Features of a new calorimetry unit to measure heat production and net energy by group-housed pigs

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Abstract

The Swine Calorimeter Unit (SCU) has been constructed at the University of Illinois at Urbana-Champaign. The objective of the SCU is to be able to determine net energy (NE) of diets and ingredients fed on an ad-libitum basis to group-housed pigs in all phases of production. The SCU allows for calculating NE based on the indirect calorimetry procedure. There are 6 calorimetry chambers in the SCU. Each chamber is made air-tight, and measures 1.8×2.0×2.7 m, has fully slatted floors, and a volume of 10.2 m³, with a capacity to hold 4 to 10 growing-finishing pigs depending on size. There are 4 manure screens and 2 urine pans under the slatted floors. Each chamber is equipped with a fresh air supply system. A regulator unit controls humidity and temperature in each chamber. The 'classic line system' developed by Sable Systems International is used to measure gas exchanges in the chambers. Methane, carbon dioxide, and oxygen gases are measured in a determined period and are reported in percentage units. The initial objectives include comparisons of net energy in individually housed and group-housed pigs.

Keywords: calorimeter; group housing; net energy

Description of the swine calorimeter unit structure

The swine calorimeter unit (SCU) is located at the Swine Research Center at the University of Illinois at Urbana-Champaign. The unit is a wood frame construction on a steel chassis, with oriented strand board walls, a wood truss roof, and a plywood floor. All surfaces on the inside are coated with sprayed-on plastic for water-tightness. The unit consists of a feed storage room, an access corridor, 3 equipment rooms, 6 calorimeter chambers, a computer room, and a mechanical room (Figure 1). The feed storage room is temperature- and humidity controled to avoid spoilage of feed. The air handling and gas analyzing equipment for each chamber is located in the 3 equipment rooms, and includes systems to control fresh air supply to the chambers, equipment to control temperature and relative humidity inside the chambers, and equipment to analyze air samples for oxygen, methane, and carbon dioxide. All equipment is wire-connected to the master computer, which is located in the computer room. This allows for real-time monitoring of all equipment and monitoring of the well-being of animals in the chambers. The mechanical room is where utility entrances are located.

Description of the chamber structure

Each chamber is composed of the main chamber for animals and a secondary chamber to collect faces and urine underneath the main chamber. The main chamber has a volume of 6.5 m³. The doors

Figure 1. Plan of the swine calorimeter unit.
of the chambers are air-tight by means of a gasketed surface and have rubber-metal handles for complete closing. The secondary chamber has a volume of 3.1 m³. The floors in the chambers are galvanized steel modular slotted floors with the animal contact surface made of a series of spaced triangular bars. The air supply duct and diffuser, which provides the air exchange needed to hold 4 complete closing. The secondary chamber has a volume of 3.1 m³. The floors in the chambers are flat stainless steel wire screens and 2 pans for feces and urine collection, respectively.

The parameter generation and control unit (PGC)

Attached to the calorimetry chamber is the PGC unit (PARAMETER, Black Mountain, NC, USA). There are two PGC units in each equipment room, controls humidity and temperature in a single chamber via flexible air ducts. The precision for maintenance of the temperature can be controlled with an accuracy of ±0.1 °C and relative humidity is controlled within a range of ±0.5%. This level of precision is ensured by the use of the dew point control system. The PGC air handler contains a blower rated at 700-1,100 m³ of air per hour. The rated maximum heat of rejection for each unit is approximately 7,300 W per hour.

Fresh air intake and air exchange system

Two air supply systems are placed in each equipment room. These systems provide clean air for the air exchange into the chambers and provide the baseline needed for the gas analyzer. The fresh air intake and air exchange system consists of a centrifugal inline fan (Fantech, Lenexa, KS, USA), which has a maximum rated airflow of 293 m³ per hour. The AccuValve® (ACCUTROL LLC, Monroe, CT, USA) is also part of the system. A controller modulates the blades inside the AccuValve® to achieve the airflow determined in the set point and moderates the airflow to enter each calorimeter chamber. The air exchange in the chamber is also controlled by the AccuValve, and chamber pressure is regulated by a manual rotary plate valve located in the exhaust duct, which allows chamber air to vent to the outside of the building.

Gas analyzers

There are 3 gas analyzers located in the 3 equipment rooms. The analyzers are the ‘classic line’ developed by Sable Systems International (SABLE SYSTEM INT., Las Vegas, NV). Each system analyzes air from 2 calorimeter chambers, and consist of 2 pumps, a multiplexer, a sub-sampler, a humidity sensor, an oxygen analyzer, a carbon dioxide analyzer, and a methane analyzer. The sub-sample first enters the methane analyzer, then the carbon dioxide analyzer, and as the last step the oxygen analyzer. The gas analyzers provide readings in percentage units with high resolution. Those values are obtained in a determined period to enable calculation of total heat production from each chamber.

Conclusion

The SCU has been constructed to determine net energy (NE) in diets and ingredients fed to pigs, to compare NE values between individually housed and group-housed pigs, and to investigate effects of feed additives and feed processing on NE.

Can feeding behaviour explain part of the variation observed in growing pigs' body composition?

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Abstract

This study focused on the relationship between feeding behaviour and the composition of the body gain in growing pigs. Feeding behaviour and body composition traits were calculated using individual information from 165 pigs during the last 28 days of the finishing period of 3 growing trials. A linear regression model describing the relationship between relative cumulative feed intake (CFI) and time of each pig was used to calculate a new index (DAreg) representing the regularity of feeding behaviour. Across studies, moderate and significant (P<0.001) correlations were found between DAreg and FV (r=0.57) and IFV (r=0.55). Correlations between feeding behaviour traits and the % of protein and lipid of the body gain were weak. Additionally, behavioural traits including DAreg explained only 17% of the variation of the proportion of lipid on body gain. Other factors than feeding behaviour are modulating growing pigs’ body composition.

Keywords: feed intake pattern, precision farming, nutrition

Introduction

Large variability on lipid and protein body composition is observed in pigs fed and raised in similar conditions. Some evidence suggests that part of this variation might be explained by differences in feeding behaviour patterns and its effect on plasmatic concentration of metabolic hormones (Le Naou et al., 2018). Feeding behaviour is normally described using daily traits such as the time spent eating per day, meal frequency, intervals between visits, and others. However, those traits are very irregular within and between days, which makes it difficult to obtain representative descriptive statistics. A more regular index to describe feeding behaviour and its distribution over time can be obtained by studying the evolution of the cumulative feed intake (CFI) within the day. The objectives of this research were to evaluate the potential of using a CFI index to represent feeding behaviour, and to explore the influence of feeding behaviour on body composition in growing-finishing pigs raised in ad-libitum conditions.

Materials and methods

Feed intake information from 165 pigs recorded during the last 28 days of 3 experimental trials (average body weight 91.9±10.7 kg) (Andretta et al., 2014; 2016; Dickner-Ouellet et al., 2018, study 1, 2 and 3, respectively) was used in this study. Pigs had free access to feed and fresh water throughout the experiments. Fluorescent lighting was provided from 06.00 to 18.00 h. Total body lean and fat content was measured with a X-ray dual-energy densitometer (GE Lunar Prodigy Advance; GE Healthcare, Madison, WI) at the beginning and at the end of the studied growing period. The percentage of body protein (PdDG) and lipid (LdDG) gain during the period were calculated. The total number of feeder visits (FV), the interval between visits (IFV), the duration of FV (DFV), the feed intake rate (IR; g/min) and the percentage of the total feed intake consumed in nocturnal and diurnal visits (PFN and PFID, respectively) were calculated. A linear regression model describing the relationship between the relative CFI and time was performed for each pig. Relative CFI was expressed as % of total feed intake over a week (Figure 1). The regression line represents the hypothetical situation of a pig that eats continuously the same amount of feed over a week. The sum of the absolute values of the areas of the deviations (DAreg) between the observed CFI and