



Effects of betaine and heat stress on lactation and postweaning reproductive performance of sows

F. A. Cabezón, K. R. Stewart,¹ A. P. Schinckel, PAS, and B. T. Richert

Department of Animal Sciences, Purdue University, West Lafayette, IN 47907-2054

ABSTRACT

This study was conducted to evaluate the underlying physiological changes during heat stress and the effect of betaine supplementation in lactating sows. Twenty sows were housed in 2 rooms (each with 10 sows) to simulate heat stress (HS: 31°C from 0800 to 1600 h and 26°C for the rest of the day) or thermoneutral (TN: 22°C during the entire trial) conditions. Treatments were randomly allotted to each sow to receive 0.00% or 0.22% of a betaine supplement in their diets. Sows were blocked by parity as they entered the farrowing rooms at d 110 to 112 of gestation. Sows housed in the HS condition had ad libitum access to feed. Sows housed in the TN condition were pair fed with sows in the HS room. Follicle size was measured every 12 h with a real time ultrasound from weaning to ovulation. Betaine supplemented sows had 0.23°C lower rectal temperature than control sows ($P = 0.048$). Respiration rates and rectal and skin temperatures were 36 breaths/min and 0.44 and 3.55°C greater under HS than TN conditions, respectively ($P < 0.004$). Homocysteine and cortisol serum concentrations did not differ between treatments ($P > 0.44$) or environments ($P > 0.25$). The mean follicle diameter was smaller under HS than TN conditions ($P = 0.003$). Betaine supplemented sows had greater follicle diameter than control sows ($P = 0.043$). The time to ovulation from weaning was 2.1 d longer in HS sows than TN sows ($P = 0.005$).

Key words: betaine, follicle, heat stress, lactation, sow

INTRODUCTION

Heat stress has multiple effects on animal metabolism and physiology (Baumgard and Rhoads, 2013). These include increased body core temperature, homeorhetic adaptations to dissipate radiant heat, increased respiration rates, reduced intestinal barrier integrity, elevated circulating concentration of stress markers, and reduced feed intake as a strategy to reduce heat production (Prunier et al., 1997; Pearce et al., 2013; Williams et al., 2013). Heat stress is estimated to cost the United States swine industry over \$360 million annually (St-Pierre et al., 2003).

Heat stress can impair the ovarian function (Rozenboim et al., 2007). Decreased follicular growth rate, increased occurrence of anestrus, and longer wean-to-estrus intervals have been reported in sows during high ambient temperatures (Lucy et al., 2001; Bertoldo et al., 2012). The impaired ovarian function can be attributed to the reduction in blood flow to ovaries, because during heat stress more blood flow is directed to the skin to dissipate heat (Wolfenson et al., 1981).

Betaine is a tri-methyl derivative of glycine, which is synthesized from choline. Betaine acts as an osmoprotectant by increasing water retention capacity in cells (Chambers and Kunin, 1985; Eklund et al., 2005). Betaine has a relevant role in the conversion of homocysteine into methionine (Kidd et al., 1997). High levels of homocysteine have been associated with defective implantation and early pregnancy failure in women (Holmes, 2003). Dietary betaine supplementation has been shown to improve reproductive performance in sows when betaine was supplemented during lactation (Ramis et al., 2011; Cabezón et al., 2016a).

The objectives of this trial were to have a better understanding of the underlying metabolic and physiological changes during heat stress in lactating sows and to evaluate to what extent betaine supplementation can reduce the effects of heat stress.

MATERIALS AND METHODS

Animals, Housing, and Treatments Groups

The Purdue University Institutional Animal Care and Use Committee approved all procedures involving animals. This study was conducted in the farrowing facility at Purdue University Animal Science Research farm. The trial was performed from October 26 to November 27, 2015. Twenty sows (commercial crossbred Yorkshire and Landrace) were housed in 2 rooms (each with 10 sows) to simulate heat stress (HS) or thermoneutral (TN) conditions. Each room had one heater and 2 fans. Each fan had 2 operating options (off or 100% speed) that work independently to each other. The heater in the HS room was set to achieve 31°C from 0800 to 1600 h and 26°C for the rest of the day. The heater in the TN room was set to achieve 22°C during the entire trial. In both rooms, one fan (fan and screen opening of 0.41 × 0.41 m and 0.48 × 0.46

¹Corresponding author: krstewart@purdue.edu

m, respectively) was running at 100% speed during the entire trial and the other fan was kept off. In the HS room the screen opening was reduced to 42.1% to maintain the temperature. The second fan in the TN was only turned on when the temperature exceeded the desired temperature. Temperature, relative humidity, and dew point were recorded every 5 min with 4 logger devices (EL-USB-2, DATAQ Instruments Inc., Akron, OH) in each farrowing room. The loggers were placed at 0.7 m from the floor at the level of sows, away from water sources and air currents. The thermal humidity index (THI) was calculated with the equation described in previous studies: $THI = T_{db} + 0.36T_{dp} + 41.5$, where T_{db} represents the dry-bulb temperature in °C and T_{dp} represents the dew point temperature in °C (Thom, 1958; Buffington et al., 1981).

Within in each room sows were randomly assigned to receive 0.00% or 0.22% of betaine product (96% betaine, Vistabet, AB Vista, Marlborough, UK) supplementation in their diets (Tables 1 and 2). The total choline content of the lactation diet from corn and soybean meal was 1.18 g/kg, which exceeded the NRC (2012) requirement of 1 g/kg. Sows were blocked by parity as they entered the farrowing rooms at d 110 to 112 of gestation. Sows were fed 2.72 kg/d in the farrowing rooms until farrowing. After farrowing sows housed in the HS room had ad libitum access to feed. Sows housed in the TN room were pair fed with sows of similar parity in the HS room. At the farrowing room sows were fed twice per day, at 0700 and 1500 h. The heat stress and the betaine treatment started 1 d after the sows were moved into the farrowing rooms. Lactation length was on average 18.22 ± 1.31 d. Sows were fed 2.2 kg/d at the breeding barn.

Sow BW and Backfat Measurements

Sow BW were recorded as sows entered the farrowing house, d 2 after farrowing, and at the end of lactation. Body weight change during lactation was analyzed as the weight at weaning minus the weight at d 2 of lactation. Backfat depth measurements were performed the day sows were moved in the farrowing room and at weaning, by the same person with a real time ultrasound (Aloka 500, Aloka Co., Tokyo, Japan) and a 3.5-MHz linear transducer following the procedure described by Maes et al. (2004).

Piglet Management and BW Measurements

Cross fostering was allowed only during the first 48 h within the same treatment in the same environment. Only one exception was done to this rule with an early farrowing sow in the TN room fed betaine diet that farrowed only 4 born alive. In this case, 5 piglets were cross fostered from another sow housed in another TN room with control diet. Litter size was standardized to approximately 9 or more piglets. Piglet processing (ear notching, tail docking, castration, teeth clipping, and supplemental iron injection) was performed during the first 48 h. Individual piglet weights were recorded on d 2 and the day before

weaning, to estimate the piglet and litter gain. Heat lamps were used to heat the piglets.

Respiration Rate and Rectal and Skin Temperature

Respiration rates and rectal and skin temperatures were recorded every day (0730 and 1530 h) from the first day in the farrowing room to weaning. Recording of a.m. and p.m. respiration rates and rectal and skin temperatures on the first day at the farrowing room was done to establish basal values. Respiration rates were recorded by 2 or more technicians as the number of breaths (flank movement) counted in 30 s. Then the observed number of breaths was multiplied by 2 to obtain the number of breaths per min-

Table 1. Ingredient composition of the lactation diet based on corn and soybean meal¹

Ingredient, %	Control	Betaine
Corn ²	63.565	63.565
Soybean meal ²	28.600	28.600
Swine grease	3.000	3.000
Limestone ²	1.450	1.450
Monocalcium ²	1.390	1.390
Swine vitamin premix ³	0.250	0.250
Sow vitamin premix ⁴	0.250	0.250
Swine trace mineral premix ⁵	0.125	0.125
Selenium premix	0.050	0.050
Phytase	0.100	0.100
Salt	0.500	0.500
Plasma protein	0.500	0.500
Corn premix	0.220	0.000
Betaine premix	0.000	0.220
Total	100.000	100.000

¹For the betaine diet the basal lactation diet was supplemented with 2.20 g/kg of betaine product (96% betaine, Vistabet, AB Vista, Marlborough, UK) to replace an equal quantity of corn. The total choline content from corn and soybean meal of the lactation diet was 1.18 g/kg, which exceeded the NRC (2012) requirement of 1 g/kg.

²NRC (2012).

³Swine vitamin premix provided the following per kilogram of diet: 6,614 IU of vitamin A, 661 IU of vitamin D₃, 44 IU of vitamin E, 2.20 mg of vitamin K, 0.04 mg of vitamin B₁₂, 8.82 mg of riboflavin, 22.05 mg of pantothenic acid, and 33.07 mg of niacin.

⁴Sow vitamin premix provided the following per kilogram of diet: 0.22 mg of biotin, 1.65 mg of folic acid, 551.16 mg of choline, 4.96 mg of pyridoxine, 22 IU of vitamin E, 0.20 mg of chromium, and 49.60 mg of carnitine.

⁵Swine trace mineral premix provided the following per kilogram of diet: 121.25 mg of Fe, 121.25 mg of Zn, 15.02 mg of Mn, 11.30 mg of Cu, and 0.46 mg of I.

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