The effects of oxidizing air purification on swine barn air quality and pig health, performance, and behavior during the farrowing phase of production

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Oxidizing air purification (OAP) technology did not affect air quality parameters in a commercial-like sow nursing environment. However, OAP did differentially affect piglet performance and behavior. More work is needed to determine whether OAP has meaningful beneficial effects on pig health, performance, and welfare.

Summary

This study investigated the effects of a novel oxidizing air purification (OAP) technology on swine barn air quality and piglet performance and behavior during the farrowing (i.e., nursing) phase of production. Shortly before farrowing, sows were randomly assigned to a room that contained two OAP mobile units or a room that did not. Concentrations of particulate matter size 10 microns or smaller (PM_{10}), ammonia (NH_3) and hydrogen sulfide (H_2S) were measured weekly. Piglets were weighed every six days during the farrowing phase to determine body weights and average daily gain (ADG). Piglet behavior was evaluated from video recorded throughout the experimental period. Particulate matter, NH_3 and H_2S were not significantly different between the OAP and control rooms. Despite air quality parameters not being different, piglets exposed to OAP spent more time nursing on days 1 and 10 of age. Control piglets tended to be heavier at weaning than OAP piglets. These results suggest that OAP may affect pig welfare, as indicated by some differences in behavior and performance, but the mechanism is not clear. Further work is needed to fully elucidate the effect of OAP on piglet health, performance and behavior.

Introduction

Particulate matter (i.e., dust), ammonia (NH_3) and hydrogen sulfide (H_2S) present in air at high concentrations have the potential to negatively affect pig health, performance and welfare. Therefore, mitigation of these contaminants is important to the swine industry. The most common method of managing air quality in swine facilities is ventilation; however, none of the widely used ventilation systems provide full control over the environmental air quality of the barn. Several supplemental strategies for improving indoor air quality have been developed and tested, but their use is not widespread, and concerns about particulate matter and gas emission exposures within swine facilities remain. Therefore, there is a need to identify novel strategies to mitigate indoor air quality challenges.

One potential alternative method is oxidizing air purification (OAP) technology, which uses ozone to oxidize and reduce common air-quality emissions of concern. Early studies have shown ozone to be effective at reducing indoor gas emissions (Priem, 1977; Elenbaas-Thomas et al., 2005; Banhazi, 2011); however, humans and animals cannot be directly exposed to ozone without risk to their health. The OAP technology used in this study (CerroZone Mobile Units; now owned and marketed by Micron Pure, LLC.; St. Louis, MO) mitigates this issue by utilizing a closed purification environment to perform the following: 1) intake room air, 2) convert the oxygen contained within room air to ozone, 3) allow ozone to oxidize and remove pathogens and volatile compounds of concern from the air, and 4) exhaust the purified air back into the barn. The objective of this study was to evaluate the use of OAP on swine barn air quality and swine welfare, as indicated by performance and behavior traits.

Procedures

Animals were housed in the farrowing rooms at the NDSU Swine Research and Teaching Center. This study took place during two repeated

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trials (i.e., one winter trial and one summer trial). In trial one (winter), sows were randomly assigned to the OAP treatment farrowing room (n = 4 sows) or the control treatment farrowing room (n = 5 sows). In trial two (summer), three sows were randomly assigned to each treatment room. Oxidizing air purification mobile units were powered on in the OAP treatment rooms when sows entered the rooms. Environmental air samples were collected on days 0 (when sows entered the farrowing rooms), 7, 14, 21, and 28 to analyze for NH_3 and H_2S. Particulate matter (PM_{10}) was collected on the same days. During lactation, piglets were weighed every six days to calculate average daily gain (ADG). Video cameras positioned above each gestation stall recorded piglet behavior. Six hours of behavioral data (0800-1000, 1100-1300, 1400-1600 h) when piglets were one, two, three, seven, 10, and 14 days of age were analyzed for nursing duration and frequency and postural traits of lying, standing and sitting. Piglets were weaned at 23.7 ± 4.8 days of age.

Table 1. Least squares means for air quality parameters by treatment (oxidizing air purification [OAP] and control) and day of study (day 0 is when sows were moved into farrowing).

Trait	Day	OAP	Control	SED[1]	*P*-value[2]
Ammonia (NH_3), ppm					
	0	5.70	2.80	1.79	0.14
	7	5.87	5.50	1.79	0.84
	14	8.47	4.43	1.79	0.05
	21	4.74	4.72	1.79	0.99
	28	5.87	5.73	1.79	0.94
Hydrogen sulfide (H_2S), ppm					
	0	0.128	0.090	0.046	0.44
	7	0.146	0.092	0.046	0.27
	14	0.063	0.038	0.046	0.59
	21	0.112	0.108	0.046	0.92
	28	0.087	0.080	0.046	0.88
Particulate matter size 10 microns or smaller (PM_{10}), µg/m^3					
	0	59.1	11.4	234.9	0.84
	7	175.6	579.9	241.6	0.11
	14	496.8	47.7	242.3	0.07
	21	17.0	151.5	242.3	0.58
	28	43.6	30.4	242.3	0.96

[1] Standard error of the difference between the two treatments on a day is reported.
[2] *P*-value is for the difference between treatments on the same day.

Results and Discussion

Environmental air quality parameters were not significantly different between treatments on any day; however, NH_3 and PM_{10} tended to be higher on day 14 in the OAP rooms compared to the control rooms (Table 1). The lack of differences between rooms may be due to the low concentrations of each parameter already present in the farrowing rooms compared with those typically observed in large commercial facilities. A repeated trial effect was observed for NH_3 and H_2S, with NH_3 concentration being lower during the summer trial compared to the winter trial (0.70 ± 0.80 ppm vs. 10.07 ± 0.80 ppm; $P < 0.0001$) and H_2S concentration being lower during the summer trial compared to the winter trial (0.04 ± 0.02 ppm vs. 0.15 ± 0.02 ppm; $P = 0.0005$). These repeated-trial effects were expected, given the likelihood of increased NH_3 and H_2S concentrations during winter months when ventilation within the barn is minimized to maintain acceptable room temperature.

Although no meaningful differences in air quality between treatment rooms were observed, we did identify differences in piglet behavior and performance between treatments. Piglets exposed to OAP spent more time nursing on days 1 and 10 of age (Figure 1; $P = 0.01$ and 0.01, respectively) and tended to spend more time nursing on days 2, 7, and 14 of age ($P = 0.06$, 0.09, and 0.07, respectively). This resulted in OAP piglets spending more time nursing compared to control piglets overall (126.1 ± 13.1 min vs. 77.6 ± 11.7 min; $P = 0.007$). For nursing frequency, OAP piglets nursed more frequently than control piglets (8.48 ± 1.00 vs. 5.56 ± 0.98; $P = 0.04$), which was largely driven by OAP piglets performing more nursing bouts at one day of age compared to control piglets (11.6 ± 1.8 vs. 5.4 ± 1.7 bouts; $P = 0.01$).

Effective nursing during the first 24-48 hours postfarrowing is required for ensuring adequate piglet colostrum intake. The nursing results presented here provide some evidence that OAP improved piglets' ability to nurse during this critical period, which may have future immunity and health benefits. However, regardless of increased OAP piglet nursing duration and frequency during this period, control piglets tended to be heavier than OAP treatment piglets at weaning (Figure 2; $P = 0.07$) and tended to have greater overall ADG compared to OAP piglets (0.72 ± 0.03 vs. 0.63 ± 0.04 lb/d; $P = 0.097$).

Postural data is presented in Table 2. No main treatment effects

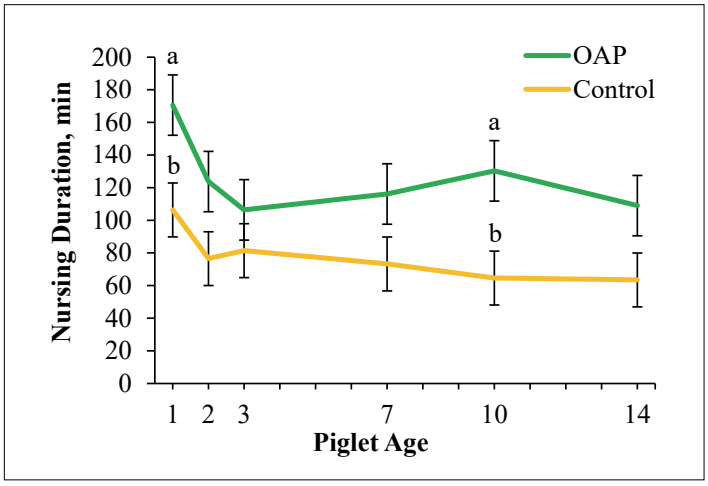

Figure 1. Effect of oxidizing air purification (OAP) on nursing duration of piglets.

[a,b] Time points with differing superscripts differ between treatments at $P < 0.05$.

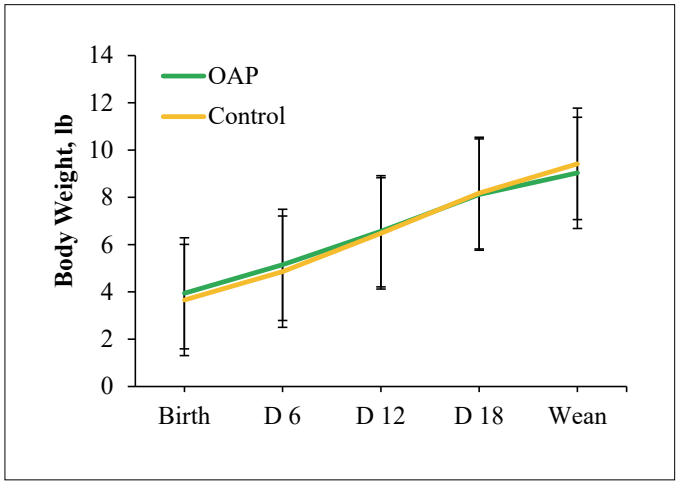

Figure 2. Effect of oxidizing air purification (OAP) on piglet weight throughout the farrowing phase of production.

were observed for lying ($P = 0.58$) or standing ($P = 0.68$). However, there was a tendency for increased lying exhibited by control pigs compared to OAP pigs at 10 days of age ($P = 0.09$).

No treatment differences for standing were observed at any time point ($P > 0.10$). There was a main effect of treatment on the percentage of piglets sitting per day ($P = 0.0003$), with OAP piglets exhibiting a greater percentage of sitting per day compared to CON-f piglets (3.20 ± 0.27 vs. 1.79 ± 0.29). This result was largely driven by OAP piglets exhibiting greater sitting percentages at one and three days of age ($P = 0.0006$ and 0.04, respectively) and tending to exhibit a greater sitting percentage at 14 days of age ($P = 0.053$) compared to control piglets. The increased sitting behavior performed by OAP piglets on days 1 and 3 may be related to common postural changes associated with nursing duration and frequency, which were also increased in the OAP treatment. However, more work is needed to confirm this potential interpretation.

Table 2. Least squares means for piglet postural data by treatment (oxidizing air purification [OAP] and control) and day of age.

Trait	Day	OAP	Control	SED[1]	*P*-value[2]
Percentage of pigs lying per day					
	1	68.1	63.3	5.1	0.36
	2	67.4	66.5	5.3	0.87
	3	70.2	72.2	5.3	0.71
	7	76.2	76.7	6.5	0.93
	10	66.6	77.0	5.8	0.09
	14	64.5	70.1	7.8	0.48
Percentage of pigs standing per day					
	1	19.3	27.3	4.7	0.10
	2	21.6	28.3	4.9	0.18
	3	19.1	23.0	4.9	0.43
	7	19.2	18.9	5.6	0.96
	10	27.4	20.5	5.2	0.20
	14	29.0	27.2	6.6	0.78
Percentage of pigs sitting per day					
	1	4.90	2.52	0.59	0.0006
	2	3.00	2.29	0.63	0.27
	3	2.81	1.44	0.63	0.04
	7	2.87	1.58	0.76	0.11
	10	3.06	2.33	0.69	0.31
	14	2.56	0.59	0.96	0.05

[1] Standard error of the difference between the two treatments on a day is reported.
[2] *P*-value is for the difference between treatments on the same day.

Conclusion

In conclusion, oxidizing air purification (OAP) did not affect air quality parameters in a commercial-like sow nursing environment. However, OAP did differentially affect piglet performance and behavior. Continuing work in this area will evaluate the effect of OAP on pig health, as well as the environmental and pig microbiomes.

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