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OIL APPLICATION TO REDUCE DUST AND ODOUR EMISSIONS FROM SWINE BUILDINGS

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Abstract
Dust levels in pig barns can be reduced by up to 95% through oil sprinkling. Thus, it is believed that there should be a consequent reduction in odour since some odourants also present in the air may be adsorbed by dust particles. However, the effectiveness of oil application on odour redcution in pig buildings has not always been consistent. Some studies have measured higher odour concentrations in rooms where oil was applied compared to the control rooms. This raises the question of what impact intrinsic odours emitted from the oils may have on odour reduction. Some oils available for application appear notably stronger than the odours emitted from animal sources.

A study investigating the effectiveness of different oils for dust and odour reduction was conducted in three phases. The first phase involved the assessment of intrinsic odour emissions

from nine processed or crude vegetable oils and one mineral oil, in comparison to a control treatment. The second phase, investigated the effectiveness of using an essential oil injected into the headspace of stored manure to either reduce odour concentration or improve hedonic tone. In the third phase, the effectiveness of different oil treatments on dust and odour reduction was evaluated using pigs housed in environmental chambers.

The results of this study showed that refined bleached and deodorized (RBD) sunflower, soybean and canola oils outperformed other oils, exhibiting desirable intrinsic odour qualities. Furthermore, although a commercial essential oil improved hedonic tone of odours emitted from pig manure, the cost of application appeared too high and consequently, rendered it an impractical solution. Finally, in the third phase of the study, the three vegetable oils identified above effectively reduced dust levels in the environmental pig chambers by up to 72% but were ineffective at reducing odour levels.

OIL APPLICATION TO REDUCE DUST AND ODOUR EMISSIONS FROM SWINE BUILDINGS

It is commonly believed that odourous compounds (odourants) emitted into the air typically bond to dust particles also present in the air. In other words, these dust particles serve as "odour-carriers" and a secondary source of odour emissions both within confined animal facilities and in the atmosphere outside the facilities. Consequently, among other air quality benefits, the removal of suspended dust particles from the air inside pig barns is alleged to result in reduced odour emissions from these facilities (Bottcher et al., 1999; Hoff et al., 1997; Williams, 1989; Hammond et al., 1979; Burnett, 1969; Day et al., 1965).

Oil sprinkling is reported to be an effective technique for reducing dust concentrations in pig barns by 34 to 95% depending on the oil application rate (Lemay and Godbout, 2003; Payeur et al., 2002; Wang et al., 2002; Zhang et al., 2002; Godbout et al., 2001; Goodrich et al., 2001; Lemay et al., 2000; Jacobson et al., 1999; Kirychuk et al., 1999; Lemay et al., 1999; Perkins and Feddes, 1996; Zhang et al., 1996; Takai et al., 1995; Zhang et al., 1994). On the other hand, the effects of oil sprinkling on odour reduction are not as definitive. Some researchers recorded reductions in odour emissions from pig barns in their studies (Lemay and Godbout, 2003; Goodrich et al., 2001; Feddes et al., 1999; Zhang, 1997) while others did not (Lemay and Godbout, 2003; Payeur et al., 2002; Godbout et al., 2001; Jacobson et al., 1999).

Lemay and Godbout (2003) found a 20% reduction in odour emissions following the sprinkling of canola oil on pigs in a bench-scale study. Despite these results, the authors were unable to establish good correlation between odour and dust reductions. These findings were corroborated by Payeur et al. (2002). Goodrich et al. (2001) sprinkled a mixture of soybean oil and water on finisher pigs in a room in a commercial barn and reported a mean odour reduction of 10% compared to a control room. It should be noted though that, over the length of their study odour reduction ranged approximately between -50% and 60%, the negative reduction implying that at times odour concentration was lower in the control room. Similar to the findings of Lemay and Godbout (2003), Feddes et al. (1999) reported a 20% reduction in odour achieved by sprinkling canola oil on pigs. In yet another study, Zhang (1997) reported that rooms sprinkled with canola oil were subjectively less odourous than non-treatment rooms.

Contrary to their bench scale trial, Lemay and Godbout (2003) observed no reduction in odour concentration following the sprinkling of canola oil on pigs in a full-scale production trial. Similar to the results presented by Goodrich et al. (2001), they recorded higher odour emissions from the oil treatment rooms compared to the control rooms on some days. Lemay and Godbout, (2003) speculated that strong smells emitted by the canola oil may have contributed to the increased emissions and recommended further research to determine if weak-smelling oils were more effective at reducing odour emissions from pig barns than stronger-smelling oils.

PHASE I: AN EVALUATION OF DIFFERENT APPLICATION OILS

There is little or no literature on the odour-specific characteristics of oils sprinkled in confined pig facilities to reduce dust and pig odours. At best, Takai and Pedersen (1999) suggested that strong-smelling vegetable oils may affect animal behavior and consequently, would not be suitable for oil sprinkling purposes. In another study, Zhang et al. (1995) studied various attributes of oils that would facilitate their effective application. They concluded that vegetable oils were more appropriate for oil sprinkling application compared to mineral oils because they were biologically safe for humans and animals to ingest, readily available, exhibited good sprinkling qualities and were relatively inexpensive. Crude canola, purified canola, flax, corn, sunflower and soybean oils were identified as oils that met these criteria.

OBJECTIVES

The objectives of this phase of the study were to:

1. Compare odour intensities and hedonic tones of 9 different vegetable oil treatments and a mineral oil treatment to a control treatment, i.e., treatment without oil.

2. Identify 5 top-performing oil treatments from (1) above and compare odour intensity, hedonic tone of undiluted samples and olfactometer samples and, odour concentration to a control (no oil) treatment.

MATERIALS AND METHODS

Experiment 1

Nine vegetable oils and one mineral oil were selected for evaluation based on the conclusions drawn by Zhang et al. (1995) and on their availability, locally. The selected oils included: crude canola; refined, bleached and deodorized (RBD) canola; RBD corn; refined (R) flax; refined and bleached (RB) flax; ingestible, heavy-grade (HG) mineral oil; R soybean; RB soybean; RBD soybean and; RBD sunflower. Eleven 65 L Tedlar™ film (TST20SG4, DuPont Canada, Mississauga, ON) bags were filled to about half their volume (50%) with carbon-filtered air. Approximately 500 mL of each type of oil was poured into an aluminum tray taped to the bottom of 10 bags, i.e., one oil treatment assigned per bag. The 11th bag, with no oil in its tray, served as a control treatment. Subsequently, each bag was further filled to about 90% (59 L) of total capacity with carbon-filtered air. The eleven air-filled bags were randomly laid out on tables and covered to conceal their identity and contents. Each bag was left undisturbed at room temperature (mean 22^{o}C) for approximately 48 h to enable emissions from the oils saturate the air in the bags.

A panel of six trained observers evaluated the bagged air after 48 h. Odour intensity and hedonic tone were measured directly from the bags. Odour intensity was measured using an 8-point odour intensity referencing scale (OIRS) standard technique ASTM (1999) modified by St. Croix Sensory (2000). Hedonic tone was measured using a 9-point scale as outlined in Table 1. The 6 observers independently evaluated each bag sequentially before the next bag was evaluated. A nasal mask (AC'SCENT® SWIFT™, St. Croix Sensory, Stillwater, MN) constructed from a carbon fiber/epoxy blend with a polytetrafluoroethylene (PTFE) coating was assigned to each panelist to minimize cross-contamination and facilitate the evaluation.

This experiment was replicated four times but not always with the same panelists. At the end of the study, 5 oils demonstrating the most desirable odour characteristics, among other parameters, were earmarked for further evaluation.

Table 1. Nine-point Odour Hedonic Tone Categorical Scale

Characterization	Scale
Like extremely	+4
Like very much	+3
Like moderately	+2
Like slightly	+1
Neither like nor dislike	0
Dislike slightly	-1
Dislike moderately	-2
Dislike very much	-3
Dislike extremely	-4

Experiment 2

Five vegetable oils were selected for the second experiment based on the results of the first experiment. The oils selected included: RBD canola; RBD corn; RB soybean; RBD soybean and; RBD sunflower. Twelve 65 L Tedlar™ film bags were filled to about half their volume (50%) with carbon-filtered air. Similar to experiment 1, approximately 500 mL of each type of oil was poured into aluminum trays taped to the bottom of 10 bags, with each oil treatment assigned to a pair of bags. No oil was poured into the trays in the remaining 2 bags assigned to the control treatment. Finally, the 12 bags were filled to about 90% (59 L) of their total capacity with carbon-filtered air. Air from one of the paired bags within each treatment was discreetly analyzed randomly for odour intensity and hedonic tone by a panel of 7 trained observers 48 h after filling the bags.

Following the analysis, approximately 30 L of air from the second bag in each paired treatment was randomly collected into two 17 L Tedlar™ film sampling bags using a sampling device (odour sampling lung, University of Alberta, Edmonton, AB) and analyzed for odour concentration and hedonic tone by dynamic forced-choice olfactometry (UA olfactometer, University of Alberta, Edmonton, AB). In the latter analysis, hedonic tone was analyzed at 2 detection levels (higher concentration) above each panelist's detection threshold.

This experiment was replicated three times but not always with the same observers. At the end of the study, oils showing the most desirable characteristics were earmarked for further study.

RESULTS AND DISCUSSION

Experiment 1

The results of the odour intensity and hedonic tone measurements are presented in Tables 2 and 3. In the former, means of odour intensity ranged between 2.1 and 6.3 on the 8-point OIRS. The hedonic tone ranged between 0.03 and -1.75 on a 9-point categorical scale. Table 3 on the other hand, shows the overall performance rating (i.e., relative to odour intensity and hedonic tone) of each oil treatment compared to the other treatments.

Table 2. Odour Characteristics of Emissions from Various Types of Oils*

Treatment	Odour Intensity ([1]Scalar Value)	Hedonic Tone ([2]Scalar Value)
Control	3.5[ad]	-0.73[ad]
Crude Canola	6.3[e]	-1.75[d]
HG Mineral Oil	3.6[ab]	-0.54[abc]
R Flax	5.9[e]	-1.52[cd]
R Soybean	5.5[e]	-1.52[cd]
RB Flax	5.8[e]	-1.19[bcd]
RB Soybean	5.3[e]	-0.33[ab]
RBD Canola	2.6[cd]	-0.35[ab]
RBD Corn	4.3[a]	-0.71[abc]
RBD Soybean	3.1[bcd]	0.03[a]
RBD Sunflower	2.1[c]	-0.04[a]

*Means followed by the same letter within each column are not significantly different (P>0.05). Bonferroni adjusted comparison test.
[1]Odour intensity measurements relative to an 8-point n-butanol intensity referencing scale.
[2]Odour hedonic tone measurements based on a 9-point categorical scale.

The results presented in Table 3 suggest that 5 oils with the most desirable odour characteristics (in order of overall ranking) included, RBD Sunflower, RBD Soybean, RBD Canola, RB Soybean and Mineral Oil. However, when the cost per litre of the various oils was taken into consideration, HG mineral oil was approximately 4 to 9 times more expensive than the vegetable oils listed in Table 4. Consequently, HG mineral oil was eliminated from the list of selected oils and replaced with RBD corn which ranked 6th among the oil treatments (7th overall).

Table 3. Performance Ratings of Various Oil Treatments

Treatment	Performance Rating			
	Odour Intensity[A] (Max = 11)	Hedonic Tone[B] (Max = 11)	Total[(A+B)] (Max = 22)	Overall (Max = 11)
Control	4	7	11	6
Crude Canola	11	11	22	11
HG Mineral Oil	5	5	10	4.5
R Flax	10	9.5	19.5	10
R Soybean	8	9.5	17.5	9
RB Flax	9	8	17	8
RB Soybean	7	3	10	4.5
RBD Canola	2	4	6	3
RBD Corn	6	6	12	7
RBD Soybean	3	1	4	2
RBD Sunflower	1	2	3	1

Table 4. Price Values of Various Types of Oils

Treatment	Cost ($/L)
HG Mineral Oil	8.96
RB Soybean	1.00
RBD Canola	1.19
RBD Corn	1.83
RBD Soybean	1.26
RBD Sunflower	2.33

Experiment 2

The results of the second experiment are presented in Tables 5 and 6 below. In the former, the odour intensity of the undiluted samples (OIUS) ranged between 3.4 and 5.4 on the 8-point OIRS with a corresponding hedonic tone (HTUS) ranging between -0.22 and -0.87. Odour concentration measured by olfactometry (OCO) ranged between 114 and 1002 ou.m^{-3} while the hedonic tone (HTO), measured at 2 concentration levels higher than the detection threshold, ranged between -1.39 and -1.91.

Table 5. Odour Characteristics of Emissions from Refined and Bleached Vegetable Oils*

Treatment	Undiluted Sample		Olfactometry	
	[1]Odour Intensity (Scalar Value)	[2]Hedonic Tone (Scalar Value)	[3]Concentration ($ou.m^{-3}$)	[4]Hedonic Tone (Scalar Value)
Control	4.4^{bd}	-0.87^{a}	132^{a}	-1.58^{ac}
RB Soybean	5.4^{c}	-0.65^{a}	1002	-1.91^{c}
RBD Canola	3.7^{ab}	-0.56^{a}	147^{a}	-1.90^{c}
RBD Corn	4.7^{cd}	-0.46^{a}	368	-1.39^{a}
RBD Soybean	3.4^{a}	-0.22^{a}	130^{a}	-1.83^{bc}
RBD Sunflower	3.4^{a}	-0.56^{a}	114^{a}	-1.49^{ab}

*Means followed by the same letter within each column are not significantly different (P>0.05). Bonferroni adjusted comparison test.
[1]Odour intensity (OIUS) measurements of undiluted samples relative to on an 8-point n-butanol intensity referencing scale.
[2]Odour hedonic tone (HTUS) measurements of undiluted samples based on a 9-point categorical scale.
[3]Odour concentration (OCO) measured by olfactometry.
[4]Odour hedonic tone (HTO) measurements based on a 9-point categorical scale analysis of samples diluted by the olfactometer.

Table 6. Performance Ratings of Refined and Bleached Vegetable Oils

Treatment	Performance Rating					
	OIUS[A] (Max = 6)	HTUS[B] (Max = 6)	OCO[C] (Max = 6)	HTO[D] (Max = 6)	Total[(A+B+C+D)] (Max = 24)	Overall (Max = 6)
Control	4	6	3	3	16	5
RB Soybean	6	5	6	6	23	6
RBD Canola	3	3.5	4	5	15.5	4
RBD Corn	5	2	5	1	13	3
RBD Soybean	1.5	1	2	4	8.5	1.5
RBD Sunflower	1.5	3.5	1	2	8.5	1.5

A performance rating of the 6 treatments (Table 6) relative to the measurement parameters listed in Table 2.5 signified that RBD soybean and RBD sunflower performed the best overall, similar to the results of the 1st experiment (Table 2.3). Contrary to experiment 1, RBD corn ranked 3rd overall in experiment 2 while RBD Canola ranked 4th. Furthermore, the HTUS and HTO of RBD corn were more desirable than those of RBD sunflower and RBD soybean, respectively, even though its OIUS and OCO remained higher. Conflicts between the results of both experiments may relate largely to the subjectivity of the measurements, considering the fact that the experiments and replications were conducted several weeks and days apart, respectively, and often with different groups of panelists. Other possibilities include, changes in the character of the emissions from the oils in the storage period between the two experiments and the ability of Tedlar™ film to release certain gaseous compounds or to absorb other kinds (Zhang et al., 2001).

To help decide on which oil would qualify for the 3rd phase of this study, the overall performance ratings of RBD corn and RBD canola in experiments 1 and 2 (i.e., 6th vs. 3rd and 3rd vs. 4th, respectively) were combined, indicating that the latter (combined rating = 7) outperformed the former (combined rating = 9).

CONCLUSION

Initially nine vegetable oil treatments and one mineral oil treatment were compared to a control on the basis of odour intensity, hedonic tone and the combined performance ratings of the two parameters. Of the ten oil treatments, 5 namely, RBD sunflower, RBD soybean, RBD canola, RB soybean and RBD corn (ranked in descending order of performance), exhibited the most desirable overall odour characteristics relative to their price value.

In a second experiment, the 5 top performing oil treatments were compared to a control treatment on the basis of odour intensity and hedonic tone of undiluted air samples, olfactometer measurements of odour concentration and hedonic tone and a combined performance rating of the four measured parameters. Once again, RBD soybean and RBD sunflower ranked as the top two oil treatments indicating no significant differences ($p>0.05$) between the two relative to the measured odour parameters. Although there was discrepancy between the performance ratings of RBD corn and RBD canola in the first and second experiments, RBD canola was ranked third overall based on combined performance ratings of both experiments.

Furthermore, the results of this experiment clearly show that certain types of sprinkling oils used to improve air quality in livestock housing systems possess intrinsic odour characteristics that could negate their potential impact on livestock odour reduction. This suggests that due diligence must be used when selecting oils to mitigate the impact of livestock confinements on air quality, even when the motive of using such technologies is not to specifically reduce odours.

PHASE II: AN EVALUATION OF ESSENTIAL OILS

Essential oils have the potential to reduce odour and gas emissions either through their application to livestock manure (Varel and Miller, 2000; Varel, 2001; Varel and Miller, 2001; Varel, 2002) or their injection into the air (Otieno and Magagula, 2001). In either case, such reductions may be accomplished through a variety of physical, chemical or biochemical means or a combination of processes (Helander et al., 1998; Savard, 1997; Ultee et al., 1999).

Typically, essential oils comprise of mixtures of plant-derived biochemical compounds (Savard, 1997; Otieno and Magagula, 2001). These compounds are often selected on the basis of their unique characteristics in order to meet certain, specific objectives. Since each mixture exhibits characteristics specific to its constituents and proportions thereof, it is anticipated that the effects of different essential oils on odour will vary accordingly and it remains a question of, what commercially available essential oils are best-suited to livestock odour reduction.

OBJECTIVES

The original intent of this phase of the study was to compare the effects of different commercially available essential oils on the characteristics of pig odour and to make a selection based on the results. Although the support of different essential oil manufacturers was solicited, only one supplier expressed willingness to participate in this study by supplying their product.

Hence, the objective of this phase of the study was to compare odour intensity, hedonic tone (undiluted and olfactometer samples) and concentration of malodourous air emitted from pig manure with and without (control treatment) an essential oil injected into the container headspace.

MATERIALS AND METHODS

Six 65 L Tedlar™ film (TST20SG4, DuPont Canada, Mississauga, ON) bags were filled to about half their volume (50%) with carbon-filtered air. Approximately 500 mL of slurry pig manure, stored at 4 ^{o}C for 7 days, was poured into aluminum trays taped to the bottom of the bags. Each bag was further filled to about 90% (59 L) of its total capacity with carbon-filtered air. The 6 air-filled bags were randomly laid out on tables, covered to conceal their identity and contents and left undisturbed for about 12 h at room temperature (mean 22 ^{o}C).

After 12 h, odourous air was evacuated from each bag for about 30 s at a rate of 5 L.min^{-1} using a computer-controlled vacuum system. Subsequently, the bags were refilled with carbon-filtered air for 30 s at a rate of 5 L.min^{-1} using a medical nebulizer (UP-DRAFT 1700, Hudson RCI, Temecula, CA) operating at a pressure of 69 kPa (10 psi), while simultaneously injecting approximately 100 µL of an essential oil blend (Ecosorb PR200S4L, OMI Industries, Barrington, IL) via the nebulizer into the headspace of only 3 of the treatment bags. A preliminary investigation had indicated that 100 µL of the essential oil was sufficient to detect a change in hedonic tone of the air in the bags without overwhelming the olfactory senses. No essential oil was added to the other 3 refilled control treatment bags. Approximately 45 min after refilling the bags, the 6 undiluted bag samples were randomly and discreetly analyzed for odour intensity and hedonic tone by a panel of 6 trained observers.

Following analyses of the undiluted air samples, approximately 30 L of air from each bag was collected at random and used to fill two 17 L Tedlar™ film sampling bags to about 80% capacity with a sampling device (odour sampling lung, University of Alberta, Edmonton, AB). These latter samples were analyzed for odour concentration and hedonic tone by dynamic forced-choice olfactometry (UA olfactometer, University of Alberta, Edmonton, AB).

The entire experiment was replicated three times using the same observers to analyze the undiluted samples.

RESULTS AND DISCUSSION

Table 7 shows means of the various measurements conducted in the second phase of the study. Although the OIUS of the control and essential oil treatments were similar, the HTUS was slightly higher in the latter signifying a less offensive odour. Characterizing the HTUS measurements according to the categories presented in Table 2.1 suggests the control treatment odour would be qualified as ranging between "dislike very much" and "dislike extremely" while the undiluted essential oil treatment sample odour qualified as being "disliked very much".

Table 7. Odour Characteristics of Pig Manure Emissions Treated with an Essential Oil*

Treatment	Undiluted Sample		Olfactometry	
	[1]Odour Intensity (Scalar Value)	[2]Hedonic Tone (Scalar Value)	[3]Concentration ($ou.m^{-3}$)	[4]Hedonic Tone (Scalar Value)
Control	7.3[a]	-3.54	484	-2.50
Essential Oil	7.1[a]	-2.86	1765	1.04

*Means followed by the same letter within each column are not significantly different (P>0.05). Bonferroni adjusted comparison test.
[1]Odour intensity (OIUS) measurements of undiluted samples relative to on an 8-point n-butanol intensity referencing scale.
[2]Odour hedonic tone (HTUS) measurements of undiluted samples based on a 9-point categorical scale.
[3]Odour concentration (OCO) measured by olfactometry.
[4]Odour hedonic tone (HTO) measurements based on a 9-point categorical scale analysis of samples diluted by the olfactometer.

Similarly, a higher but more distinct HTO value was measured in the essential oil treatment compared to the control treatment. However, relative to the olfactometer measurements, odour from the former treatment would be qualified as being "liked slightly", while that from the latter would be qualified as ranging between "dislike moderately" and 'dislike very much". It appears these differences in hedonic tone measurements between the undiluted sample and olfactometry exist relative to the concentration of the analyzed samples. In other words, the persistence of some odourants within the odour may have been altered as a result of their dilution with neutral air in the olfactometer. Another alternative is that some of the volatile compounds emitted from the manure and essential oil might have been absorbed by the sampling equipment material, e.g., the sampling bag film (Zhang et al., 2001) or other material the odourous air came in contact with while being transported in the olfactometer.

Furthermore, the higher OCO measurement of the essential oil treatment sample compared to the control, flags the need to include parameters other than concentration in odour reduction assessments. Consider for example, the OCO of the former treatment was about 3.6 times (log scale = 1.2 times) that of the control. Literally speaking, this might not qualify the essential oil treatment as an effective odour reduction technology. However, it is evident from the HTO measurements that the former did in fact cause a significant reduction (approximately 3.5 scalar points) in odour offensiveness.

Another factor to consider regarding the application of odour mitigating technologies is cost. Table 8 shows the estimated cost of application of the essential oil in a commercial pig operation assuming the air in the facility were stagnant and odourous emissions were allowed to accumulate for at least 12 h prior to application of the essential oil. It also shows that if the application rate of the essential oil were reduced 100 times (or even a 1000 times) and the cost per litre of oil reduced by half (or 1/30th), the estimated cost per pig over a 15-week period would be uneconomical.

Table 8. Estimated Cost of Applying an Essential Oil in Odourous Manure Emissions Accumulated Over 12 h

	Winter		Summer	
	[1]Experimental	[2]Economized	[1]Experimental	[2]Economized
Oil Application Rate ($mL.m^{-3}$ of air)	1.54	0.0154	1.54	0.0154
Ventilation Rate ($L.s^{-1}$ per pig)	2	2	50	50
Oil Usage ($L.day^{-1}$ per pig)	0.266	.00266	6.65	0.0665
Oil Cost ($\$.L^{-1}$)	30	15	30	15
Oil Application Cost ($/pig over 15 wks)	837	4	20935	105

[1]Based on an oil application rate of 100µL/65 L of air and cost of $30/L of oil
[2]Based on an oil application rate of 1µL/65 L of air and cost of $15/L of oil

Varel (2002) conducted a study adding 16.75 mM (2.5 $g.L^{-1}$ or 2.6 $mL.L^{-1}$ of solution) of either carvacrol or thymol, two essential oil constituents, directly into 500 mL of swine slurry. At this concentration, fermentation was suppressed and production of specific odourants and other gaseous emissions reduced. According to AOPA (2004), a farrow to finish pig operation generates approximately 65.7 L of manure per day per pig on average, suggesting that approximately 0.34 L of carvacrol or thymol per day per pig would be required to treat manure. At the rates presented in Table 8 this would correspond to a cost of between $5 and $10 per pig per day.

CONCLUSION

Approximately 100 µL of a commercial essential oil injected into about 65 L of odourous air in a sealed sampling bag had, no effect on odour intensity, significantly increased odour concentration and significantly improved the pleasantness (hedonic tone) of the odourous air. However, even though essential oils may be effective for odour abatement based on their effect on hedonic tone, the estimated cost of application per pig per day makes these oils too exorbitant to utilize in pig production today.

PHASE III: TESTING THE EFFECTS OF OIL APPLICATION ON ODOUR AND DUST IN A BENCH-SCALE PIG TRIAL

Previous work conducted by Lemay and Godbout (2003) suggested that some oils used to improve air quality in pig barns may possess inherently stronger and more offensive odour characteristics than pig odours, thereby confounding the use of such oils for odour mitigation. The results of the first phase of this study indicated that some oils are more offensive than others. Of the 10 oils tested, only 5 exhibited similar or more desirable odour characteristics than the control treatment, i.e., a bagged blank air treatment. Although oils exhibiting favourable intrinsic odour characteristics were identified, the next logical step in the process would be to evaluate the effects of these oils on livestock odour emissions in confined housing systems.

OBJECTIVE

The objective of this phase of the study was to compare dust and odour emissions from 3 vegetable oil sprinkling treatments and a control treatment, i.e., a treatment with no oil application, using bench-scale pig chambers.

MATERIALS AND METHODS

Twelve bench-scale environmental chambers located at IRDA, QC, were used to conduct the experiment. Each chamber housed four pigs with average initial and final weights of 47.8 and 69.0 kg, respectively. Three oil sprinkling treatments, namely, RBD canola oil, RBD soybean oil and RBD sunflower oil and, a control (no oil application) treatment, were randomly assigned to the chambers, i.e., 3 chambers per treatment. This study was replicated 3 times (trials), housing a different batch of pigs for 3 weeks per trial. The pigs were fed ad libitum with the same standard pelleted diet over the course of the experiment to achieve the desired animal weight range. Lights in the chambers were turned on at 7:00 in the morning and off at 19:00 at night.

Three portable, manual oil-sprinkling systems were fabricated and used to sprinkle the different oils in the chambers. Each system comprised of a pump, an oil container, a pressure gage and a sprinkling nozzle. Every morning, the oils were sprinkled in the chambers at a rate of 10 $ml.m^{-2}.day^{-1}$, except on odour sampling days when oil application occurred following sample collection.

Temperature and relative humidity in the chambers were measured at the exhaust of each chamber with combined temperature and relative humidity probes (Model CS500, Campbell Scientific Canada Corporation, Edmonton, AB). Each sensor was scanned per minute and the average was recorded every 10 min. All the probes were connected to a centralized data acquisition system (Model CR-10, Campbell Scientific Canada Corporation, Edmonton, AB). Total dust mass concentration was monitored on a continuous basis. Total dust mass concentration was established by weighing the amount of dust collected on a filter over a one-week period at a calibrated sampling rate of 2 L/min. One filter per chamber was used per sampling week. Odour samples were collected once a week in 25 L Tedlar™ film (TST20SG4, DuPont Canada, Mississauga, ON) bags and analyzed by olfactometry (UA olfactometer, University of Alberta, Edmonton, AB) within 24 h of sample collection. During sampling, each bag was filled with odourous air from a chamber for approximately 15 min with a sampling device (odour sampling lung, University of Alberta, Edmonton, AB) operating at a flow rate of about 1.7 $L.min^{-1}$. Once filled, the bag was subsequently deflated to approximately ⅔ its initial volume (~16 L) to accommodate pressure-induced volumetric changes during air shipment to the olfactometry laboratory. The doors to the bench-scale chambers were not opened for at least 12 h prior to sample collection.

RESULTS AND DISCUSSION

Room Air Conditions

On average, the chamber temperatures were not significantly different (P>0.05) between treatments over the duration of the study (Fig. 1). However, within each treatment, there was significant difference in chamber temperature (P<0.05) from one week to the next, corresponding to declining seasonal ambient temperatures and consequently, ventilation rates (Fig. 2). On average, chamber ventilation rate decreased from 89 to 17 $L.s^{-1}$ per pig between the 1st and last trials (Fig. 2). This study was conducted between September and December 2003, a period when ambient temperatures typically decrease with time, subsequently lowering the ventilation requirements of pigs.

Relative humidity in the chambers appeared similar from week to week among the treatments (Fig. 3). This outcome was expected since ventilation rates are typically adjusted to maintain temperature, relative humidity and pollutants within targeted levels in pig barns.

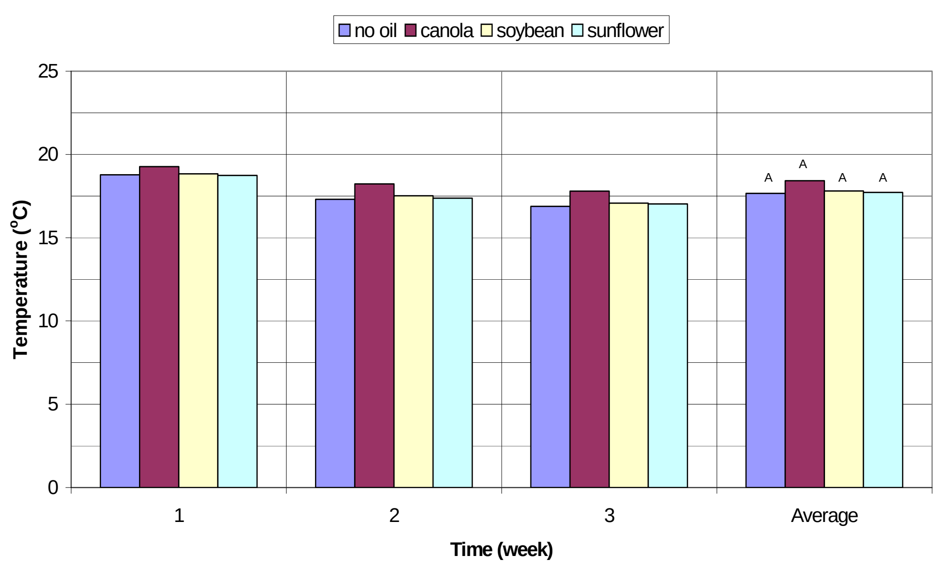

Fig. 1. Average Weekly Chamber Temperatures. Averages Followed by the Same Letter are not Statistically Different (P>0.05).

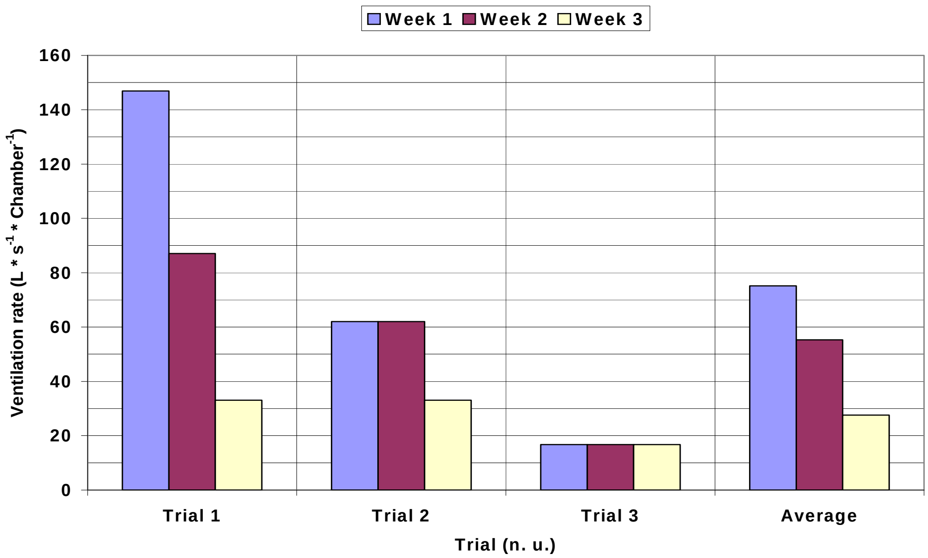

Fig. 2. Ventilation Rate Measurements in the Chambers.

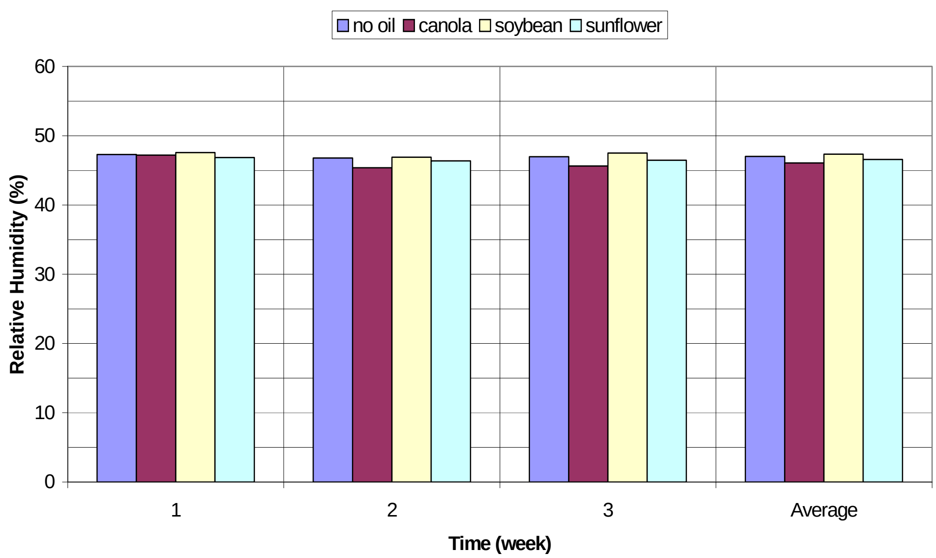

Fig. 3. Average Weekly Chamber Relative Humidity.

Pig Performance

Measurements of pig performance, namely, average daily gain (ADG), average daily feed intake (ADFI) and feed efficiency (FE), are presented in Table 9. With an ADG ranging between 0.90 and 1.10 $kg.d^{-1}$ per pig (Mean = 1.01 $kg.d^{-1}$ per pig) and, FE ranging between 1.83 and 2.80 $kg_{feed}.kg^{-1}_{gain}$ (Mean = 2.17 $kg_{feed}.kg^{-1}_{gain}$), the results show that pig performance was above normal relative to commercial pig production. CDPQ (2005) reported adjusted ADG of commercially produced pigs weighing between 25 and 107 kg was 0.807 $kg.d^{-1}$ per pig with an average FE of 2.66 $kg_{feed}.kg^{-1}_{gain}$. The smaller number of pigs and less competition for food, water and space may have contributed to the higher ADG in the bench-scale trial compared to commercial pig production. Lachance et al. (2005) also obtained high animal performance using the same experimental setup as this experiment.

Table 9. Average Pig Performance Under Different Oil Application Treatments[1]

	Trial	Treatment			
		Control	RBD Canola	RBD Soybean	RBD Sunflower
ADG ($kg.d^{-1}$)	1	1.02 (0.16)	1.01 (0.02)	1.10 (0.09)	0.90 (0.04)
	2	1.05 (0.09)	1.10 (0.14)	1.06 (0.07)	1.10 (0.12)
	3	0.91 (0.01)	0.94 (0.05)	0.93 (0.08)	1.00 (0.07)
ADFI ($kg.d^{-1}$)	1	2.38 (0.10)	2.33 (0.37)	2.39 (0.17)	2.50 (0.18)
	2	2.19 (0.22)	2.36 (0.15)	2.22 (0.19)	2.31 (0.13)
	3	1.92 (0.33)	1.87 (0.48)	1.68 (0.02)	1.83 (0.20)
FE ($kg_{feed}.kg^{-1}{}_{gain}$)	1	2.39 (0.50)	2.30 (0.33)	2.17 (0.10)	2.80 (0.34)
	2	2.09 (0.14)	2.17 (0.22)	2.08 (0.04)	2.12 (0.20)
	3	2.12 (0.38)	1.99 (0.50)	1.83 (0.20)	1.94 (0.26)

[1]Values in parentheses represent the standard deviations of the respective measurements.

Dust Mass Concentration

Figure 4 presents the average dust mass concentration results for the overall experiment. It can be observed that the three oil treatments were very effective at reducing the dust mass concentration in the chambers. On average, the RBD canola, RBD soybean and RBD sunflower oil significantly reduced dust mass concentration by 72, 68 and 72%, respectively, compared to the control rooms where no oil was applied ($P<0.05$).

Godbout et al. (2001) used the same experimental setup to study the effects of 3 experimental diets combined with 4 crude canola oil application rates on ammonia, dust and odour emissions. With the oil sprinkled at a rate of 10 $ml.m^{-2}.day^{-1}$, they measured an 85% average reduction in dust emissions over four trials. Similarly, Payeur et al. (2002) achieved 76% dust emission reduction by applying crude canola oil at a rate of 10 $ml.m^{-2}.day^{-1}$ in three full-scale production trials investigating the impact of a low protein diet, plus fermentable carbohydrates, on dust and odour emissions from swine buildings. The oil sprinkling treatment reduced dust emissions from 2.2 to 0.5 mg/s (Pooled SEM: 0.2 mg/s). Thus, the reductions reported in this study, i.e., from 2.02 to 0.58 mg/s (SEM 0.16 mg/s) fall within the range of average dust emission reductions reported in previous studies.

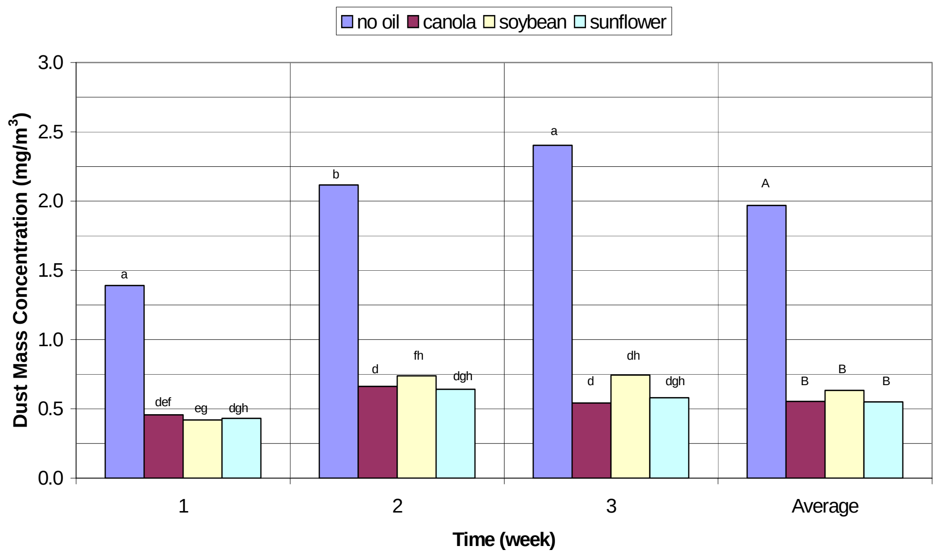

Fig. 4. Average Weekly Chamber Dust Mass Concentration. Averages followed by the same letter are not statistically different (P>0.05).

Odour Emissions

Mean odour emission rates per unit floor area for the four treatments are presented in Fig. 5. The results showed no significant differences (P>0.05) in odour emission rates either between the oil treatments and the control or, among the oil treatments alone. In other words, although the oil treatments effectively reduced dust concentrations, there does not appear to be a correlation between odour and dust reduction.

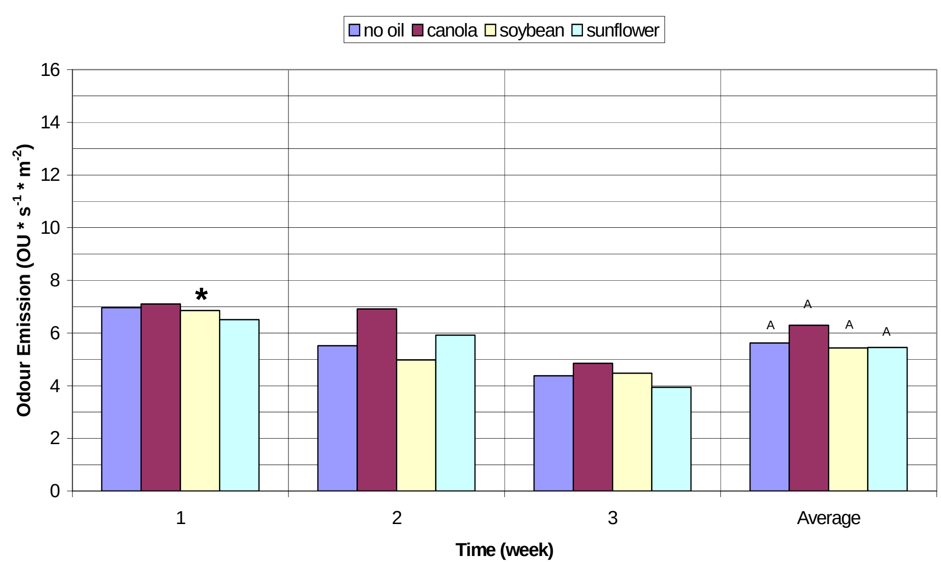

Fig. 5. Average Weekly Chamber Odour Emissions. Averages Followed by the Same Letter are not Statistically Different (P>0.05). *One odour measurement was out of range compared to the other rooms and was taken out of the analysis.

On average, odour emission rates of the 3 oil treatments and control treatment ranged between 5.5 $ou.s^{-1}.m^{-2}$ and 6.3 $ou.s^{-1}.m^{-2}$ agreeing with emission rates reported in other studies. Heber et al. (1998) reported an average odour emission rate of 5 $ou.s^{-1}.m^{-2}$ for a pig finisher barn. Godbout et al. (2001) measured a mean odour emission rate of 10 $ou.s^{-1}.m^{-2}$ from grower-finisher pigs weighing between 50 and 80 kg and housed in small-scale production rooms. In another study conducted by Godbout et al. (2003), odour emission rates from grower-finisher rooms housing 256 pigs ranged between 6.2 and 7.1 $ou.s^{-1}.m^{-2}$.

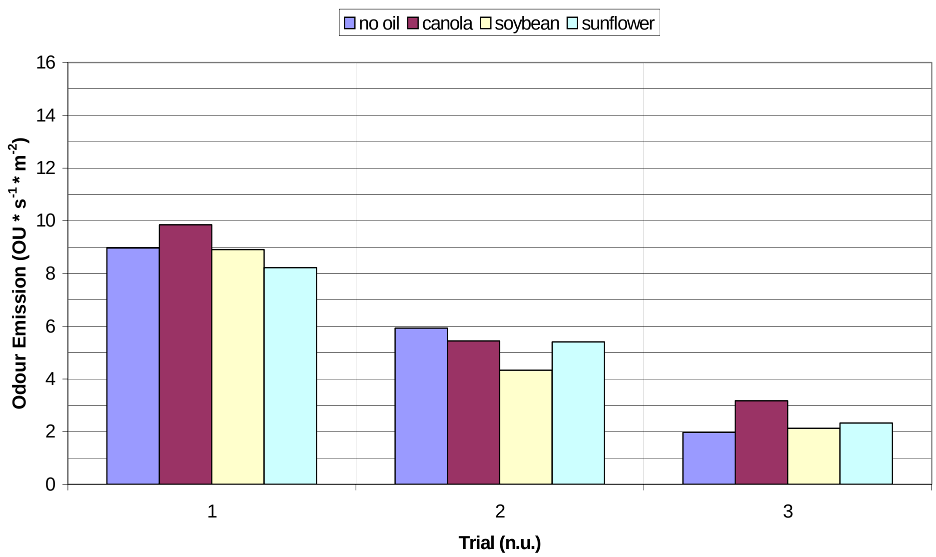

Fig. 6. Average Chamber Odour Emissions Within Trials

Interestingly, the mean odour emission rates of the treatments decreased weekly (Fig. 5) and with each subsequent trial (Fig. 6). These trends mostly result from seasonal changes in ambient temperature and consequently are associated with a reduced ventilation rates (Fig. 2). Watts (2000) reported that a 40 kg (live weight) grower pig emits about 12 $ou.s^{-1}$ and emits twice as much odour in summer as it does in winter. Since the emission rates are a function of ventilation rate, the declining emission rates within trials and among trials seem to relate primarily to ventilation rates.

The hedonic tone results presented in Fig. 7 ranged between –2.4 and –2.6 on a 9-point hedonic tone scale as indicated in Table 2.1. As shown, there was no significant difference (P>0.05) in hedonic tone between the various treatments. This implies that none of the oil treatments was capable of improving the odour character of emissions exhausted from the chambers.

CONCLUSIONS

The application of RBD canola, RBD soybean and RBD sunflower oil were effective in reducing dust emissions in bench-scale pig chambers between 68 and 72% compared to a control (no oil) treatment. However, the oil treatments had no significant effect on reductions in odour emission rate nor did they significantly improve the offensive character (hedonic tone) of the air. There appeared to be no bias in the evaluation within each trial since the pigs and chambers were handled similarly. There were no significant differences in average temperature, relative humidity and pig performance among all the chambers.

Since the oil treatments were ineffective for odour emission rate reduction nor did they cause a positive change in odour character in the bench-scale study, further evaluation of oil sprinkling in a full-scale production facility for the same purpose is not recommended.

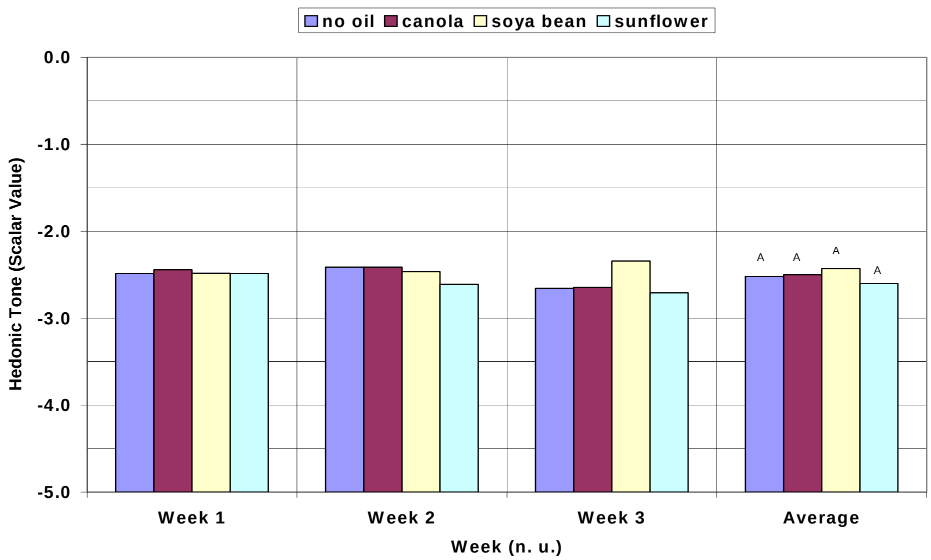

Fig. 7. Average Weekly Chamber Odour Hedonic Tone. Averages Followed by the Same Letter are not Statistically Different (P>0.05)

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