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Indoor Air Quality and Biological Impacts on the Workplace in Housing Systems for Fattening pigs

In this research of a variety of housing systems for fattening pigs, the impact by microorganisms and their metabolic products, as well as the effects of dust and harmful gases, was central. No distinct differences between the housing systems could be determined regarding the dust and gas concentrations. The biological hazards as well as the impact on animal health varies between the different housing systems.

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Occupational safety and health, harmful gases, dust, bio aerosols, endotoxin, pig fattening

Literature

Literature references can be called up under LT 04311 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

Against the background of a high prevalence of respiratory diseases among the workers with the housing of fattening pigs as well as conspicuous negative pulmonary results among the fattening pigs, it will be necessary to determine within the framework of an interdisciplinary cooperating project the impact of and hazards for humans, animals and the environment wherever it occurred in fattening pig facilities. To achieve this research has been carried out in representative systems of housing fattening pigs especially taking into account organic systems in comparison to conventional systems. In correspondence with the current discussion in the field of occupational medicine and the occupational safety and health area the impact through micro organisms and their metabolic products (so-called biological hazards) as well as the effects of dust and harmful gases are central in this research.

Pig facilities

Research for this project has been conducted in four different housing systems for fattening pigs: A, B, C and D (*Table 1*).

The four different housing systems were selected, because the represent typical and common practical solutions for housing systems, which are managed without straw (systems A and B) and with straw litter (systems C and D). Therefore the four systems are appropriate to describe the status quo concerning the indoor air quality and the impact of biological substances on the worker in such systems. Two of the systems, i.e. A and B, correspond to the BAT criteria, as well as to most of the requirements laid down in the draft to the German law for the protection of agricultural animal husbandry. These two systems have a fully slatted floor with a reduced slats area (50% of the total area with a 6% slot share) and every stall is provided with a Porky-Play occupation technique (27 animals/stall; 0.90 m^2 /animal). Housing system C is a deep litter system with straw (converted old building), which is managed according to German Bioland-standards (Bioland, 2004) and natural ventilation, where air exchange is only possible by tilting or removing the windows (20 animals/stall; 1.3m^2/animal). System D is designed according to the EEC directive on organic production of agricultural products (EEC 2092/91, 2003) with separate climatic areas; it is provided with a natural ventilation system with spaceboards and wind breaker nets on both sides of the stall (1.3 m^2/animal inside and 1.0 m^2/animal outside).

Experimental lay out

Each of these four housing systems were tested on six different measuring dates, three in the cold season and three in the hot season.

Registered parameters
The feeding and straw used in the four systems were examined and data on details of food consumption, daily weight gain and number of fattening days collected. Furthermore the room temperature and humidity in all the systems, or compartments were determined as additional parameter. (Co. ROTRONIC, Model Hygroclip).

Table 1: Parameters of housing systems

Housing system	use of - straw	separate climatic areas	ventilation	feeding	management
A	occupation technique	no	forced ventilated DIN 18910	four-phases mash feeder	all in - all out
B	occupation technique	no	forced ventilated DIN 18910	four-phases fluid feeder	all in - all out
C	deep litter system	no	naturally ventilated	one-phases dry feeder	continual
D	minimal litter system	yes	naturally ventilated	two-phases dry and wet feeder	continual

Measurements concerning the indoor air quality inside the four systems contain concentrations of NH_3, CO_2 and CH_4 over NDIR spectroscopes, i.e. photo-acoustical infrared spectroscope, as well as dust measurements.

The examinations of particle mass concentration and -distribution were executed in accordance with the viewpoint of environmental- (PM10) and labour protection (EN481). The PM-determination took place partly with scatter light photometers, partly with aerosol spectrometers. The latter measuring device was also used for the determination of the particle fractions corresponding to occupational medicine aspects.

The health status of the fattening pigs was determined by adspection of the animals and by analysis of serological and coprological samples as well as by organs- and results of samples of organs of slaughtered animals. Besides the sero-prevalence of antibodies against the influenza-, the PRRS- and the circovirus, as well as mycoplasm hyo-pneumoniae, parasites and more obvious results of organ samples were documented.

Results and discussion

The analysis of the feed used in the four housing systems showed that there is clearly a below-average provision of crude protein, especially at the beginning of the fattening period in the feeding of systems C and D.

The registered indoor temperatures and humidity of the four systems, i.e. compartments are within the limits as determined for forced and natural ventilated systems, as described in literature (A/B: about 13 - 36 °C and 21 - 75 %; C/D about 2 - 29 °C and 36 - 86%), during all fattening periods

In the naturally ventilated systems C and D the tendency for lower CO_2 and NH_3 concentrations were registered, as expected (average values C/D: CO_2 about 1220/900 ppm; NH_3 about 7/2 ppm), compared to the forced ventilated systems A and B (average value A/B: CO_2 about 1530/1600 ppm; NH_3 about 8/7 ppm). The explanation for these CO_2 values are particularly the different ventilation systems and consequently the different air exchange rates. The reasons for the generally lower NH_3-concentrations in the systems C and D may be due to the lower average indoor temperatures in both these systems and the obviously lower crude protein intake of the animals (see above). It also has to be taken into account that system D was equipped with separate functional, i.e. climate areas and the measurings of CO_2, NH_3 and CH_4 concentrations were carried out only in clean (i.e not dirtied by excrement, etc.) feeding and lying areas of the stall. In total the determined CO_2 and NH_3 concentrations were in the lower to mean ranges compared to literature. In contrast to the housing systems A and B average CH_4 concentrations, the concentrations of the C and D systems were clearly higher (peaks of above 100ppm) and revealed a wider scattering range (A/B: CH_4 about 0 - 30 ppm; C/D: CH_4 about 6 - 190 ppm). These two systems can therefore be found in the upper regions compared to literature.

The measured particle mass concentrations of PM 10 revealed a slight decreasing tendency in the housing systems from A to D (Average A/B: about 1,3/0,9; C/D: about 0,5/0,4), but the values of systems A and B were on a similar level as the normal scattering range of values - with the exception of the feeding - in similar housing systems. No significant influence of feeding on the particle concentrations was registered. By comparing the “peak to mean relationship” of the PM 10 concentrations it was revealed that these values in the housing systems C and D were clearly higher than in the systems A and B (peak to mean: A/B about 4,3/4,1; C/D about 10,1/20/7). A possible reason for this may be the continual litter of straw in connection with the stronger fluctuations of the air exchange rate in housing systems C and D.

In the evaluation of the data in connection with airborne biological substances and hazards (endotoxins, mould and bacteria), no differences between systems A and B were determined. Therefore the data flowed into the analyses as a whole. When the systems were compared, the deep litter system C revealed the highest impact., and system D, built according to European organic production directives revealed the lowest impact by airborne endotoxins (stationary sampling).

The mean value in that case was 14495 EU/m^3 for system C, in comparison to 5544 EU/m^3 in both the systems A and B and 2876 EU/m^3 in system D. In D the scattering of values was clearly lower than in the other systems.

Where the airborne mould is concerned, the highest values were registered in system C with a mean value of 4622 KBE/m^3 air (A and B: 1058 KBE/m^3; D: 2151 KBE/m^3), whereas both the systems C and D revealed a scattering of values in comparison to systems A and B. Similar observations were made where the concentration of all bacteria was concerned (C: 16.1 Mio KBE/m^3, A and B: 0.2 Mio KBE/m^3, D: 4.4 Mio KBE/m^3).

When comparing on location (stationary sampling) and person related measurements (personal sampling), the person related values were always significant higher than the stationary measured values. Concerning the personal sampling, systems A and B always revealed lower values than systems C and D. The reason was that activities resulting in strong bio-aerosol emissions (e.g. littering, manual feed refill) were not executed here - with the exception of the weekly straw refill of the occupational technique with only small amounts of straw.

The tests concerning animal health determined that about 45% of the tested animals had conspicuous lung diseases and about 36% of the examined pigs revealed liver diseases, mostly caused by worm blight. Whereas the distribution of lung diseases in all systems were more or less evenly spread, the liver diseases were only found with the pigs of systems C and D. This probably isn’t as a result of the housing system as such, but caused by the inefficient hygienic management (neglected hygiene, deworming).

As there is not much of a difference in the occurrence of infections in the different systems (compartments), the kind of housing systems of animals is not the main reason for the variance, but other factors are responsible (among others: vaccination programmes, cold related stress, septicaemic or enteral infections, transport related stress or hierarchy fights).

Conclusions

In general the concentration, impact respectively of bio aerosol such as endotoxin, mould, and bacteria was found to be on an very high level in all four housing systems; especially the endotoxins. In opposite to the determined gas- and dust concentrations, significant differences between the four housing systems concerning the concentration of airborne biological substances occurred to some extent. The test results lead to the conclusion that the extent of the impact cannot be ascribed to the different housing systems as such, but first of all to their individual organisation and management. In order to evaluate the impact of humans and animals as a result of the conditions in which the animals are kept, it can be deduced that the classification of the housing systems, as set down in the BAT concept especially, isn’t very powerful, in fact, the systems should be differentiated more clearly. The test results stress the meaning of implementation, dimensioning und control of the ventilation systems as well as cleanliness, i.e. hygiene and especially the management of the systems, whose key role concerns the amount of emissions of harmful gases as well as animal health. Procedures of adapting the ventilation, the feeding, the manure removal and the structuring in different functional and climatic areas with in the compartments, pens respectively to the respective time of the day or year or event, always considering the needs of animals and humans should be the aim at all times.