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Research article

Influence of solid–liquid separation strategy on biogas yield from a stratified swine production system

André Cestonaro do Amaral [a], Airton Kunz [a, b, *], Ricardo Luis Radis Steinmetz [b], Lucas Antunes Scussiato [a], Deisi Cristina Tápparo [a], Taís Carla Gaspareto [c]

[a] Western Paraná State University, UNIOESTE/CCET/PGEAGRI Cascavel, PR, Brazil
[b] Embrapa Swine and Poultry, Concórdia, SC, Brazil
[c] Contestado University – UNC Concórdia, SC, Brazil

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ABSTRACT

As the fourth largest swine producer and exporter, Brazil has increased its participation in the global swine production market. Generally, these units concentrate a large number of animals and generate effluents that must be correctly managed to prevent environmental impacts, being anaerobic digestion is an interesting alternative for treating these effluents. The low-volatile solid concentration in the manure suggests the need for solid–liquid separation as a tool to improve the biogas generation capacity. This study aimed to determine the influence of simplified and inexpensive solid–liquid separation strategies (screening and settling) and the different manures produced during each swine production phase (gestating and farrowing sow houses, nursery houses and finishing houses) on biogas and methane yield. We collected samples in two gestating sow houses (GSH-a and GSH-b), two farrowing sow houses (FSH-a and FSH-b), a nursery house (NH) and a finishing house (FH). Biochemical methane potential (BMP) tests were performed according to international standard procedures. The settled sludge fraction comprised 20–30% of the raw manure volume, which comprises 40–60% of the total methane yield. The methane potential of the settled sludge fraction was approximately two times higher than the methane potential of the supernatant fraction. The biogas yield differed among the raw manures from different swine production phases (GSH-a 326.4 and GSH-b 577.1; FSH-a 860.1 and FSH-b 479.2; NH -970.2; FH 474.5 $NmL_{biogas}.gVS^{-1}$). The differences were relative to the production phase (feed type and feeding techniques) and the management of the effluent inside the facilities (water management). Brazilian swine production has increased his participation in the global market, been the fourth producer and the fourth exporter. The segregation of swine production in multiple sites has increased its importance, due to the possibilities to have more specialized units. Generally, these units concentrate a large number of animals and generate effluents that must be correctly managed to avoid environmental impact. Due to the biodegradability of manure, anaerobic digestion is an interesting alternative to treat these effluents. The low volatile solid concentration in the swine manure suggests the need for solid–liquid separation as a tool to improve biogas generation capacity. The present study aimed to determine the influence of simplified and cheap solid–liquid separation strategies (based on screening and settling) and different manure of each swine production phases (gestating and farrowing sows houses, nursery houses and finishing houses) on biogas and methane yield. We collected samples in two gestating sows house (GSH-a and GSH-b), two farrowing sows house (FSH-a and FSH-b), a nursery house (NH) and a finishing house (FH). The Biochemical Methane Production (BMP) tests were performed according to international standard procedure (VDI 4630). The settled sludge fraction responds for 20–30% of raw manure volume, producing 40–60% of the total methane yield. The methane potential of settled sludge fraction was about 2 times higher than the supernatant fraction. There are differences on biogas yield between the raw manure of different swine production phases (GSH-a 326.4 and GSH-b 577.1; FSH-a 860.1 and FSH-b 479.2; NH 970.2; FH 474.5 $NmL_{biogas}.gVS^{-1}$). The differences are relative to production phase

* Corresponding author.
E-mail address: airton.kunz@embrapa.br (A. Kunz).

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(feed type, feeding techniques, etc.), but also the management of the effluent inside the facilities (water management).

1. Introduction

A typical swine production system can be separated into four phases: 1) breeding and gestation (breeding females and their maintenance during the gestation period – 114 days); 2) farrowing (birth of baby pigs until weaning at approximately 7 kg–21–28 days); 3) nursery (care of pigs immediately after weaning until approximately 25 kg–35–42 days); and 4) finishing (feeding pigs from 25 kg to a slaughter weight of 120 kg–90–105 days). The production process is organized according to the market demand and regional characteristics (Dias et al., 2011). The segregation of swine production into multiple sites is increasingly important because it enables more specialized units. Farrow-to-wean, farrow-to-feeder, off-site nursery, feeder-to-finishing and wean-to-finish are the most noteworthy types of units (Miele and Miranda, 2013). The relation between the stratified units and the swine production stages is shown in Fig. 1.

Swine manure characteristics are a function of several factors, such as swine age, diet (feeding and antibiotic) and house design (Brooks et al., 2014). The variability in the methane potential of effluent streams can be associated with changes in production management practices, such as feed, feeding techniques and effluent handling methods (Amaral et al., 2014; Gopalan et al., 2013).

In Brazil, swine waste management strategies primarily include storage in reception pits and land applications (Kunz et al., 2009-a). Anaerobic digestion has intensified in recent years due to the low cost and easy operation of geomembrane-covered lagoons. However, these biodigesters have limitations due to their low technology and low organic loading rate (approximately 0.5 kgVS m^{-3} d^{-1}), high hydraulic retention time (>30 days), low total solid concentration (<3% $w.v^{-1}$) and low biogas yield (0.36 $m^3.kgVS^{-1}.d^{-1}$) (Bortoli et al., 2009; Vivan et al., 2010).

Biogas generation can be improved by the use of better biodigestion technologies; increasing the substrate solid concentration, for example, through co-digestion (Fierro et al., 2014; Zhang et al., 2015); or using preliminary solid–liquid separation processes, such as mechanical separators or screens (Deng et al., 2012; Hjorth et al., 2010; Sutaryo et al., 2013). The total solids content of typical swine manure ranges from 1 to 2% ($w.v^{-1}$) (Deng et al., 2012). Wastewater with a low concentration of organic matter may present low biogas yields, which should be compensated with larger digester reactor and hydraulic retention times (Hamelin et al., 2011).

Manure solid separation or concentration, which is a strategy that can potentially contribute to environmental and biogas/methane yield, has recently increased (Popovic and Jensen, 2012). The best performance strategies have been applied using commercial technologies, such as a) screw presses, b) flocculation using polymers and drainage with filter bland separators, and c) decanter centrifuges (Sommer et al., 2015). These technologies require substantial investment, which may be economically prohibitive for some production scales.

Gravity settling is an attractive option for separation due to its

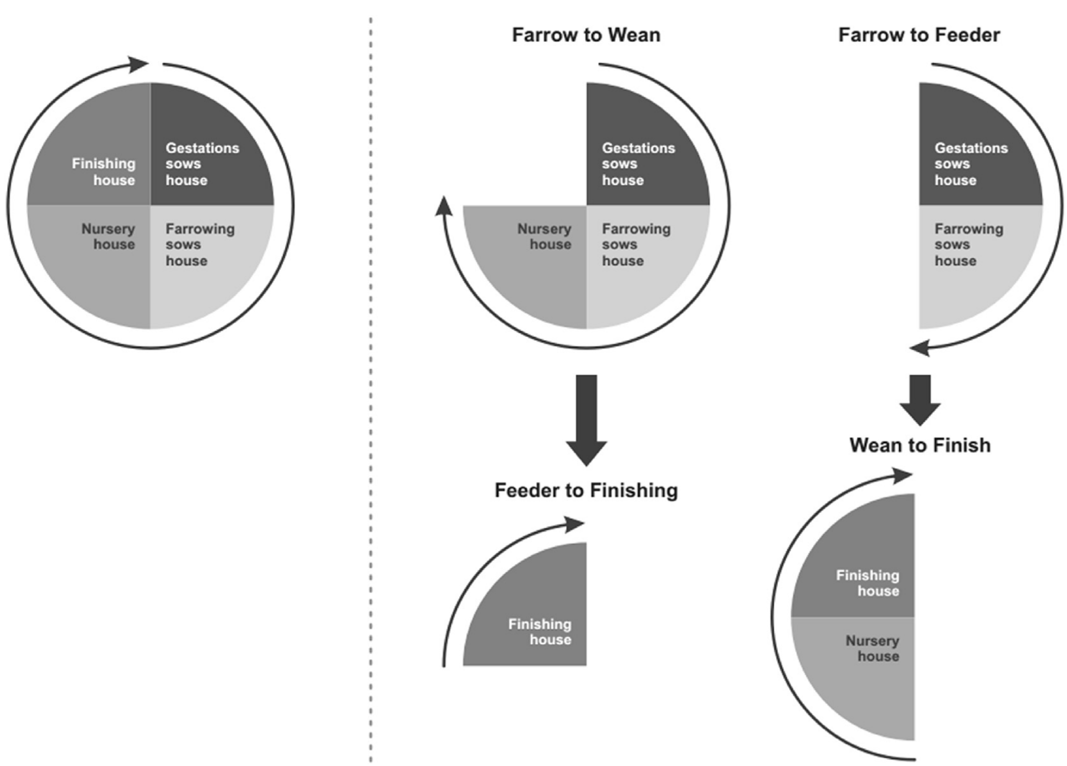

Fig. 1. Differences between swine production in a single and multiples sites and stratified animal production phases.