Pig building dustiness as affected by canola oil in the feed

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Welford, R.A., Feddes, J.J.R. and Barber, E.M. 1992. **Pig building dustiness as affected by canola oil in the feed**. Can. Agric. Eng. **34**:365-373. Experiments were performed in a swine grower-finisher room to determine the effect of canola oil treatment of feed on several indices of dustiness. The effectiveness of the oil treatment was assessed over 18 weeks by measuring the respirable dust particle counts (RPC), airborne dust inhalable mass concentration (IMC), and dust sedimentation rate (DSR). The dry feed contained 0% and 2% canola oil on alternate weeks. The pen floors were partially slatted during the first 8 weeks and were totally slatted during the last 10 weeks. The mean RPC was 45% higher for the oil treatment compared to the no-oil treatment. The mean IMC was 31% lower for the oil treatment compared to the no-oil treatment. The mean DSR within the room was 7% lower and within the recirculation duct was 9% lower for the oil treatment compared to the no-oil treatment. None of these differences were statistically significant ($P > 0.1$). Workers reported that the building did not seem to be as dusty, especially during feed handling, when the feed was oiled. The results of this experiment suggested that, whereas canola oil additions to feed may appear to reduce nuisance dust levels in pig buildings, the concentration of respirable dust particles may not be reduced by the feed treatment. The nitrogen content of the dust was significantly higher ($P < 0.05$) for the oil treatments compared to the no-oil treatments. This result suggests that a greater percentage of the dust may be of animal or microbial origin when dust concentrations are lowered by adding oil to feed.

Des expériences ont été effectuées dans une salle de croissance-finition pour porcs afin de déterminer l'effet du traitement de la nourriture à l'huile de canola sur plusieurs indices de contenu en poussière. L'efficacité du traitement à l'huile a été évaluée durant une période de 18 semaines en mesurant le nombre de particules de poussières respirables (RPC), la concentration massique de poussière aspirable (IMC), et le taux de sédimentation de la poussière (DSR). Le contenu de la nourriture sèche en huile de canola alternait entre 0% et 2% d'une semaine à l'autre. Le plancher des enclos était partiellement couvert de lattes durant les 8 premières semaines; il était complètement couvert durant les 10 dernières semaines. Le RPC moyen avec le traitement à l'huile était de 45% supérieur à celui mesuré en l'absence de traitement. Le IMC moyen avec le traitement à l'huile était de 31% inférieur à celui trouvé sans le traitement. Le DSR moyen mesuré dans la salle lors du traitement à l'huile était de 7% inférieur à celui mesuré sans le traitement; dans le conduit de recirculation, il était de 9% inférieur avec le traitement. Aucune de ces différences n'a été statistiquement significative ($P > 0.1$). Les travailleurs ont rapporté que le bâtiment ne semblait pas être aussi poussiéreux lors des traitements à l'huile, surtout lors de la manutention de la nourriture. Les résultats de ces expériences ont indiqué que, malgré la réduction apparente de la nuisance par la poussière dans les porcheries grâce aux traitements de la nourriture avec de l'huile de canola, la concentration de particules de poussières respirables pourrait ne pas être réduite par ce traitement. Le contenu en azote de la poussière lors des traitements à l'huile a été significativement plus élevé ($P < 0.05$) qu'en l'absence de traitement. Ce résultat indique qu'une plus grande proportion de la poussière pourrait être d'origine animale ou microbienne lorsque les concentrations de poussière sont réduites par l'ajout d'huile à la nourriture.

INTRODUCTION

The move towards intensive livestock production has led to an increase in the use of confinement housing of pigs. The air quality inside these units becomes a concern for workers and for environmentalists. Airborne contaminants can make conditions unpleasant and even unhealthy for workers (Donham et al. 1988) and may increase disease and reduce performance of the pigs (De Boer and Morrison 1988). Of the airborne contaminants, aerosols including dust and airborne microorganisms have been especially implicated as a problem in pig buildings. In addition to health related concerns, dust creates a nuisance in and near pig buildings, increases labor requirements for building and equipment maintenance, and interferes with the performance of heating and ventilating equipment.

Dust particles in pig buildings originate from several sources including bedding, feed, skin, hair, feces, mucous, outside air and barn workers (Dawson 1991). In a pig building without bedding or dust control measures, feed has been thought to be the most important source of dust (Curtis et al. 1975; Honey and McQuitty 1979; Donham et al. 1986; Heber et al. 1988).

Possibilities for control of dust have been extensively reviewed (Owen 1982; Carpenter 1986; Dawson 1991; Barber et al. 1991). Reducing feed dust has been a priority in much of the recent research. Only after feed dust has been removed as a major source of dust is it likely to be feasible to consider filtration and air scrubbers (Barber et al. 1991). Once feed has been delivered to the animals, the potential for dust production appears to be more closely linked to feeder design and to feed wastage than it is to the type of feed (Dawson 1991). Where dry mash feed is used, the most promising technology for control of feed dust involves adding fat or oil to the feed.

Gast and Bundy (1986) concluded that oils added to dry pig feed at the rate of 1% reduced dust counts in laboratory feed drop tests by as much as 99%. Recent laboratory research (Heber and Martin 1988) has shown that vegetable oils are more effective than animal fat in reducing feed dustiness.

Aerial dust levels in naturally and mechanically ventilated pig grower buildings were reduced by 21 to 82% in one series of trials where tallow was added to dry feed at the rate of 5% (Chiba et al. 1985). The same researchers (Chiba et al. 1987) later measured a 53% reduction in total dust mass concentrations from tallow additions at 7% to dry pig feed. The addition of the fat was found to increase the crude protein content of the settled dust from 16.0 to 20.4% which suggests that the feed treatment affected the proportion of dust of animal versus plant origin. Gore et al. (1986) measured a 46% reduction in settled dust in a weanling room due to the addition of 5% soybean oil to dry feed. This result suggests that the effect of the oil was to reduce dust production rather than to increase the rate of dust sedimentation.

Practical farm experience with canola oil in Western Canada agrees with the above-noted research findings in that canola oil addition to dry pig feed appears to reduce the total dustiness in pig buildings. Farmers can see that there is less dust in the air and less dust accumulation on equipment and pen partitions. However, the results reported by Chiba et al. (1987) seem to suggest that fat additions to feed may change the proportion of dust from various sources. There does not seem to be any reason to believe that oil additions to feed will reduce or affect sources of dust other than feed, in particular sources of animal origin. The effect of canola oil additions on the proportion and number of smaller, respirable sized, dust particles apparently is not known. This information is necessary to predict the impact of oiled feed on reducing health related risks due to dust. Therefore, this project was conducted to determine the effect on building dustiness of adding canola oil to dry pig feed in a grower-finisher building.

EXPERIMENTAL PROCEDURE

Description of test building

The experiment was carried out in a swine feeder room, 11.6 m x 6.7 m, located in the Sinclair Swine Centre at the Edmonton Research Station, University of Alberta (Fig. 1). The room had a manure collection pit under a totally slatted floor. The manure was flushed out of the building every second day.

The room was ventilated by a negative pressure system consisting of two two-speed exhaust fans mounted in the ceiling. Fresh air was introduced through slot inlets located above a recirculation air duct. Recirculated room air (300 L/s) assisted in mixing and projecting the incoming air. The small fan operated continuously at low speed and exhausted 130 L/s to supply the minimum ventilation requirements. The larger fan was thermostatically controlled to operate at low speed whenever the room temperature was above 24°C. When both fans were operating at low speed, the total ventilation rate was 1670 L/s. The fan airflow rates were determined by measuring the air velocity profile in the ducts that extended from the ceiling, through the attic, and out through the roof. The average velocity in the ducts was determined by a hot wire anemometer (Velocicalc, TSI Inc., St. Paul, MN).

Supplemental heat was supplied by heated water supplied from a unit heater and circulated through 38 mm diameter

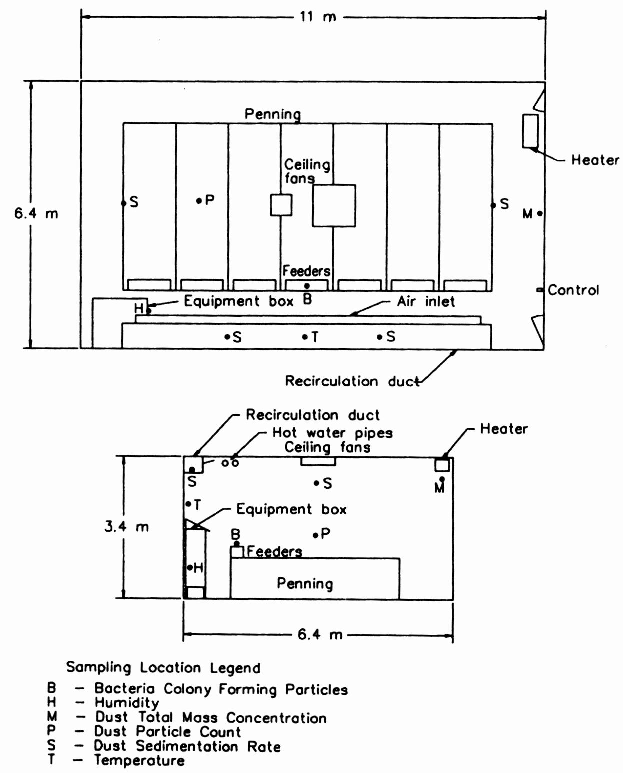

Fig. 1. Floor plan and section view of the experimental room showing sampling locations.

bare steel pipes. Operation of the unit heater was independent of the fans in that it was manually controlled on or off. The water temperature in the pipes was also manually controlled.

The room had seven pens enclosing a total pen area of 36.4 m^2. The number of pigs in the room varied from 32 to 62 (average = 49) during the experiment, and the pigs varied in mass from 35 kg to over 100 kg (average = 70 kg). The average pen space allowance was 0.74 m^2/pig, equal to that which is recommended for pigs at a market mass of 100 kg (VIDO 1987). The total room air volume was 200 m^3 or 4 m^3/pig, considerably greater than a volume of 2.0 to 2.5 m^3/pig which would be more typical of most grower-finisher rooms where relatively less space is devoted to access alleys. Typical of commercial grower-finisher rooms, the pigs had unlimited access to self-feeders and water nipples. The feeders were manually filled twice weekly. Bedding was not used during the experiment.

Experimental design

The main treatment effect was the comparison of dustiness for feed with or without canola oil. Rations were prepared on site at the Edmonton Research Station Feed Mill. The feed without oil was a mash growing ration (15-16% protein) consisting of barley, soy meal, wheat, and a supplement. The feed with oil was an identical growing ration with the addition of 20 kg of canola oil per 1000 kg of feed (2% by mass). The rate of oil addition was selected after consulting canola oil supplier guidelines to farmers in Saskatchewan.

A total of 18 one-week trials was conducted. The experiment was blocked such that a week with no oil in the feed was always followed by a week with oil in the feed. At the start of each trial the room was cleaned to allow a consistent starting point. The room was allowed to reach equilibrium for the first five days of the trial. Settled dust measurements were taken over the full 7 days of each trial. Measurements of airborne dust mass concentration were taken over 24 hours on the sixth day of the trial only. All other measurements were taken over 48 hours during the sixth and seventh days of each trial.

To enhance the range of applicable conditions represented by the experiment, two types of floor were used. For the first 8 trials, concrete sidewalk blocks were used to cover approximately two-thirds of the pen area, thereby simulating a partially slatted floor typical of that used in commercial feeder buildings. During the last 10 trials, the pen floor was restored to the original fully slatted configuration.

Monitoring equipment and methods

The equipment used to measure and record the room conditions was kept inside a ventilated plywood box placed in a corner of the room. The box was pressurized with filtered outside air to protect the instruments. Air sampling lines extended through ports in the box out into the room. Sampling locations for all of the measured variables were as shown in Fig. 1.

Dust measurements

Dustiness was assessed by measuring particle counts, RPC (particles/mL), inhalable mass concentration, IMC (mg/m^3), and dust sedimentation rates, DSR (mg•m^{-2}•h^{-1}). Airborne dust particle counts were monitored for five minutes out of every thirty minutes. Dust was sampled from one representative location in the room. Two instruments were used to count and size the airborne particles. An aerodynamic particle sizer (APS) (Model 3300, TSI Inc., St. Paul, MN.) was used for most of the study. Due to mechanical problems, a forward light scattering particle counter (Model 210, Climet Instruments, Redlands, CA) was substituted for five weeks of the study. The two particle counters were calibrated against each other through identical sampling systems, and a calibration factor was subsequently applied to all data collected with the light scattering counter. The data from the dust counters were collected by a personal computer (Model 8086, International Business Machines, Boca Raton, FL). Respirable dust was defined as all those particles within the size range of 0.5 to 5.0 μm.

The mass concentration of airborne dust was determined at the location shown in Fig. 1 by collecting all of the dust from a sample of air on a filter placed on the top stage of a cascade impactor (Anderson 1958). The inlet of this sampler is designed such that the efficiency of particle collection is nearly 100% for particles less than 5 μm in diameter and decreases to 0% for particles greater than 100 μm in diameter. The dust sample so collected is considered to be representative of that which would be inhaled by a human. This measure of airborne dust will be referred to as the inhalable mass concentration (IMC) to distinguish it from the larger total mass concentration often reported in the literature. The impactor operated for 24 hours and the mass of material collected on the filter was recorded. Only one sample was taken during each experimental trial. The flow rate through the sampler was assumed to be constant over the sampling period. Even though the gathering dust deposit may have increased the resistance to air flow, the deposits were relatively small and there was no obvious decline in the rate of airflow. No attempt was made to account for the influence of potential changes in the moisture content of the filters or of the dust deposits. This oversight is thought unlikely to have had a large impact on the accuracy of the experiment because the relative humidity within the room was fairly consistent over all trials.

The dust sedimentation rate (DSR) was measured in each trial by weighing the mass of dust that settled onto an open petri dish over a 7-day period. The petri dishes were set at two representative locations in the room and at two locations inside the recirculation duct. Reference filter papers were exposed during each trial to determine the influence of changes in humidity on the tare mass of the filter papers.

Airborne microorganisms

Monitoring for airborne microorganisms was conducted once during each trial. The intention of this monitoring was to determine the general level of bacteria in the air and was not intended to isolate or quantify individual species of pathogenic bacteria. A high volume slit sampler (Casella London Ltd., London, England) was used to sample room air and impact the colony forming particles onto the culture medium. The culture medium (Bacto Plate Count Agar, Difco Laboratories, Detroit, MI) is a non-selective medium for culturing bacteria. After sampling took place, the medium was incubated aerobically for 48 hours at room temperature (23°C). After incubation, a representative area of the plate was marked, and the number of bacteria colony forming particles (BCFP) within that area was counted.

Other measurements and observations

The nitrogen content of the feed, of settled dust, and of dry pen floor scrapings was measured to assist in identifying the source of the settled dust. Samples were obtained only once for each of the oil and flooring treatments. Analyses for total Kjeldahl nitrogen were performed according to procedures recommended by Bradstreet (1965).

The relative humidity of the experimental room was determined from measurements of the dewpoint temperature with a dewpoint hygrometer (Model 880, Cambridge Systems, Watertown, MA) or from measurements of the wet-bulb temperature with a hand-held digital thermohygrometer (General Eastern, Watertown, MA). The room dry-bulb temperature was recorded at 15 minute intervals as measured with a thermistor (Uni-Curve UUB31J1, Fenwal, Cambridge, MA) located at mid-height adjacent to an interior wall.

The number of pigs in each pen was recorded for the last 48 hours of each trial. The average pig mass in the room during each trial was estimated by assuming a linear growth between measured masses recorded when pigs entered and left the room.

A pen wetness score was assigned to each pen. A completely dry pen floor was given a score of 1 while a completely wet pen floor was given a score of 10. A median score was calculated for all 7 pens for the last 48 hours of each trial during which time the dust particle count was measured.

RESULTS AND DISCUSSION

The various measures of room dustiness are summarized in Table I. The effects of the feed treatment and of the flooring treatment are isolated within the table. Settled dust data are presented separately for the room and the mixing duct sampling locations. An apparent dust sedimentation velocity (ADSV) was calculated as the ratio of room DSR to IMC.

Testing for the effects of non-controlled variables

Treatment summaries are given in Table II for various independent variables that were measured but uncontrolled and that could affect dustiness in the pig building. Between the oil and no-oil treatments, none of the differences in the confounding variables were statistically significant ($P < 0.05$). Therefore, any differences in dustiness between the two treatments may be attributed to differences in oil content of the feed.

For the comparison between the two flooring types, differences in number of pigs, pen wetness score, room temperature and outside temperature were not statistically significant, whereas differences in average and total pig mass, ventilation rate and relative humidity were significant

Table I: Summary of dustiness measurements*

Treatment	Oil	No-oil	Averages
Room Dust Sedimentation Rate, DSR ($mg•m^{-2}•h^{-1}$)			
Partial⁺	51.4 ± 12.9 (4)	45.1 ± 14.3 (4)	48.2 ± 15.7 (8)[a]
Total	75.0 ±21.2 (5)	89.1 ± 29.4 (5)	82.0 ± 28.7 (10)[b]
Averages	64.5 ± 20.4 (9)	69.5 ± 27.1 (9)	67.0 ± 24.0 (18)
Duct Dust Sedimentation Rate, DSR ($mg•m^{-2}•h^{-1}$)			
Partial	58.7 ± 13.2 (4)	63.0 ± 44.1 (4)	60.8 ± 37.6 (8)
Total	85.3 ± 16.6 (5)	95.4 ± 38.6 (5)	90.3 ± 33.2 (10)
Averages	73.5 ± 17.2 (9)	81.0 ± 46.6 (9)	77.2 ± 35.2 (18)
Inhalable Mass Concentration, IMC (mg/m^3)			
Partial	4.1 ± 0.3 (2)	5.6 ± 0.3 (2)	4.9 ± 0.4 (4)
Total	3.1 ± 1.3 (5)	4.7 ± 2.3 (5)	3.9 ± 2.1 (10)
Averages	3.4 ± 1.3 (7)	5.0 ± 2.3 (7)	4.2 ± 1.9 (14)
Respirable Particle Count, RPC (particles/mL)			
Partial	11.1 ± 7.8 (4)	7.2 ± 7.7 (4)	9.1 ± 8.9 (8)
Total	20.5 ± 6.8 (5)	15.9 ± 10.9 (3)	18.6 ± 9.9 (8)
Averages	15.8 ± 8.2 (9)	10.9 ± 10.9 (7)	14.0 ± 9.4 (16)
Apparent Dust Sedimentation Velocity, ADSV (m/h)			
Partial	13.2 ± 2.5 (2)	9.1 ± 3.4 (2)	11.1 ± 4.2 (4)
Total	27.4 ± 15.0 (5)	20.8 ± 9.2 (5)	24.1 ± 13.9 (10)
Averages	23.3 ± 15.1 (7)	17.5 ± 9.4 (7)	20.4 ± 12.6 (14)
Bacteria Colony Forming Particles, BCFP (Counts)			
Partial	75 ± 19 (24)	66 ± 10 (24)	71 ± 15 (48)[c]
Total	123 ± 45 (32)	115 ± 46 (40)	118 ± 45 (72)[d]
Averages	102 ± 37 (56)	96 ± 37 (64)	99 ± 37 (120)

* Table entries format: mean ± standard deviation (# of observations)

⁺ Refers to portion of floor which was slatted

[a] Means for the same variable with different superscripts are significantly different ($P < 0.05$)

(P < 0.05). The higher ventilation rate is related to the higher total pig mass. Higher pig mass would lead to higher heat and moisture production by the animals. A higher ventilation rate would be required to keep the room at a constant temperature if outside temperature was constant. These significant differences between variables other than flooring could affect dustiness measurements. Different pig mass and ventilation rates could have affected the amount of dust that became airborne. More pig mass would lead to higher feed consumption. Higher feed consumption would lead to more feed being moved or agitated, resulting in more dust becoming airborne from the feed. Higher ventilation rates could affect particle concentration by selectively removing more small particles and could affect settling rates by keeping particles suspended longer due to higher airspeeds in the room. Differences in pig mass also would be expected to affect microorganism levels (Muller and Wieser 1987; Webster 1990). Jones et al. (1982) found significantly higher BCFP counts when the number of animals occupying an airspace was increased. Therefore, although differences in dust measurements between the flooring treatments will be presented, no attempt will be made to test hypotheses about the effect of flooring because of the inability to account for the effects of the various confounding variables.

Particle size distribution

A typical airborne aerosol particle size distribution follows a log-normal distribution (Hinds 1982). The size distribution in this experiment was truncated on the lower end of the distribution because the dust particle counters could only distinguish particles as small as 0.5 µm. The distribution was truncated on the upper end because of limitations in the air sampling system. Experience with the sampling system suggested that a significant but unpredictable proportion of particles larger than 5 µm may be removed from the airspace and deposited within the upstream tubing.

The measured data for particles between 0.5 and 5.0 µm were fitted to a doubly truncated log-normal distribution (Cohen 1950). The chi-square goodness of fit test (Steel and Torrie 1980) was used to compare samples of collected data with the theoretical curve. For example, Fig. 2 shows the comparison between the calculated truncated normal curve and the data from trial 17. The actual data curve is based on measurements made on 14 million individual particles. Figure 2 shows very little difference between the two curves. The chi-square goodness of fit test indicated that there was no significant difference between the curves (P < 0.05) and it was concluded that the sampled aerosol could be approximated by a doubly truncated log-normal distribution. The normal statistical procedures can be used with sufficient accuracy for the truncated distribution (Cohen 1950).

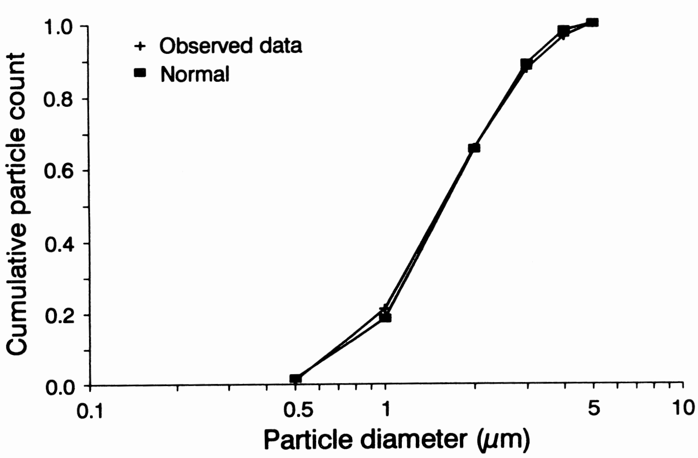

Fig. 2. Measured dust particle size distribution (Trial 17) versus theoretical doubly truncated log-normal distribution.

Testing for effects on dustiness

The room DSR (Table I) was 7% lower for the oil treatment (64.5 mg•m^{-2}•h^{-1}) compared to the no-oil treatment (69.5 mg•m^{-2}•h^{-1}). Similarly, the recirculation duct DSR was 9% lower for the oil treatment (73.5 mg•m^{-2}•h^{-1}) compared to the no-oil treatment (81.0 mg•m^{-2}•h^{-1}). Neither of these differences was statistically significant (P > 0.10).

Average dust IMC was 31% lower for the oil treatment (3.4 mg/m^3) than for the no-oil treatment (5.0 mg/m^3). This difference was not statistically significant over 14 samples (P > 0.10). Workers in the barn observed less dust when handling the oiled feed. The observations of the workers along with the trend to lower IMC measurements indicate that the measured differences in dustiness were practically significant to the workers.

The IMC decrease with the addition of oil to the feed is consistent with the decrease in settled dust. However, this may have been a fortuitous result given the sampling schedule that was used. The settled dust measurement gave an average DSR over the entire 7 days of each trial and during each trial the feeders were filled twice. The IMC measurements, on the other hand, were conducted only over one 24-hour period during which time the feeders were not filled. Because the two measurements were conducted over different time periods, they cannot necessarily be compared directly.

Notwithstanding the difficulty of comparing settled and airborne dust measurements, an average dust sedimentation velocity (ADSV) was calculated by dividing the room DSR measurement by the IMC. The average ADSV for the oil treatment (23.3 m/h) was higher than for the no-oil treatment (17.5 m/h) but this difference was not significant (P > 0.10). A higher ADSV would indicate a shift to relatively more larger sized particles or an increase in the average particle density. Particle size distribution statistics were not calculated in this experiment because particle count data were not available beyond the respirable particle size range.

The average RPC was 15.8 particles/mL for the oil treatment compared to 10.9 particles/mL for the no-oil treatment. This difference was not statistically significant (P > 0.10). The data do not support the hypothesis that RPC is reduced by adding oil to the feed and, indeed, suggest a trend to higher RPC under the oil treatment. It is known that larger, non-respirable, particles remove respirable dust from the airspace through coagulation (Hinds 1982). It is conceivable that the oil treatment, by reducing the concentration of larger sized

Table II: Treatment summaries for independent variables that could affect building dustiness*

Treatment	Oil	No-oil	Averages
Average number of pigs (pigs)			
Partial⁺	46 ± 9 (4)	44 ± 11 (4)	45 ± 12 (8)
Total	50 ± 14 (5)	55 ± 9 (5)	52 ± 13 (10)
Averages	48 ± 14 (9)	50 ± 11 (9)	49 ± 12 (18)
Average pig mass (kg)			
Partial	60 ± 10 (4)	63 ± 14 (4)	61 ± 14 (8)[a]
Total	81 ± 9 (5)	74 ± 8 (5)	78 ± 10 (10)[b]
Averages	71 ± 11 (9)	69 ± 13 (9)	70 ± 12 (18)
Total pig mass (kg)			
Partial	2681 ± 288 (4)	2671 ± 488 (4)	2676 ± 463 (8)[c]
Total	3927 ± 875 (5)	4071 ± 756 (5)	4000 ± 914 (10)[d]
Averages	3374 ± 771 (9)	3449 ± 738 (9)	3411 ± 755 (18)
Pen wetness score			
Partial	5.3 ± 1.1 (4)	4.9 ± 2.1 (4)	5.1 ± 1.9 (8)
Total	4.1 ± 0.8 (5)	4.1 ± 1.1 (5)	4.1 ± 1.1 (10)
Averages	4.6 ± 1.1 (9)	4.4 ± 1.8 (9)	4.5 ± 1.5 (18)
Outside temperature (°C)			
Partial	-5.5 ± 4.5 (4)	-2.3 ± 4.0 (4)	-3.9 ± 4.9 (8)
Total	-5.6 ± 4.8 (5)	-7.0 ± 15.6 (5)	-6.3 ± 12.9 (10)
Averages	-5.6 ± 5.3 (9)	-4.9 ± 13.5 (9)	-5.2 ± 10.3 (18)
Room temperature (°C)			
Partial	20.1 ± 1.0 (4)	19.2 ± 2.2 (4)	19.6 ± 2.0 (8)
Total	20.7 ± 0.5 (4)	20.8 ± 0.4 (4)	20.8 ± 0.5 (8)
Averages	20.4 ± 0.9 (8)	20.0 ± 1.8 (8)	20.2 ± 1.4 (16)
Room relative humidity (%)			
Partial	58 ± 10 (4)	60 ± 9 (4)	59 ± 11 (8)[e]
Total	44 ± 4 (4)	45 ± 5 (4)	44 ± 5 (8)[f]
Averages	50 ± 9 (8)	52 ± 8 (8)	52 ± 9 (16)
Ventilation rate (L/s)			
Partial	305 ± 107 (4)	225 ± 147 (4)	265 ± 148 (8)[g]
Total	503 ± 133 (4)	600 ± 340 (4)	551 ± 298 (8)[h]
Averages	404 ± 139 (8)	413 ± 302 (8)	408 ± 235 (16)

* Table entries format: mean ± standard deviation (# of observations)

⁺ Refers to portion of floor which was slatted

[a] Means for the same variable with different superscripts are significantly different ($P < 0.05$)

Table III: Summary of nitrogen content data*

Treatment	Oil	No-oil	Averages
Dust nitrogen (%)			
Partial+	5.4 ± 0.2 (8)	5.4 ± 0.2 (8)	5.4 ± 0.2 (16)[a]
Total	5.7 ± 0.1 (8)	5.4 ± 0.1 (8)	5.5 ± 0.1 (16)[b]
Averages	5.6 ± 0.2 (16)[c]	5.4 ± 0.2 (16)[d]	5.5 ± 0.2 (32)
Feed nitrogen (%)			
Partial	2.9 ± 0.2 (8)	3.1 ± 0.1 (8)	3.0 ± 0.2 (16)[e]
Total	2.6 ± 0.3 (8)	2.9 ± 0.1 (8)	2.8 ± 0.2 (16)[f]
Averages	2.8 ± 0.3 (16)[g]	3.0 ± 0.1 (16)[h]	2.9 ± 0.2 (32)
Floor scrapings nitrogen (%)			
Partial	3.1 ± 0.2 (8)	3.9 ± 0.3 (8)	3.5 ± 0.3 (16)[j]
Total	2.9 ± 0.4 (8)	3.0 ± 0.1 (8)	2.8 ± 0.3 (16)[k]
Averages	3.0 ± 0.3 (16)[m]	3.4 ± 0.2 (16)[n]	3.2 ± 0.3 (32)

* Table entries format: mean ± standard deviation (# of observations)

\+ Refers to portion of floor which was slatted

[a] Means for the same variable with different superscripts are significantly different (P < 0.05)

feed dust particles, effectively reduced coagulation as an important mechanism for removal of the smaller particles. The results of this project suggest that mass dustiness values (DSR and IMC) could be reduced by the addition of oil without significantly affecting the number of particles less than 5 μm (i.e. the RPC).

Testing for effects on airborne microorganisms

There was no significant difference (P > 0.10) in airborne microorganism counts (Table II) between the oil treatment (102) and the no-oil treatment (96). Oil addition to the feed apparently did not affect airborne microorganism levels.

Testing for effects on the nitrogen content of dust

A summary of nitrogen content measurements is given in Table III. The overall average nitrogen content for the settled dust was 5.4% with a range of 5.1% to 5.9%. The nitrogen content of the settled dust was higher than the overall average nitrogen content for either feed (2.9%) or floor material (3.2%). That settled dust had a higher nitrogen content than feed agrees with measurements by Aengst (as quoted by Hartung 1986) who found that dust had a higher percentage of protein than feed. Feddes et al. (1992) found that 90% of the airborne dust particles in turkey buildings were of fecal origin as identified by scanning electron microscope and that the dust had a higher nitrogen content than the feed. The higher nitrogen content for settled dust compared to floor scrapings was not expected since the airborne dust was assumed to be primarily originating from the floor deposits. The floor scrapings were assumed to be a composite of feed and fecal particles. It is possible that fewer feed particles and greater numbers of the smaller particles of fecal origin become airborne and then settle elsewhere in the building. Also, the contribution of nitrogen to the overall dust sample by particles of skin and dander may be a significant factor. Research is required to identify all of the sources of nitrogen in the animal airspace.

The nitrogen content of the feed with oil was significantly lower (P < 0.05) than the feed without oil. The difference in nitrogen content suggests that the rations may have been slightly different between treatments due to milling or to different ingredients, in addition to the effect of the oil itself. The nitrogen content of the material from the floor was highly variable, with individual sample nitrogen contents ranging from 2.6% to 4.6%. As in the case of feed nitrogen, the nitrogen content of the floor material was significantly lower (P < 0.05) in the no-oil treatment.

Despite the lower nitrogen content of the oiled feed, the dust nitrogen content in the oil treatment was significantly higher (P < 0.05) than in the no-oil treatment. These data suggest a need to more carefully examine the constituents of pig barn dust under different feeding, building, and management systems. The findings agree with those of Chiba et al. (1987) and indicate that the dust remaining when feed is oiled or has fat added has a higher nitrogen content than when the feed is not oiled or fat enriched. The data strongly suggest that dust of animal or microbial origin becomes a greater percentage of the total dust when dust concentrations are lowered by adding oil to the feed.

SUMMARY AND CONCLUSIONS

Dustiness in a swine grower-finisher room was assessed over 18 weeks by measuring the respirable dust particle counts (RPC), airborne dust inhalable mass concentration (IMC), and dust sedimentation rate (DSR). The dry feed contained 0% and 2% canola oil on alternate weeks. The pen floors were partially slatted during the first 8 weeks and were totally slatted during the last 10 weeks.

Because the pig mass and the ventilation rate were significantly different between the two flooring treatments, the effect of flooring on dust levels could not be analyzed. Neither pig mass nor ventilation rate was different between the two feed treatments.

Relatively large, and practically significant, differences were measured between the oil and no-oil treatments in terms of RPC, IMC, and DSR. However, none of the difference between feed treatments was statistically significant ($P > 0.10$). The mean RPC was 45% higher for the oil (15.8 particles/mL) compared to the no-oil treatment (10.9 particles/mL). The mean IMC was 31% lower for the with-oil treatment (3.4 mg/m^3) compared to the no-oil treatment (5.0 mg/m^3). The mean DSR within the room was 7% lower (64.5 versus 69.5 $mg \bullet m^{-2} \bullet h^{-1}$) and within the recirculation duct was 9% lower (73.5 versus 81.0 $mg \bullet m^{-2} \bullet h^{-1}$) for the oil treatment compared to the no-oil treatment. Workers reported that the building did not seem to be as dusty, especially during feed handling, when the feed was oiled. The results of this experiment suggested that, whereas canola oil additions to feed appear to reduce nuisance dust levels in pig buildings, the concentration of respirable dust particles may not be reduced by the feed treatment.

The nitrogen content of the dust was significantly higher ($P < 0.05$) during the oil treatment (5.6%) compared to the no-oil treatment (5.4%). This result suggests that dust of animal or microbial origin may become a greater percentage of the dust when dust concentrations are lowered by adding oil to feed.

Ultimately dust control measures must be compared, not just on the basis of measures of dustiness, but rather on the basis of their effects on dust production rates and on dust removal mechanisms such as sedimentation. Further studies are needed to quantify the effects of engineering controls, such as oil additions to feed, on the various sources and sinks of dust.

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