluded that the treatment of manure in the experimental units does affect the odour emission to a certain extent. However, it is important to mention that an increased hydrogen sulphide concentration is observed when the daily flushing of the manure takes place during treatment of the manure. This increased hydrogen sulphide concentration and other odour compounds are also observed around the “JH Forsuring NH4+” acidification system when it is treating the manure.

At both locations A and B, no accumulation of manure was recorded in the slurry channels. Therefore, the daily use of the “JH Forsuring NH4+” acidification system does not negatively affect the performance of the slurry channel system.

The consumption of sulphuric acid was 7.1 kg per produced pig at location A and 5.8 kg per produced pig at location B. The total electricity consumption for the acidification system amounted to 1.5 kWh per produced pig in test location B. On three days during the test period, repair work was carried out on the acidification system at location A and on five days at location B. The calculated uptime for the “JH Forsuring NH4+” acidification system was 99% during the first test period at location A and 100% during the test period at location B and the second test period at location A.

References

[1] Pedersen, P.: (2004): Svovlsyrebehandling af gylle i en slagtesvinestald med drænet gulv. Meddelelse nr. 683, Videncenter for Svineproduktion.

[2] Dansk standard (2003): Luftundersøgelse – Bestemmelse af lugtkoncentration ved brug af dynamisk olfaktometri. DS/EN 13725:2003.

[4] Pedersen, P., Albrechtsen, K.: (2012): JH Forsuringsanlæg i slagtesvinestald med drænet gulv.

Meddelelse nr. 932, Videncenter for Svineproduktion.

[5] Normtal for husdyrgødning 2004. http://anis.au.dk/normtal/

[6] Normtal for husdyrgødning 2013. http://anis.au.dk/normtal/

[7] Byggeblad om valg af betonkvalitet i forbindelse med forsuring af gylle. SEGES. https://www.landbrugsinfo.dk/Byggeri/Byggeblade/Sider/Byggeblad_102_17_19_20111101.pdf

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Appendix

Figure A1. Design of the finisher units where the test was performed at location A.

Figure A2. Design of the finisher units where the test was performed at location B.

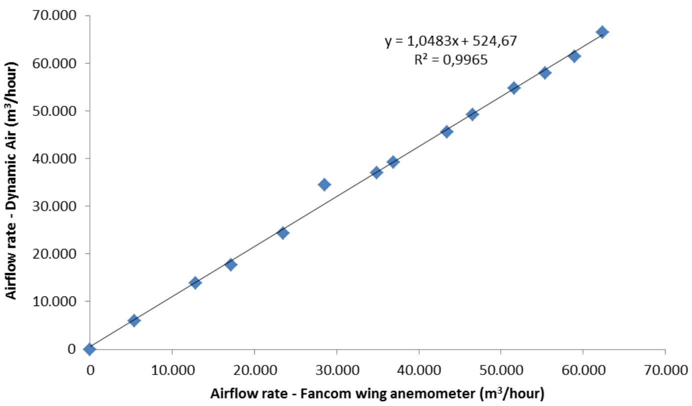

Figure A3. The relation between the air flow rates measured with Dynamic Air and a calibrated Fancom wing anemometer in experimental unit 1 at location B.

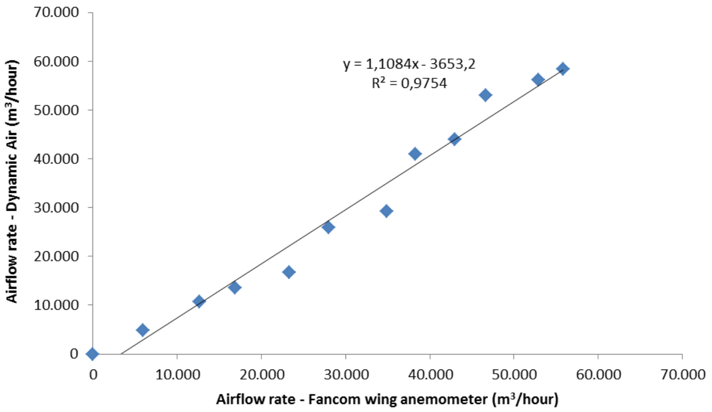

Figure A4. The relation between the air flow rates measured with Dynamic Air and a calibrated Fancom wing anemometer in experimental unit 2 at location B.

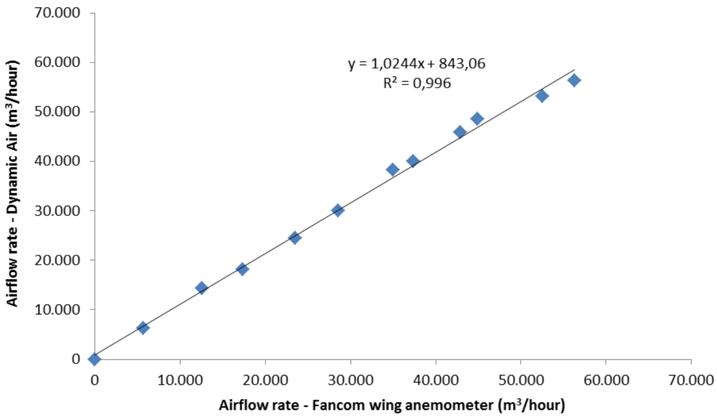

Figure A5. The relation between the air flow rates measured with Dynamic Air and a calibrated Fancom wing anemometer in control unit 1 at location B.

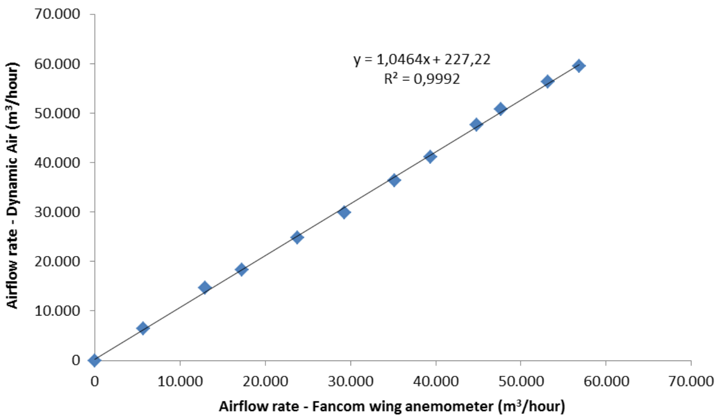

Figure A6. The relation between the air flow rates measured with Dynamic Air and a calibrated Fancom wing anemometer in control unit 2 at location B.

Table A1. Feed composition at location B.

Component	Content
Raw protein, %	15.99
Feed units (FEsv) per 100 kg	100
Raw fat, %	1.73
Ash, %	5.71
Raw products	
Wheat, %	6.625
Barley, %	12.269
Soy meal, %	6.126
Minerals, %	0.8
Whey, %	37.090
Water, %	37.090

Table A2. Feed consumption at location B between 16 April 2012 and 15 April 2013.

	Control units 1 & 2	Experimental units 1 & 2
Feed units (FEsv), total	975.750	1,046.500
Feed units (FEsv) per produced pig	184	197

Table A3. Measurement uncertainty of the applied measurement methods

Measurement method	Measurement uncertainty
Collection of odour samples	20 %
Olfactometric odour analysis LUFA Nord-West	2.3 dB
Ammonia – Kitagawa gas detector tubes 105SD	5 %
Ammonia - INNOVA	5 %
Carbon dioxide – Kitagawa gas detector tubes 126SF	10 %
Hydrogen sulphide – Jerome 631-XE	5 %
Airflow rate – Fancom measurement wings	< 10 %
Temperature – TSI VelociCalc 8347	1 °C
Relative air humidity – TSI VelociCalc 8347	5 % RH
pH – DS 287	-
Dry matter, total – DS 204	10 %
Ammonia+ammonium-N, filt. – SM 17. ver. 4500	5 %
Total-N – DS/EN I 11905	10 %

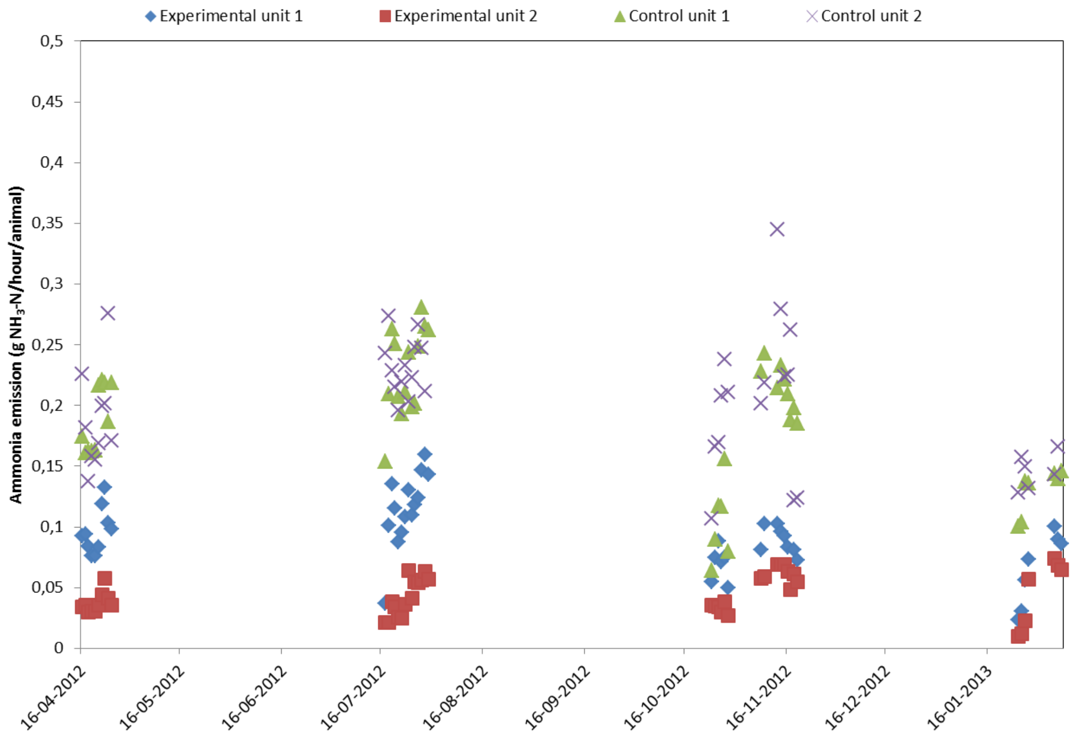

Figure A7. Ammonia emissions measured with INNOVA in the exhaust air from the control and experimental units at test location B on 48 days between 16 April 2012 and 7 February 2013. Each mark represents a daily mean.

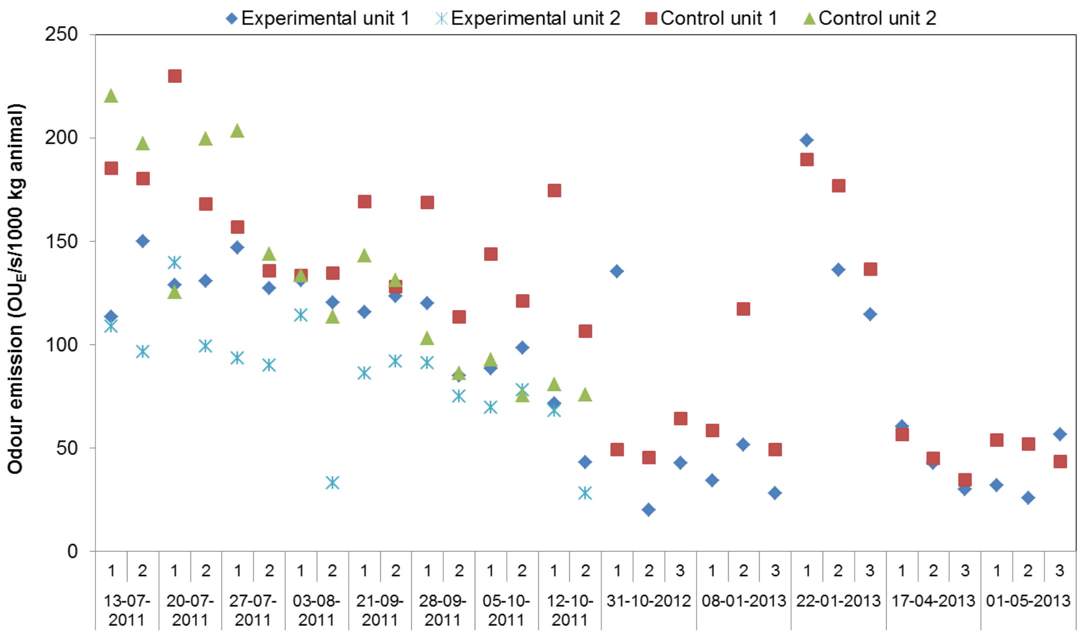

Figure A8. Odour emissions measured in the exhaust air from each control and experimental unit at test location A on 8 days between 13 July 2011 and 12 October 2011 and on 5 days between 31 October 2012 and 1 May 2013.

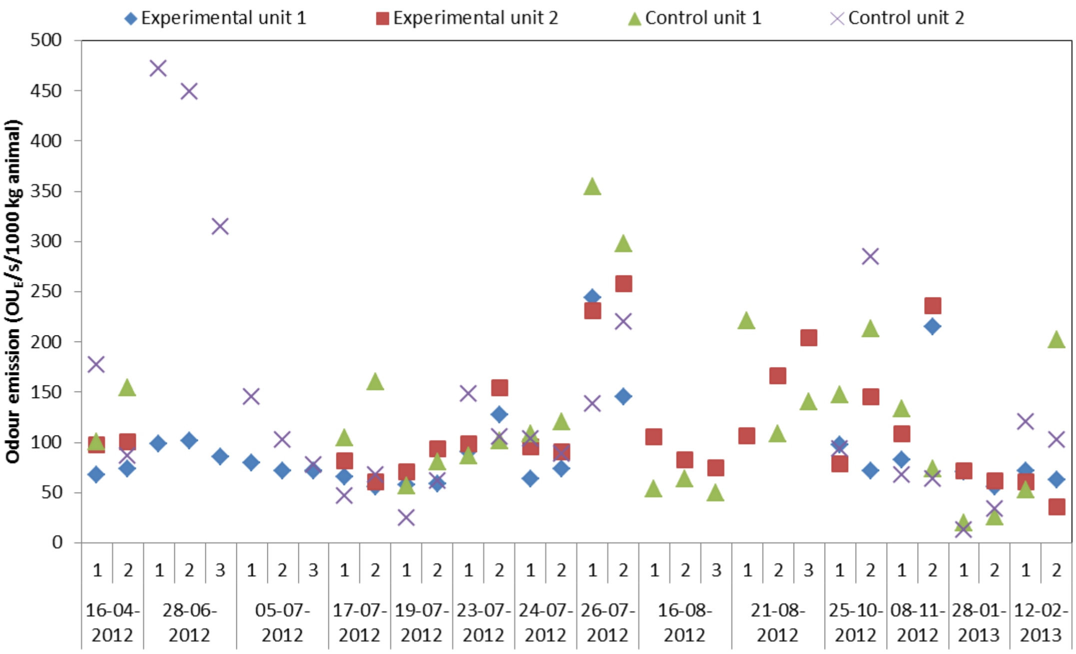

Figure A9. Odour emissions measured in the exhaust air from each control and experimental unit at test location B on 8 days between 16 April 2012 and 12 February 2013.

Table A4. Indoor temperature, outdoor temperature, ventilation rate, ammonia concentration and -emission on each measurement day with ammonia measurements at location A. Weight of animals is listed for the date of the beginning of each measurement period.

Date		Experimental unit 1	Control unit 1
09-06-2012	Weight of animals (kg)	47	47
	Indoor temperature (°C)	19.0	20.5
	Outdoor temperature (°C)	12.1	
	Ventilation rate (m³/hour)	10,041	7,936
	Ammonia concentration (ppm)	1.05	4.49
	Ammonia emission (g NH_3-N/h/animal)	0.030	0.10
15-06-2012	Indoor temperature (°C)	19.2	20.1
	Outdoor temperature (°C)	12.0	
	Ventilation rate (m³/hour)	9,326	8,548
	Ammonia concentration (ppm)	2.34	8.04
	Ammonia emission (g NH_3-N/h/animal)	0.066	0.20
16-06-2012	Indoor temperature (°C)	20.4	20.8
	Outdoor temperature (°C)	15.8	
	Ventilation rate (m³/hour)	12,049	13,061
	Ammonia concentration (ppm)	1.69	5.26

	Ammonia emission (g NH_3-N/h/animal)	0.061	0.20
17-06-2012	Indoor temperature (°C)	19.4	20.1
	Outdoor temperature (°C)	13.1	
	Ventilation rate (m³/hour)	10,888	9,765
	Ammonia concentration (ppm)	1.78	5.58
	Ammonia emission (g NH_3-N/h/animal)	0.059	0.16
18-06-2012	Indoor temperature (°C)	19.1	19.8
	Outdoor temperature (°C)	13.1	
	Ventilation rate (m³/hour)	10,608	9,735
	Ammonia concentration (ppm)	1.89	5.82
	Ammonia emission (g NH_3-N/h/animal)	0.061	0.17
19-06-2012	Indoor temperature (°C)	19.5	19.8
	Outdoor temperature (°C)	13.9	
	Ventilation rate (m³/hour)	10,692	11,035
	Ammonia concentration (ppm)	2.08	7.26
	Ammonia emission (g NH_3-N/h/animal)	0.067	0.26
04-07-2012	Weight of animals (kg)	67	67
	Indoor temperature (°C)	23.4	23.5
	Outdoor temperature (°C)	21.0	
	Ventilation rate (m³/hour)	19,691	21,863
	Ammonia concentration (ppm)	1.32	2.87
	Ammonia emission (g NH_3-N/h/animal)	0.074	0.19
05-07-2012	Indoor temperature (°C)	23.1	22.8
	Outdoor temperature (°C)	19.8	
	Ventilation rate (m³/hour)	17,893	20,171
	Ammonia concentration (ppm)	1.43	3.32
	Ammonia emission (g NH_3-N/h/animal)	0.073	0.20
06-07-2012	Indoor temperature (°C)	22.1	21.6
	Outdoor temperature (°C)	18.3	
	Ventilation rate (m³/hour)	16,137	21,523
	Ammonia concentration (ppm)	1.71	3.23
	Ammonia emission (g NH_3-N/h/animal)	0.083	0.21
07-07-2012	Indoor temperature (°C)	22.3	21.8
	Outdoor temperature (°C)	19.1	
	Ventilation rate (m³/hour)	17,336	21,258
	Ammonia concentration (ppm)	1.57	3.28
	Ammonia emission (g NH_3-N/h/animal)	0.079	0.21
08-07-2012	Indoor temperature (°C)	23.4	23.1
	Outdoor temperature (°C)	20.1	
	Ventilation rate (m³/hour)	17,816	19,698
	Ammonia concentration (ppm)	1.50	3.56
	Ammonia emission (g NH_3-N/h/animal)	0.076	0.21
17-09-2012	Weight of animals (kg)	45	45
	Indoor temperature (°C)	20.6	20.0
	Outdoor temperature (°C)	15.7	

	Ventilation rate (m^3/hour)	9,955	12,101
	Ammonia concentration (ppm)	1.39	3.60
	Ammonia emission (g NH_3-N/h/animal)	0.041	0.13
18-09-2012	Indoor temperature (°C)	19.9	19.3
	Outdoor temperature (°C)	12.5	
	Ventilation rate (m^3/hour)	8,716	9,230
	Ammonia concentration (ppm)	2.02	5.22
	Ammonia emission (g NH_3-N/h/animal)	0.054	0.15
30-10-2012	Weight of animals (kg)	86	88
	Indoor temperature (°C)	18.7	17.7
	Outdoor temperature (°C)	5.0	
	Ventilation rate (m^3/hour)	5,102	4,808
	Ammonia concentration (ppm)	2.74	9.29
	Ammonia emission (g NH_3-N/h/animal)	0.043	0.14
31-10-2012	Indoor temperature (°C)	18.6	18.0
	Outdoor temperature (°C)	7.0	
	Ventilation rate (m^3/hour)	6,300	6,144
	Ammonia concentration (ppm)	2.48	8.65
	Ammonia emission (g NH_3-N/h/animal)	0.051	0.18
08-01-2013	Weight of animals (kg)	72	72
	Indoor temperature (°C)	18.7	18.2
	Outdoor temperature (°C)	6.6	
	Ventilation rate (m^3/hour)	5,772	6,045
	Ammonia concentration (ppm)	3.27	6.32
	Ammonia emission (g NH_3-N/h/animal)	0.057	0.12
09-01-2013	Indoor temperature (°C)	18.8	18.0
	Outdoor temperature (°C)	5.7	
	Ventilation rate (m^3/hour)	5,113	5,350
	Ammonia concentration (ppm)	2.60	6.67
	Ammonia emission (g NH_3-N/h/animal)	0.040	0.11
10-01-2013	Indoor temperature (°C)	19.2	18.6
	Outdoor temperature (°C)	1.4	
	Ventilation rate (m^3/hour)	4,044	3,411
	Ammonia concentration (ppm)	3.04	8.99
	Ammonia emission (g NH_3-N/h/animal)	0.037	0.093
11-01-2013	Indoor temperature (°C)	18.8	18.8
	Outdoor temperature (°C)	3.6	
	Ventilation rate (m^3/hour)	3,798	2,980
	Ammonia concentration (ppm)	3.29	10.1
	Ammonia emission (g NH_3-N/h/animal)	0.038	0.090
12-01-2013	Indoor temperature (°C)	18.8	18.8
	Outdoor temperature (°C)	3.1	
	Ventilation rate (m^3/hour)	3,655	3,031
	Ammonia concentration (ppm)	3.77	10.6
	Ammonia emission (g NH_3-N/h/animal)	0.042	0.097

13-01-2013	Indoor temperature (°C)	18.8	18.5
	Outdoor temperature (°C)	2.2	
	Ventilation rate (m^3/hour)	3,554	2,768
	Ammonia concentration (ppm)	3.910	10.94
	Ammonia emission (g NH_3-N/h/animal)	0.042	0.092
14-01-2013	Indoor temperature (°C)	18.7	18.4
	Outdoor temperature (°C)	1.0	
	Ventilation rate (m^3/hour)	3,469	2,698
	Ammonia concentration (ppm)	3.65	11.3
	Ammonia emission (g NH_3-N/h/animal)	0.038	0.093
15-01-2013	Indoor temperature (°C)	18.8	18.4
	Outdoor temperature (°C)	0.2	
	Ventilation rate (m^3/hour)	3,372	2,508
	Ammonia concentration (ppm)	4.18	11.8
	Ammonia emission (g NH_3-N/h/animal)	0.044	0.091
18-01-2013	Indoor temperature (°C)	18.8	18.5
	Outdoor temperature (°C)	-0.3	
	Ventilation rate (m^3/hour)	3,174	2,500
	Ammonia concentration (ppm)	4.91	14.5
	Ammonia emission (g NH_3-N/h/animal)	0.049	0.11
19-01-2013	Indoor temperature (°C)	18.8	18.4
	Outdoor temperature (°C)	-0.5	
	Ventilation rate (m^3/hour)	3,304	2,549
	Ammonia concentration (ppm)	4.74	13.1
	Ammonia emission (g NH_3-N/h/animal)	0.049	0.11
20-01-2013	Indoor temperature (°C)	18.9	18.3
	Outdoor temperature (°C)	-1.3	
	Ventilation rate (m^3/hour)	3,134	2,511
	Ammonia concentration (ppm)	5.16	14.3
	Ammonia emission (g NH_3-N/h/animal)	0.049	0.11
21-01-2013	Indoor temperature (°C)	18.9	18.3
	Outdoor temperature (°C)	1.2	
	Ventilation rate (m^3/hour)	3,253	2,598
	Ammonia concentration (ppm)	5.09	13.5
	Ammonia emission (g NH_3-N/h/animal)	0.051	0.11
17-04-2013	Weight of animals (kg)	88	88
	Indoor temperature (°C)	20.0	20.0
	Outdoor temperature (°C)	13.7	
	Ventilation rate (m^3/hour)	9,984	11,762
	Ammonia concentration (ppm)	2.67	7.14
	Ammonia emission (g NH_3-N/h/animal)	0.083	0.25
18-04-2013	Indoor temperature (°C)	18.6	18.3
	Outdoor temperature (°C)	11.1	
	Ventilation rate (m^3/hour)	8,859	8,803
	Ammonia concentration (ppm)	2.01	6.30

	Ammonia emission (g NH_3-N/h/animal)	0.055	0.17
19-04-2013	Indoor temperature (°C)	18.4	17.9
	Outdoor temperature (°C)	6.9	
	Ventilation rate (m^3/hour)	6,727	5,305
	Ammonia concentration (ppm)	2.57	8.47
	Ammonia emission (g NH_3-N/h/animal)	0.054	0.14
30-04-2013	Indoor temperature (°C)	18.8	17.9
	Outdoor temperature (°C)	7.0	
	Ventilation rate (m^3/hour)	6,849	5,483
	Ammonia concentration (ppm)	3.22	7.62
	Ammonia emission (g NH_3-N/h/animal)	0.068	0.13
01-05-2013	Indoor temperature (°C)	19.3	19.0
	Outdoor temperature (°C)	5.11	
	Ventilation rate (m^3/hour)	5,188	3,917
	Ammonia concentration (ppm)	4.14	11.7
	Ammonia emission (g NH_3-N/h/animal)	0.081	0.16

Table A5. Indoor temperature, outdoor temperature, ventilation rate, ammonia concentration and -emission on each measurement day with ammonia measurements at location B. Weight of animals is listed for the date of the beginning of each measurement period.

Date		Experimental unit 1	Experimental unit 2	Control unit 1	Control unit 2
16-04-2012	Weight of animals (kg)	81	45	58	69
	Indoor temperature (°C)	20.0	20.0	19.9	21.0
	Outdoor temperature (°C)	10.1			
	Ventilation rate (m^3/hour)	17,226	18,550	20,070	23,746
	Ammonia concentration (ppm)	5.52	2.40	9.84	10.8
	Ammonia emission (g NH_3-N/h/animal)	0.093	0.034	0.18	0.23
17-04-2012	Indoor temperature (°C)	19.9	19.9	19.0	20.5
	Outdoor temperature (°C)	9.6			
	Ventilation rate (m^3/hour)	17,281	15,476	19,249	18,466
	Ammonia concentration (ppm)	5.46	3.25	9.33	10.9
	Ammonia emission (g NH_3-N/h/animal)	0.094	0.036	0.16	0.18
18-04-2012	Indoor temperature (°C)	19.9	19.7	19.1	20.2
	Outdoor temperature (°C)	11.0			
	Ventilation rate (m^3/hour)	20,784	20,252	23,422	18,187
	Ammonia concentration (ppm)	4.23	1.92	7.60	8.61
	Ammonia emission (g NH_3-N/h/animal)	0.084	0.030	0.16	0.14
19-04-2012	Indoor temperature (°C)	20.2	19.8	19.4	20.4
	Outdoor temperature (°C)	13.2			
	Ventilation rate (m^3/hour)	29,608	32,750	33,091	30,350
	Ammonia concentration (ppm)	3.21	1.46	6.34	7.24
	Ammonia emission (g NH_3-N/h/animal)	0.077	0.031	0.16	0.16
20-04-2012	Indoor temperature (°C)	20.4	20.0	19.8	20.7

	Outdoor temperature (°C)	11.2			
	Ventilation rate (m^3/hour)	18,613	20,789	21,975	18,714
	Ammonia concentration (ppm)	4.22	1.87	8.22	9.17
	Ammonia emission (g NH_3-N/h/animal)	0.076	0.030	0.16	0.16
21-04-2012	Indoor temperature (°C)	20.0	19.3	19.2	20.6
	Outdoor temperature (°C)	11.8			
	Ventilation rate (m^3/hour)	21,187	25,481	25,182	17,602
	Ammonia concentration (ppm)	4.15	1.82	9.61	11.1
	Ammonia emission (g NH_3-N/h/animal)	0.083	0.035	0.22	0.17
22-04-2012	Indoor temperature (°C)	19.9	19.0	19.1	20.3
	Outdoor temperature (°C)	13.0			
	Ventilation rate (m^3/hour)	24,405	27,844	28,270	21,436
	Ammonia concentration (ppm)	5.09	2.08	8.64	10.3
	Ammonia emission (g NH_3-N/h/animal)	0.12	0.044	0.22	0.20
23-04-2012	Indoor temperature (°C)	20.0	18.8	19.2	20.5
	Outdoor temperature (°C)	12.4			
	Ventilation rate (m^3/hour)	22,149	26,624	26,642	21,595
	Ammonia concentration (ppm)	6.37	2.86	8.98	10.4
	Ammonia emission (g NH_3-N/h/animal)	0.13	0.057	0.22	0.20
24-04-2012	Indoor temperature (°C)	20.2			
	Outdoor temperature (°C)	13.2	12.3	11.0	12.5
	Ventilation rate (m^3/hour)	23,063	28,299	21,398	30,769
	Ammonia concentration (ppm)	4.88	2.07	9.49	10.4
	Ammonia emission (g NH_3-N/h/animal)	0.10	0.041	0.19	0.28
25-04-2012	Indoor temperature (°C)	19.5			
	Outdoor temperature (°C)	12.1	12.1	11.9	12.1
	Ventilation rate (m^3/hour)	22,35	26,188	26,086	20,413
	Ammonia concentration (ppm)	4.45	1.72	9.10	9.29
	Ammonia emission (g NH_3-N/h/animal)	0.099	0.035	0.22	0.17
17-07-2012	Weight of animals (kg)	73	41	52	62
	Indoor temperature (°C)	20.4	20.8	19.8	
	Outdoor temperature (°C)	17.4			
	Ventilation rate (m^3/hour)	54,665	32,303	59,374	
	Ammonia concentration (ppm)	0.73	0.88	2.98	
	Ammonia emission (g NH_3-N/h/animal)	0.037	0.021	0.15	
18-07-2012	Indoor temperature (°C)	21.1	21.2	20.5	21.3
	Outdoor temperature (°C)	18.6			
	Ventilation rate (m^3/hour)	51,070	39,503	55,137	48,744
	Ammonia concentration (ppm)	2.04	0.79	4.50	6.02
	Ammonia emission (g NH_3-N/h/animal)	0.10	0.022	0.21	0.24
19-07-2012	Indoor temperature (°C)	21.1	21.3	21.0	21.6
	Outdoor temperature (°C)	19.4			
	Ventilation rate (m^3/hour)	58,19	49,965	58,51	53,106
	Ammonia concentration (ppm)	2.43	1.00	5.21	6.053
	Ammonia emission (g NH_3-N/h/animal)	0.14	0.039	0.26	0.27

20-07-2012	Indoor temperature (°C)	20.6	20.7	20.0	21.4
	Outdoor temperature (°C)	18.1			
	Ventilation rate (m^3/hour)	52,509	45,677	59,039	46,171
	Ammonia concentration (ppm)	2.30	1.00	4.90	5.88
	Ammonia emission (g NH_3-N/h/animal)	0.12	0.034	0.25	0.23
21-07-2012	Indoor temperature (°C)	21.3	21.1	20.5	22.1
	Outdoor temperature (°C)	18.5			
	Ventilation rate (m^3/hour)	53,712	46,432	58,608	47,815
	Ammonia concentration (ppm)	1.69	0.74	4.13	5.59
	Ammonia emission (g NH_3-N/h/animal)	0.088	0.026	0.21	0.22
22-07-2012	Indoor temperature (°C)	21.5	20.9	20.9	21.7
	Outdoor temperature (°C)	19.8			
	Ventilation rate (m^3/hour)	54,973	49,278	59,962	48,099
	Ammonia concentration (ppm)	1.76	0.65	3.72	5.05
	Ammonia emission (g NH_3-N/h/animal)	0.096	0.025	0.19	0.20
23-07-2012	Indoor temperature (°C)	23.1	22.2	22.8	23.3
	Outdoor temperature (°C)	22.3			
	Ventilation rate (m^3/hour)	63,756	61,356	64,066	61,379
	Ammonia concentration (ppm)	1.75	0.73	3.83	4.22
	Ammonia emission (g NH_3-N/h/animal)	0.11	0.036	0.21	0.22
24-07-2012	Indoor temperature (°C)	27.4	26.2	27.5	27.8
	Outdoor temperature (°C)	27.8			
	Ventilation rate (m^3/hour)	66,665	67,349	66,781	61,735
	Ammonia concentration (ppm)	2.09	1.21	4.32	4.50
	Ammonia emission (g NH_3-N/h/animal)	0.13	0.064	0.24	0.23
25-07-2012	Indoor temperature (°C)	23.3	22.7	22.7	23.5
	Outdoor temperature (°C)	22.1			
	Ventilation rate (m^3/hour)	60,225	61,732	60,738	55,347
	Ammonia concentration (ppm)	1.87	0.82	3.80	4.38
	Ammonia emission (g NH_3-N/h/animal)	0.11	0.041	0.20	0.20
26-07-2012	Indoor temperature (°C)	23.4	23.4	23.5	24.4
	Outdoor temperature (°C)	22.4			
	Ventilation rate (m^3/hour)	63,014	64,254	65,467	64,317
	Ammonia concentration (ppm)	1.94	1.06	3.60	4.09
	Ammonia emission (g NH_3-N/h/animal)	0.12	0.055	0.20	0.22
27-07-2012	Indoor temperature (°C)	24.4	23.2	23.6	24.0
	Outdoor temperature (°C)	22.5			
	Ventilation rate (m^3/hour)	55,203	56,393	55,498	50,455
	Ammonia concentration (ppm)	2.35	1.17	5.38	6.16
	Ammonia emission (g NH_3-N/h/animal)	0.12	0.054	0.25	0.25
28-07-2012	Indoor temperature (°C)	22.6	22.0	22.4	23.1
	Outdoor temperature (°C)	20.9			
	Ventilation rate (m^3/hour)	63,481	61,605	62,023	56,024
	Ammonia concentration (ppm)	2.44	1.16	5.30	5.64
	Ammonia emission (g NH_3-N/h/animal)	0.15	0.056	0.28	0.27

29-07-2012	Indoor temperature (°C)	20.5	20.0	20.2	20.9
	Outdoor temperature (°C)	17.3			
	Ventilation rate (m^3/hour)	48,122	51,439	50,699	40,185
	Ammonia concentration (ppm)	3.54	1.56	6.18	7.49
	Ammonia emission (g NH_3-N/h/animal)	0.16	0.064	0.27	0.25
30-07-2012	Indoor temperature (°C)	19.9	18.7	18.6	20.0
	Outdoor temperature (°C)	15.3			
	Ventilation rate (m^3/hour)	34,559	36,907	48,109	31,261
	Ammonia concentration (ppm)	4.60	1.94	6.49	7.99
	Ammonia emission (g NH_3-N/h/animal)	0.14	0.057	0.26	0.21
24-10-2012	Weight of animals (kg)	79	48	61	71
	Indoor temperature (°C)	19.9	19.9	19.2	19.4
	Outdoor temperature (°C)	13.7			
	Ventilation rate (m^3/hour)	22,404	21,924	28,061	24,364
	Ammonia concentration (ppm)	2.82	2.05	2.63	3.42
	Ammonia emission (g NH_3-N/h/animal)	0.055	0.036	0.064	0.14
25-10-2012	Indoor temperature (°C)	19.6	19.8	19.4	19.4
	Outdoor temperature (°C)	11.3			
	Ventilation rate (m^3/hour)	21,775	20,355	24,827	21,884
	Ammonia concentration (ppm)	3.65	2.22	4.52	6.49
	Ammonia emission (g NH_3-N/h/animal)	0.075	0.035	0.090	0.11
26-10-2012	Indoor temperature (°C)	19.1	19.3	18.5	17.2
	Outdoor temperature (°C)	7.1			
	Ventilation rate (m^3/hour)	14,382	13,262	17,618	17,225
	Ammonia concentration (ppm)	6.27	3.20	7.813	11.4
	Ammonia emission (g NH_3-N/h/animal)	0.088	0.034	0.12	0.17
27-10-2012	Indoor temperature (°C)	19.3	18.8	18.3	16.6
	Outdoor temperature (°C)	6.4			
	Ventilation rate (m^3/hour)	12,270	13,020	15.743	16,144
	Ammonia concentration (ppm)	5.83	2.82	8.73	12.2
	Ammonia emission (g NH_3-N/h/animal)	0.071	0.030	0.12	0.17
28-10-2012	Indoor temperature (°C)	20.3	19.5	18.7	18.5
	Outdoor temperature (°C)	8.6			
	Ventilation rate (m^3/hour)	12,760	13,412	16,036	18,371
	Ammonia concentration (ppm)	5.98	3.56	11.4	13.2
	Ammonia emission (g NH_3-N/h/animal)	0.075	0.038	0.16	0.21
29-10-2012	Indoor temperature (°C)	20.7	20.1	19.3	17.9
	Outdoor temperature (°C)	10.1			
	Ventilation rate (m^3/hour)	13,629	13,113	16,848	22,390
	Ammonia concentration (ppm)	3.83	2.68	5.42	12.4
	Ammonia emission (g NH_3-N/h/animal)	0.050	0.027	0.080	0.24
08-11-2012	Weight of animals (kg)	93	62	75	84
	Indoor temperature (°C)	20.4	19.3	19.9	19.0
	Outdoor temperature (°C)	13.8			
	Ventilation rate (m^3/hour)	26,779	29,117	33,724	27,793

	Ammonia concentration (ppm)	3.14	2.50	7.63	8.79
	Ammonia emission (g NH_3-N/h/animal)	0.081	0.057	0.23	0.21
09-11-2012	Indoor temperature (°C)	19.8	19.7	19.5	19.2
	Outdoor temperature (°C)	12.7			
	Ventilation rate (m^3/hour)	24,082	25,571	28,481	22,803
	Ammonia concentration (ppm)	4.48	3.05	9.72	10.5
	Ammonia emission (g NH_3-N/h/animal)	0.10	0.059	0.24	0.20
13-11-2012	Indoor temperature (°C)	19.7	19.6	19.0	19.2
	Outdoor temperature (°C)	11.0			
	Ventilation rate (m^3/hour)	22,891	23,117	25,632	19,935
	Ammonia concentration (ppm)	4.63	3.88	9.44	12.9
	Ammonia emission (g NH_3-N/h/animal)	0.10	0.069	0.21	0.22
14-11-2012	Indoor temperature (°C)	19.5	19.6	20.1	19.0
	Outdoor temperature (°C)	14.5			
	Ventilation rate (m^3/hour)	27,978	31,463	31,750	38,319
	Ammonia concentration (ppm)	3.56	2.88	8.24	10.5
	Ammonia emission (g NH_3-N/h/animal)	0.096	0.069	0.23	0.35
15-11-2012	Indoor temperature (°C)	19.7	19.3	20.0	18.7
	Outdoor temperature (°C)	14.3			
	Ventilation rate (m^3/hour)	27,155	28,181	29,511	31,324
	Ammonia concentration (ppm)	3.51	3.20	8.42	10.5
	Ammonia emission (g NH_3-N/h/animal)	0.092	0.069	0.22	0.28
16-11-2012	Indoor temperature (°C)	18.9	19.5	19.1	19.2
	Outdoor temperature (°C)	10.8			
	Ventilation rate (m^3/hour)	20,331	22,134	24,213	21,545
	Ammonia concentration (ppm)	4.32	3.71	9.89	12.9
	Ammonia emission (g NH_3-N/h/animal)	0.083	0.063	0.21	0.22
17-11-2012	Indoor temperature (°C)	18.4	20.3	18.2	19.6
	Outdoor temperature (°C)	5.4			
	Ventilation rate (m^3/hour)	13,041	14,824	16,385	15,181
	Ammonia concentration (ppm)	5.10	4.25	12.8	17.5
	Ammonia emission (g NH_3-N/h/animal)	0.063	0.048	0.19	0.23
18-11-2012	Indoor temperature (°C)	18.4	19.3	18.2	18.2
	Outdoor temperature (°C)	10.5			
	Ventilation rate (m^3/hour)	18,010	20,353	22,102	23,09
	Ammonia concentration (ppm)	4.68	3.87	10.0	13.2
	Ammonia emission (g NH_3-N/h/animal)	0.081	0.062	0.20	0.26
19-11-2012	Indoor temperature (°C)	17.8	18.6	17.9	17.0
	Outdoor temperature (°C)	6.6			
	Ventilation rate (m^3/hour)	14,114	16,908	17,69	9,478
	Ammonia concentration (ppm)	5.32	4.25	11.6	14.6
	Ammonia emission (g NH_3-N/h/animal)	0.073	0.056	0.19	0.12
25-01-2013	Weight of animals (kg)	78	46	56	69
	Indoor temperature (°C)	19.5	19.5	18.8	20.6
	Outdoor temperature (°C)	0.7			

	Ventilation rate (m³/hour)	9,655	8,015	9,950	11,208
	Ammonia concentration (ppm)	2.80	1.49	11.7	13.6
	Ammonia emission (g NH_3-N/h/animal)	0.023	0.010	0.10	0.12
26-01-2013	Indoor temperature (°C)	20.3	19.9	19.2	20.7
	Outdoor temperature (°C)	-0.7			
	Ventilation rate (m³/hour)	10,286	9,015	9,637	11,528
	Ammonia concentration (ppm)	3.40	1.60	12.5	13.8
	Ammonia emission (g NH_3-N/h/animal)	0.031	0.012	0.10	0.13
27-01-2013	Indoor temperature (°C)	19.5	19.3	19.6	20.7
	Outdoor temperature (°C)	5.6			
	Ventilation rate (m³/hour)	15,718	13,854	15,778	16,618
	Ammonia concentration (ppm)	4.12	1.97	10.1	11.7
	Ammonia emission (g NH_3-N/h/animal)	0.056	0.022	0.14	0.16
28-01-2013	Indoor temperature (°C)	19.6	19.3	20.0	21.0
	Outdoor temperature (°C)	7.4			
	Ventilation rate (m³/hour)	16,049	14,863	16,534	17,042
	Ammonia concentration (ppm)	4.75	4.86	9.42	10.7
	Ammonia emission (g NH_3-N/h/animal)	0.073	0.057	0.14	0.15
05-02-2013	Indoor temperature (°C)	18.7	18.8	19.5	19.5
	Outdoor temperature (°C)	6.6			
	Ventilation rate (m³/hour)	15,069	16,153	15,906	14,035
	Ammonia concentration (ppm)	6.91	5.60	10.4	11.2
	Ammonia emission (g NH_3-N/h/animal)	0.10	0.074	0.14	0.13
06-02-2013	Indoor temperature (°C)	18.2	18.4	18.5	19.1
	Outdoor temperature (°C)	6.1			
	Ventilation rate (m³/hour)	14,074	15.097	14,326	14,827
	Ammonia concentration (ppm)	6.58	5.52	11.1	11.6
	Ammonia emission (g NH_3-N/h/animal)	0.089	0.068	0.14	0.14
07-02-2013	Indoor temperature (°C)	18.1	18.3	18.5	18.4
	Outdoor temperature (°C)	4.7			
	Ventilation rate (m³/hour)	12,812	13,762	13,255	15,304
	Ammonia concentration (ppm)	6.95	5.73	12.5	13.0
	Ammonia emission (g NH_3-N/h/animal)	0.086	0.065	0.15	0.17

Table A6. Weight of animals, indoor temperature, outdoor temperature, ventilation rate, odour concentration and odour emission on each measurement day with odour measurements at location A

Date		Experimental unit 1	Experimental unit 2	Control unit 1	Control unit 2
13-07-2011	Weight of animals (kg)	81	84	80	84
	Indoor temperature (°C)	19.9	20.3	19.8	20.2
	Outdoor temperature (°C)	15.4			
	Ventilation rate (m³/hour)	14,668	11,509	15,779	15,779
	Odour concentration (OU_E/m³)	386	407	518	554

	Odour emission (OU_E/s/1000 kg animal)	132	103	196	209
20-07-2011	Weight of animals (kg)	86	89	85	88
	Indoor temperature (°C)	23.0	23.2	23.2	23.6
	Outdoor temperature (°C)	21.1			
	Ventilation rate (m^3/hour)	22,240	20,850	25,530	25,530
	Odour concentration (OU_E/m^3)	277	277	312	277
	Odour emission (OU_E/s/1000 kg animal)	130	119	181	162
27-07-2011	Weight of animals (kg)	91	95	91	93
	Indoor temperature (°C)	24.3	24.9	24.2	24,6
	Outdoor temperature (°C)	23.0			
	Ventilation rate (m^3/hour)	26,345	23,487	26,609	26,609
	Odour concentration (OU_E/m^3)	255	203	278	302
	Odour emission (OU_E/s/1000 kg animal)	137	92	160	174
03-08-2011	Weight of animals (kg)	98	99	98	99
	Indoor temperature (°C)	26.3	26.1	26.1	26.3
	Outdoor temperature (°C)	24.9			
	Ventilation rate (m^3/hour)	26,601	24,334	26,799	26,799
	Odour concentration (OU_E/m^3)	202	121	202	194
	Odour emission (OU_E/s/1000 kg animal)	126	74	129	123
21-09-2011	Weight of animals (kg)	58	66	58	64
	Indoor temperature (°C)				
	Outdoor temperature (°C)	14.4			
	Ventilation rate (m^3/hour)	11,840	10,665	12,780	13,800
	Odour concentration (OU_E/m^3)	339	326	412	370
	Odour emission (OU_E/s/1000 kg animal)	120	89	149	137
28-09-2011	Weight of animals (kg)	65	72	64	70
	Indoor temperature (°C)	21.3	21.8	20.7	21.9
	Outdoor temperature (°C)	17.2			
	Ventilation rate (m^3/hour)	14,783	13,804	17,702	14,590
	Odour concentration (OU_E/m^3)	259	254	308	263
	Odour emission (OU_E/s/1000 kg animal)	103	83	141	95
05-10-2011	Weight of animals (kg)	70	78	71	75
	Indoor temperature (°C)	20.4	20.4	19.5	20.2
	Outdoor temperature (°C)	14.1			
	Ventilation rate (m^3/hour)	10,401	11,070	13,890	11,224
	Odour concentration (OU_E/m^3)	354	299	387	326
	Odour emission (OU_E/s/1000 kg animal)	94	74	132	84
12-10-2011	Weight of animals (kg)	77	84	78	82
	Indoor temperature (°C)	19.8	19.8	18.9	19.8
	Outdoor temperature (°C)	12.8			
	Ventilation rate (m^3/hour)	11,178	9,992	12,899	9,014
	Odour concentration (OU_E/m^3)	217	230	475	407
	Odour emission (OU_E/s/1000 kg animal)	57	48	141	78
31-10-2012	Weight of animals (kg)	87		89	
	Indoor temperature (°C)	20.2		17.9	

	Outdoor temperature (°C)	0.1			
	Ventilation rate (m³/hour)	7,362		7,485	
	Odour concentration (OU$_E$/m³)	481		378	
	Odour emission (OU$_E$/s/1000 kg animal)	66		53	
08-01-2013	Weight of animals (kg)	72		72	
	Indoor temperature (°C)	21.9		19.7	
	Outdoor temperature (°C)	0.1			
	Ventilation rate (m³/hour)	6,547		6,977	
	Odour concentration (OU$_E$/m³)	289		539	
	Odour emission (OU$_E$/s/1000 kg animal)	38		75	
22-01-2013	Weight of animals (kg)	86		86	
	Indoor temperature (°C)	18.7		18.5	
	Outdoor temperature (°C)	-1.0			
	Ventilation rate (m³/hour)	3,720		3,260	
	Odour concentration (OU$_E$/m³)	2,336		3,012	
	Odour emission (OU$_E$/s/1000 kg animal)	150		168	
17-04-2013	Weight of animals (kg)	88		88	
	Indoor temperature (°C)	19.4		18.1	
	Outdoor temperature (°C)	16.2			
	Ventilation rate (m³/hour)	10,943		11,593	
	Odour concentration (OU$_E$/m³)	244		234	
	Odour emission (OU$_E$/s/1000 kg animal)	44		45	
01-05-2013	Weight of animals (kg)	97		96	
	Indoor temperature (°C)	18.7		17.3	
	Outdoor temperature (°C)	11.6			
	Ventilation rate (m³/hour)	7,247		6,730	
	Odour concentration (OU$_E$/m³)	300		425	
	Odour emission (OU$_E$/s/1000 kg animal)	38		50	

Table A7. Weight of animals, indoor temperature, outdoor temperature, ventilation rate, odour concentration and odour emission on each measurement day with odour measurements at location B

Date		Experimental unit 1	Experimental unit 2	Control unit 1	Control unit 2
16-04-2012	Weight of animals (kg)	81	45	58	69
	Indoor temperature (°C)	19.6	19.2	18.8	19.2
	Outdoor temperature (°C)	11.1			
	Ventilation rate (m³/hour)	19,326	21,044	24,776	24,398
	Odour concentration (OU$_E$/m³)	646	575	671	847
	Odour emission (OU$_E$/s/1000 kg animal)	71	99	128	132
28-06-2012	Weight of animals (kg)	52			42

	Indoor temperature (°C)	22.5			22.5
	Outdoor temperature (°C)	22.5			
	Ventilation rate (m^3/hour)	63,330			61,293
	Odour concentration (OU_E/m^3)	153			186
	Odour emission (OU_E/s/1000 kg animal)	95			382
05-07-2012	Weight of animals (kg)	60			49
	Indoor temperature (°C)	26.5			25.7
	Outdoor temperature (°C)	27.5			
	Ventilation rate (m^3/hour)	68,086			70,076
	Odour concentration (OU_E/m^3)	158			323
	Odour emission (OU_E/s/1000 kg animal)	74			109
17-07-2012	Weight of animals (kg)	73	41	52	62
	Indoor temperature (°C)	20.8	20.8	20.9	20.7
	Outdoor temperature (°C)	19.7			
	Ventilation rate (m^3/hour)	58,324	49,573	61,265	55,615
	Odour concentration (OU_E/m^3)	167	159	274	155
	Odour emission (OU_E/s/1000 kg animal)	61	71	132	58
19-07-2012	Weight of animals (kg)	75	43	54	64
	Indoor temperature (°C)	20.2	20.2	20.0	20.5
	Outdoor temperature (°C)	19.9			
	Ventilation rate (m^3/hour)	57,602	48,586	58,719	47,823
	Odour concentration (OU_E/m^3)	166	194	155	140
	Odour emission (OU_E/s/1000 kg animal)	58	82	69	43
23-07-2012	Weight of animals (kg)	79	47	59	69
	Indoor temperature (°C)	23.9	23.1	23.9	23.9
	Outdoor temperature (°C)	25.8			
	Ventilation rate (m^3/hour)	66,642	64,918	67,819	68,758
	Odour concentration (OU_E/m^3)	284	238	198	309
	Odour emission (OU_E/s/1000 kg animal)	109	126	94	127
24-07-2012	Weight of animals (kg)	80	48	60	70
	Indoor temperature (°C)	26.9	25.8	27.1	26.8
	Outdoor temperature (°C)	29.4			
	Ventilation rate (m^3/hour)	66,179	67,836	67,716	69,451
	Odour concentration (OU_E/m^3)	182	174	246	236
	Odour emission (OU_E/s/1000 kg animal)	69	93	115	96
26-07-2012	Weight of animals (kg)	77	50	62	72
	Indoor temperature (°C)	23.9	23.3	23.7	23.8
	Outdoor temperature (°C)	23.9			
	Ventilation rate (m^3/hour)	67,510	63,026	67,343	65,153
	Odour concentration (OU_E/m^3)	489	512	727	477
	Odour emission (OU_E/s/1000 kg animal)	195	245	326	179
16-08-2012	Weight of animals (kg)		72	83	
	Indoor temperature (°C)		21.3	22.6	
	Outdoor temperature (°C)	21.0			
	Ventilation rate (m^3/hour)		61,393	64,519	

	Odour concentration (OU_E/m^3)		251	152	
	Odour emission (OU_E/s/1000 kg animal)		88	54	
21-08-2012	Weight of animals (kg)		78	90	
	Indoor temperature (°C)		22.2	22.9	
	Outdoor temperature (°C)	22.1			
	Ventilation rate (m^3/hour)		64,340	66,992	
	Odour concentration (OU_E/m^3)		467	436	
	Odour emission (OU_E/s/1000 kg animal)		159	157	
25-10-2012	Weight of animals (kg)	79	48	61	71
	Indoor temperature (°C)	19.3	18.6	18.5	18.6
	Outdoor temperature (°C)	11.8			
	Ventilation rate (m^3/hour)	21,219	23,494	29,009	27,774
	Odour concentration (OU_E/m^3)	688	599	921	1,218
	Odour emission (OU_E/s/1000 kg animal)	85	112	180	189
08-11-2012	Weight of animals (kg)	93	62	75	84
	Indoor temperature (°C)	20.1	19.4	19.3	19.9
	Outdoor temperature (°C)	14.3			
	Ventilation rate (m^3/hour)	26,038	32,363	32,715	29,878
	Odour concentration (OU_E/m^3)	1,254	879	560	486
	Odour emission (OU_E/s/1000 kg animal)	149	172	104	66
28-01-2013	Weight of animals (kg)	81	49	59	72
	Indoor temperature (°C)	18.5	18.8	19.1	19.3
	Outdoor temperature (°C)	8.3			
	Ventilation rate (m^3/hour)	17,643	19,582	16,732	19,394
	Odour concentration (OU_E/m^3)	641	437	197	216
	Odour emission (OU_E/s/1000 kg animal)	63	67	23	24
12-02-2013	Weight of animals (kg)	96	66	76	87
	Indoor temperature (°C)	18.7	18.0	18.9	19.1
	Outdoor temperature (°C)	2.0			
	Ventilation rate (m^3/hour)	10,496	12,954	14,544	14,607
	Odour concentration (OU_E/m^3)	1,364	710	1,421	1,628
	Odour emission (OU_E/s/1000 kg animal)	67	48	127	112