Karin Müller and Andrea Hesse, Brunswick

Results of a Carbon Dioxide Supported Stable Ventilation for Fattening Pigs

Carbon dioxide is one of the gases relevant for the climate. At the FAL in Braunschweig, practical experiments with fattening pigs tested to what extent improved stable air quality and simultaneous emission reduction are possible through temperature and CO_2 supported stable air flow.

Dipl.-Ing. agr. Karin Müller and Dr. sc. agr. Andrea Hesse were scientists at the Institute of Production Engineering and Building Research of the German Federal Agricultural Research Centre (FAL), Bundesallee 50, 38116 Braunschweig; e-mail: *bb@fal.de*

Keywords

Stable air quality, pig fattening husbandry, carbon dioxide, aeration

Literature

Literature references can be called up under LT 07321 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

Pig farmers would like to maintain good husbandry conditions with a good stable climate and good stable air quality in order to achieve good performance. But they are often under enormous cost pressure. Too high concentration of pollutant gases in the stable have a negative effect on animal health and performance, but also on the health of the stable personnel [1, 2, 3]. [4] show that an improvement of the stable climate leads to an improvement in animal health.

At the Federal Agricultural Research Centre (FAL) in Braunschweig, within the framework of a project "Construction and Production Engineering Approaches for Animal Appropriate and Environmentally Friendly Stable Air Quality" the stable ventilation was varied and compared with regard to stable air quality for fattening pigs. The goal was to improve the stable air quality and reduce emissions. According to Mayer, carbon dioxide is an indicator for stable ventilation [5]. Carbon dioxide in stables is produced mainly through respiration [6]. The level of the CO_2 concentration is determined by many factors. Animal weight, feeding, activity, husbandry systems, seasonal stable temperature and exhaust volume all have a great deal of influence [6, 7, 8].

Material and Methods

In the time period from Sept. 2004 to Jan. 2007, studies of the stable climate were conducted during seven fattening periods in four experimental areas of the Institute for Production Engineering and Building Research of the FAL Braunschweig. In four spatially divided stable sections, in each two exactly constructed compartments with different ventilation concepts were developed, one experimental variant and a control variant. All test areas were installed with cement fully slatted floors with a slit share of significantly under 15%. Slurry was stored underneath the slatted floor during each fattening period. The feeding was controlled in two phases via a pipe mash automat.

In each of areas 2 and 3, and in areas 4 and 5, a different type of ventilation was used. Sixteen pigs could be kept in areas 2 and 5, and 18 pigs in areas 3 and 4. Animal weight documentation was undertaken every four weeks. The stable climate was controlled separately in each section with a climate computer FSU8 from the Fancom Co. Forced air ventilation was the basic ventilation principle in all cases. The CO_2 concentrations were measured in all sections with a Polytron IR CO_2 NDH sensor with a measurement range of up to 5000 ppm. In addition to the CO_2, temperature, humidity, air volume and external temperature were measured continuously in all areas. All data were documented in a two-minute rhythm and stored in the climate computer. Additionally the exhaust carbon dioxide and ammonia were documented by the Institute of Technology and Biosystems Engineering (see Landtechnik 3/2006). The water and electricity consumption was monitored regularly.

The documented raw data were read into Access databases and then evaluated with the statistical program SPSS 14. A statistical test of the data was conducted with variance analyses.

Only three of seven fattening periods were included in the evaluation presented here, due to the development of the ventilation concepts and the non-comparability of the data. This evaluation thus only includes data from the period form December 2005 to January 2007.

The control run was based on a common ventilation principle, in which ventilation takes place on the basis of preset temperatures. Since the project dealt with forced air stables, heat was used in the case of too low outdoor temperatures, and in the case of too high temperatures - if no air conditioning was possible - then increased air volume flow was used to regulate temperature. The minimal exhaust performance was set at 20% of its possible total level and increased automatically depending on the internal stable temperature up to a setting of 80% maxi-

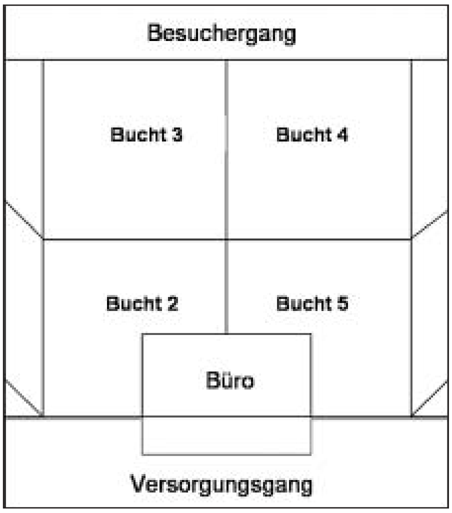

Fig. 1: Ground plan of the experimental pig-fattening stall

mal ventilation. In the experimental variations the standard setting of the exhaust was 5% minimum ventilation. In addition to the standard parameter "Temperature", a second parameter "Carbon dioxide content" affected the ventilation control. This means that the CO_2 values only had an influence on the exhaust performance, when the temperature met the requirements and that the ventilation rate was then adjusted accordingly. Pre-studies showed that for this husbandry system an air threshold value of 1000 ppm was achievable. Between 1000 ppm and 1500 ppm, the exhaust performance increases from 5% to the standard set maximum speed of 80%.

Results and Discussion

The experimental (V) and control (R_0) variations were compared in terms of CO_2 and NH_3 concentrations, air quantities, electricity consumption, indoor temperature, humidity and weight gains during fattening.

The CO_2 concentrations were lower in the testing variations in both the areas and the exhaust than they were in the control (depending on measurement site between 100 and 200 ppm). But the concentrations in the control variation (26.35% or 11.19%) varied less than those in the experimental variation (27.48% and 15.79%) Overall the CO_2 level was far below the CO_2 limit of 3000 ppm for pig stables set forth in the new Pig Husbandry Regulations of August 2006 [9]. Similar values were measured in the exhaust over the course of the study but at a higher level (see LANDTECHNIK 3/2006). The NH_3 contents in the exhaust air were also lower in the test variation (9.74 ppm) than in the reference measurements (10.58 ppm).

With regard to the air quantities it is obvious that the average in the CO_2 supported ventilation had almost twice as much exhaust volume in one hour after it was transported out (43.22 m^3/h) than in the case of common variations (26.81 m^3/h), while the values there ranged more widely (V: VK of 44.19% and R_0:VK of 62.14%). Since an additional CO_2 monitoring to the air flow first starts when the temperature is in an acceptable range, the data is measured with an external temperature of under 14 °C. These differences between the variants (V: 39.48 m^3/h and R_0: 25.10 m^3/h) are less, but show the same trend. The clearly higher amount of air in the experimental variation is explained by the low gas concentration measured there. The electricity consumption was only slightly different among the variation, and did not reflect the differences in the air quantities. A possible cause could be that in the case of a 20% minimal ventilation, a higher air resistance could be created than in a 5% minimum ventilation and for this purpose relatively more energy is used.

The indoor temperatures, controlled via the heating and ventilation, differ only slightly, but importantly, from each other. It is, however, clear that in the absence of air conditioning, ventilation reaches its limits in the summer by high outdoor temperature and that especially in this seasonal situation, a CO_2 controlled ventilation can have disadvantages. With higher outdoor temperatures than indoor temperatures, the danger exists that more warm air will be drawn in through the CO_2 control in an environment, which is already too warm for fattening pigs. An additional cooling effect through a CO_2 multi ventilation can be seen by an outdoor temperature of under 14C°, otherwise the result is more likely a "warming effect."

Very good weight gains were achieved in both variants which indicate good husbandry conditions, particularly in terms of air quality (low CO_2 and NH_3 values). Seen overall, the influence of the pollutant gas concentrations under the permitted levels for fattening performance have only a minimal effect.

The lower weight gain in the test variants could be one cause of the higher air capacity and the – in the case of female fattening pigs somewhat more strongly defined – sensibility to minimal drafts [10]. But these weight gains occurred on the basis of a non unified breeding and are thus not significant.

The overall results should be seen as trends, since due to the multi-factorial stable climate an exact division of individual influences was not possible in this test.

In contrast to the results of Häußermann, in this study in the CO_2 supported ventilation variation, lower CO_2 and NH_3 values were achieved but at the same time higher volume streams created, whereby seen overall, no reduction in the emissions could be realized [3]. These differences could be accounted for in that the differing ventilation systems and different CO_2 ventilation strategies were used.

Summary

The CO_2 supported ventilation studied here had an influence on the exhaust air flow volume if the indoor temperature was within the range it should have been. As long as higher air quantities were used in a CO_2 regulation, it can be seen critically by higher outdoor temperatures. The goal of an improved stable air quality (with regard to the CO_2 and NH_3 contents) goes always along with an increase in the air flow. In order to achieve also a reduction in emission, further studies would be desirable. Since the study results differ from literature sources, it can be concluded that each husbandry system must be individually tested in order to find measures to improve husbandry conditions, cost savings and emissions reductions.

Table 1: Average value (MW) and coefficient of variation (VK) of both aeration versions

	Variation			
	V		R_0	
	MW	VK %	MW	VK %
CO_2 (in the area) [ppm]	973.75 [a]	27.48	1145.89 [b]	26.35
CO_2 (in the exhaust) [ppm]	1544.07 [a]	15.79	1648.86 [b]	11.19
NH_3 (in the exhaust) [ppm]	9.74 [a]	53.23	10.58 [b]	56.48
Air quantity per animal [m^3/h]	43.22 [a]	44.19	26.81 [b]	62.14
Air quantity per animal [m^3/h] (outdoor temperature <14°C)	39.48 [a]	46.05	25.10 [b]	59.93
Electricity consumption [kW/Tag]	3.32 [a]	19.65	3.26 [b]	10.68
Indoor temperatures [°C]	19.02 [a]	10.45	18.87 [b]	10.04
Indoor temperatures [°C] (Outdoor temperature <14°C)	18.54 [a]	9.09	18.73 [b]	9.83
Rel. Humidity [%]	54.00 [a]	11.61	54.61 [b]	11.02
Male weight gain [g]	981.72 [a]	20.38	1001.94 [b]	14.92
Female weight gain [g]	908.71 [a]	20.78	964.42 [b]	17.58

a, b significance (≤1% probability of error)