Reducing Energy Use in Group Sow Housing Systems

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SUMMARY

In this study, controlled-chamber experiments were carried out to develop an operant mechanism that allowed the sows to demonstrate their preferred environmental temperature and to study the effects of fibre addition on growth performance and physiological response. Results showed that sows fed with high heat-increment diet were able to maintain significantly lower temperatures over the 24-hr period than those fed with standard gestation diet. Performance and physiological responses of sows fed with high heat-increment diet seemed to have not been affected by the exposure to colder temperatures. Subsequently, the developed operant mechanism and the use of high heat-increment diet were implemented in an actual gestation barn with group-housed sows and results showed that sows could tolerate temperature 8°C colder than the current set-point (16.5°C) maintained in most gestation barns without adversely affecting their growth performance and physiological response as well as their behaviour and welfare. Lower temperatures maintained in the Sow-controlled room resulted to about 59% reduction in energy cost for heating and ventilation.

INTRODUCTION

One advantage of group housing systems is that sows can better interact with and control their immediate environment, including thermal conditions. Sows housed in groups have the freedom to exhibit thermoregulatory behaviour such as huddling to maintain comfort even when the temperature in the barn is lowered. Barn temperatures currently maintained in barns with sows housed in individual stalls are based on the reported lower critical temperature (LCT) (Geuyen et al., 1984). Allowing the temperature to drop below LCT will require additional feed to maintain the sow body condition and weight gain over the gestation period. It has been estimated that sows housed in groups may have LCT values significantly lower than 15°C when given the ability to utilize thermoregulatory behaviour. Thus, if group-housed sows can maintain body condition and weight gain at temperatures lower than currently maintained in sow barns without the need for additional feed, the potential exists to significantly reduce energy costs for heating and ventilation.

However, some issues anticipated with group-housed sows include the potential for higher activity levels and aggression among sows. These problems are exacerbated when sows are put on a restricted feeding regime, which is a common practice for gestating sows to maintain optimal body condition. The sensation of feeling "full" is improved with high-fibre diets; these diets are also known to reduce the urge to feed continuously, as well as overall activity and repetitive behaviour in sows. Moreover, dietary fibre increases heat production in sows without increasing digestible energy. As such, adding fibre to the diet can be a means of reducing activity and limiting aggression in group-housed sows under reduced barn temperature.

"Preliminary results have shown that sows could tolerate temperature as low as 9°C."

MATERIALS AND METHODS

Phase 1 – Controlled environmental chamber tests

Two fully instrumented and controlled-environment chambers at Prairie Swine Centre (PSC) were used in developing the operant mechanism that allows the sows to control their own environmental temperature. The operant mechanism consisted of a manual control switch installed in the chamber along the penning at a location which the sows can access and manipulate, and a radiant heater. When a sow activates the switch, it operates the existing supplementary heating system for the entire room for a specified period, and with the radiant heater placed above the area of the switch as an immediate feedback reward. In addition to the functioning heat control switch, a 'dummy' switch that does not operate the radiant heater (i.e., unrewarded activity) was also installed close to the real switch to distinguish between deliberate behaviour by the sows to control the room temperature and random interaction with the mechanism. In addition two experimental diets were used, with sows in one chamber fed with the control diet (standard gestation diet) while sows in the other chamber were fed with the treatment diet (high heat-increment diet).

Phase 2 – Group-housed Sow Gestation Rooms
For the Phase 2 of the study, two rooms were used with one room was designated as "pre-set" with temperature maintained at 16.5°C (which is the typical set-point applied in sow barns) while the other room as "sow-controlled" with sows allowed to control their own environmental temperature using the operant mechanism developed in Phase 1.

With the exception of temperature, management of the two rooms was identical as much as possible. In the pre-set room, air temperature was set to 16.5^0C while the temperature in the sow-controlled room was set at a lower temperature of 8°C to prompt the sows to activate the heat control switch for supplemental heating. At 1 degree below the setpoint (i.e., 7°C), the supplemental room heater was set to run automatically without the need of switch press from the sows. This was done to protect the animals in the room from potentially being exposed to very cold temperatures. In addition a high-heat increment diet (treatment diet in Phase 1 trials) was fed to sows in both rooms at 2.3 kg per day per sow.

RESULTS AND DISCUSSIONS

Phase 1 - Controlled Environmental Chamber Tests
One major component needed to carry out the experiments in this research project was the design and assembly of the operant mechanism. The operant mechanism was configured to control the heating system of the chamber as well as a small radiant heater provided as an immediate feedback reward. When a sow activates the switch, it operates the existing supplementary heating system for the entire room for a specified duration as well as the small radiant heater above the location of the switch. One of the installed timers was configured to prevent sows from successively activating the heaters by deactivating the switch for a period of five minutes after its previous activation, i.e., any switch presses during this five-minute period will not operate the heaters. In order to encourage the sows to use the operant mechanism, the chambers were run at a set-point temperature of 8°C. To be able to do this, cold ambient air from outside the barn was directly drawn and streamed into the chambers.

Most of the time, sows fed with high heat-increment diet activated the operant mechanism at a relatively lower pig level temperature than sows fed with standard gestation diet. Over 3 trials, the average temperature when the operant mechanism was activated by sows fed with high heat-increment diet was 12.5 °C while that in the control chamber was higher at 13.4 °C. This suggests that sows fed with high heat-increment diet could tolerate lower temperature before calling for supplemental heat than sows fed with standard gestation diet.

Phase 2 – Group-housed Sow Gestation Rooms
Average air temperature. Air temperature in the Pre-set (control) room was uniformly distributed which ranged from 16.4 to 17.0 °C on average. Set-point temperature in this room was at 16.5 °C, which is the typical set-point for gestation rooms during heating (winter) season. Unlike in the Pre-set room, temperature in the Sow-controlled (treatment) room was relatively variable which ranged from 10.7 to 12.3 °C . On average, temperature in the Sow-controlled room was about 5 °C colder than the Pre-set room.

The actual temperatures at the instant when sows activated the operant mechanism were also recorded. Throughout the trial, majority of the temperature recorded was between 9 and 12 °C. Moreover, most switch presses were made during daytime and the corresponding average temperature recorded was 9.9 and 9.7 °C during the first and second weeks, respectively. In the succeeding weeks, switch presses occurred when the average temperature at the pig level was about 10.5 to 12 °C. This initial result suggests that the preferred environmental temperature of sows is between 9 and 12 °C, although this has to be confirmed in subsequent trials.

Natural gas and electricity consumption
The natural gas consumed for heating and the electricity consumed by the fans, room heater, and lights comprised the energy consumption of the room. Over six weeks, the Pre-set room consumed a total of 4,622.6 m^3 of natural gas for heating; this was about 78% higher than the Sow-controlled room which had a total of 1,011.1 m^3 natural gas consumed. Similarly, the total electricity consumption in the Pre-set room during this 6-week period was about 324.55 kWh while the Sow-controlled room used about 289.81 kWh of electricity to heat and ventilate the room during this period. The considerable difference in the total energy consumption (natural gas and electricity) between the two rooms was mainly due to the difference in temperatures maintained in the rooms during the trial.

Growth Performance
Table 1 shows the average daily gain (ADG), backfat depth and sow condition scores to evaluate the growth performance of sows. No significant difference ($p>0.05$) was observed in the ADG of sows in the Pre-set (0.25 ± 0.6 kg/day) and Sow-controlled (0.16 ± 0.12 kg/day) rooms over three trials, which translated to the same average backfat depth and sow condition score. On average, sows in the Sow-controlled room had an average backfat depth of 0.02 ± 0.02 mm while those sows in the Pre-set room had 0.01 ± 0.04 mm. Furthermore, using a scale of sow condition score of 1 to 5 with 1 – emaciated; 2 – thin; 3 – ideal; 4 – fat; and 5 – overly fat, an average sow condition score of 3 which is the ideal condition for gestating sows was observed in both rooms. With these results, it can be stated that sows in the Sow-controlled room were able to maintain their body condition and weight gain at relatively lower temperatures without the need for additional feed.

CONCLUSIONS

Based on the observations made in this study, the following conclusions can be made:

1. Experiments in controlled-environment chambers revealed that sows fed with high heat-increment diet tended to maintain relatively lower temperatures (11.9°C on average) in the chamber than those fed with standard gestation diet (12.7°C). Moreover, the exposure of sows fed with high heat-increment diet to relatively colder temperatures had no significant effect on their performance and physiological response.
2. Results of the implementation of the operant mechanism and high-heat increment diet in actual gestation room have shown that sows housed in groups could tolerate temperature as low as 8°C without adversely impacting their growth performance and physiological response.
3. Lower CO_2 levels were observed in the Sow-controlled room than in the Pre-set room during the heating season, which translates to the Sow-controlled room having relatively better air quality than the Pre-set room.
4. Allowing sows housed in groups to control their own environmental temperature resulted to about 75% reduction in natural gas consumption and 11% reduction in electricity consumption to heat and ventilate the room during the heating period relative to the Control room with temperature pre-set at 16.5°C.
5. No significant behavioral differences were observed between the sows in the Sow-controlled room and the Pre-set room, which implies that sow welfare was not adversely impacted by having the sows maintain relatively colder temperatures in the gestation room.
6. Using current cost estimates and application parameters, cost analysis indicated that the adoption of an operant mechanism to allow group-housed sows to control their own environmental temperature and feeding them with high heat-increment diet could lead to as much as 59% reduction in total heating and electricity cost, which can readily offset feed cost as well as the capital and operating costs for installing this system.

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Table 1. Average daily gain, backfat depth and condition score of sows in the Pre-set and Sow-controlled rooms, n=3.

Sow performance parameters	Pre-set room	Sow-controlled room
Average daily gain*, kg/day	0.25 ± 0.6	0.16 ± 0.12
Backfat depth**, mm	0.01 ± 0.04	0.02 ± 0.02
Sow condition score**	3	3

*ADG for each trial represents average from 40-42 sows per room.
**Backfat depth and condition score for each trial represents average from 12 focal sows per room. Sow condition score: 1 – emaciated; 2 – thin; 3 – ideal; 4 – fat; and 5 – overly fat