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ANAEROBIC DIGESTION OF SWINE MANURE: STRATIFIED PRODUCTION UNITS AND ITS BIOGAS POTENTIAL

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SUMMARY: Brazilian swine production is characterized by specialized units in certain stages of production. Manure from different stages of swine production presents different characteristics. Thus, the aim of this study was to investigate the biogas yield from swine manure of different production stage. Swine production stage studied were gestation sows house, farrowing sows house, nursery house and finishing house. Samples showed low concentrations of solids, indicating inadequate water management. Biogas yield were statistically different (5% significance) among all studied stages. The manure from nursery house presented the highest biogas and methane yield capacity 0.970 $Nm^3.gVS^{-1}$ followed by the farrowing sows 0.865 $Nm^3.gVS^{-1}$, finishing pigs 0.474 $Nm^3.gVS^{-1}$ and gestation sows 0.326 $Nm^3.gVS^{-1}$. The methane concentration in biogas varied from 52% to 66%. The swine growth stage affected the specific biogas yield.

Keywords: methane yield, Brazilian swine production, biodigestion

INTRODUCTION

The segregation of swine production in multiple sites has increased importance in Brazil, due to the possibilities to have more specialized units. Among them, farrow-to-wean, farrow-to-feeder, off-site nursery and feeder-to-finishing are the most noteworthy (Miele and Miranda, 2013). The Brazilian swine production process can be separated into four phases: 1) gestation (breeding females and their maintenance during the gestation period); 2) farrowing (birth of baby pigs until weaning, about 7 Kg); 3) nursery (care of pigs immediately after weaning until about 25 Kg), and; 4) finishing (feeding pigs from 25 Kg to a slaughter weight, about 120 Kg) (Dias et al., 2010) The relationship between stratified units and swine production stage are shown in Figure 1.

The swine manure characteristics can be influenced by factors as age, diet (feeding and antibiotic) and house design (Brooks et al., 2014). The variation in methane potential of the effluent streams can be linked to the variation in production management practices such as feed, feeding techniques and effluent handling methods (Gopalan et al., 2012). Swine waste management strategies in Brazil are represented mainly by short storage in receptions pits and land application (Kunz et al., 2009). Anaerobic digestion has been intensified in recent years, mainly by geomembrane covered lagoons, due to low cost and operational aspects. However, these biodigestors present limitations owing to the process low technology and low organic loading rate (around 0.5 Kg VS $m^{-3}d^{-1}$), high hydraulic retention time (>45 days), low total solids concentration (< 3% w/w) and low biogas productivity (Bortoli et al., 2009).

Thus, the present research aims to determine the biogas and methane yield from manure of different swine production stage (gestating and farrowing sows, nursery pig and finishing pig) in order to represent an inference to Brazilian stratified swine production.

MATERIAL AND METHODS

Samples: The samples were collected in West of Paraná-State, Brazil. Representative samples of gestation sows house (GSH), farrowing sows house (FSH) and nursery house (NH) were collected in a farrow-to-feeder unit, with 5500 sows located in Serranópolis do Iguaçu. The manure samples were collected with 15, 15 and 40 days of storage in the pits, respectively. The finishing house (FH) sample manure was collected in a feeder-to-finishing unit with 5000 pigs, located in São Miguel do Iguaçu. The retention time in the pits was 24 hours. None of the sampled sites used any bedding material.

Biomethane potential (BMP): BMP tests were carried out at mesophilic temperature conditions according German Standard Procedure VDI 4630 (2006). The batch tests were proceeded in 250 mL reactor flask's and the gas volume was measured using eudiometer graduates tubes. The gas production was read daily by displacement of the column of liquid sealant in the eudiometer tube and the dried biogas volume was corrected to 273 K and 1013 hPa. The mesophilic anaerobic inoculum was prepared from mix of anaerobic sludge from reactor fed with swine manure and dairy cattle manure. Two weeks before the test, the mixture of biomass was acclimatized (37 ± 1 °C) in a completed mixing reactor, fed at the rate of 0.3 $kgVS.m^{-3}.d^{-1}$ for 7 consecutive days. Then, the inoculum remained 7 days without fed, in order to reduce the biogas baseline production.

Biogas analyses: For evaluation of the biogas composition, biogas samples were analyzed by i electrochemical sensors (Dräger X-am® 700).

Physic-chemical analyses: All analyses of TS, VS and Total Ammonium Nitrogen were performed according to APHA, (2012).

Statistical analysis: All statistical analyses were performed using MS Excel. P-values below 0.05 were considered statistically different.

RESULTS AND DISCUSSION

The characteristics of swine manure samples from different growth stages in this study are presented in Table 1. Table 1 showed that different TS, VS and ammonium nitrogen contents were founded in these swine manure samples. The difference among different types of swine manure samples may be caused by different feed strategy and nutrient digestibility at different growth stage, followed by differences in manure management within the facility (Brooks et al., 2014). The GSH, FSH and NH manure showed low volatile solids concentrations (Table 1), when compared with the literature, that indicates solids content in the range of 1-3%(w/w) (Deng et al. 2012). The highly diluted manure, contain little carbon for ensuring economically attractive methane yield, requiring compensation this through bigger digesters with higher hydraulic retention times (Hamelin et al., 2011). Higher time storage in pit contributing to reduction in volatile solids in manure. Popovic and Jensen (2012) found 40% reducing in the concentration of the VS when the storage time was more than 8 weeks. This result indicates that there need to improve management of manure for GSH, FSH and NH.

The biogas yields showed differences between the evaluated samples (Table 1 and Figure 2). The highest values were found for NH, followed by FSH, FH and GSH, respectively. The difference in biogas production of samples can be due to differences of the feeding techniques applied in the swine industry. Feed wastage in weaner pigs can be up 15% (w/w), in addition are known to have poorer large intestine fermentation causing relatively poor feed conversion. On the other hand, adults sows and finishing pigs have enhanced hind gut fermentation (Shi and Noblet, 1993). There were significant statistical difference ($p < 0.05$) in biogas yield between the four samples.

The kinetic studies (Figure 2) show that GSH and FH samples evidence a maximum daily biogas yield (DMY) (95.9 and 129.25 $NmL.gVS^{-1}.d^{-1}$, respectively) on the first day of teste, but FSH and NH samples achieved DMY on third day of teste (129.25 and 234.46 $NmL.gVS^{-1}.d^{-1}$), indicating a lag phase due possible limitation for hydrolysis. The peaks of DMY may be attributed to the subsequent degradation of macromolecules insoluble substances, such as crude protein (Xie et al., 2011). The stabilization of all tests occurred between 16 and 20 days. According to VDI 4630 (2006), the production of biogas is considered stabilized when the daily biogas production becomes equal to or less than 1% of the total volume produced.

CONCLUSIONS

The swine growth stage affects the biogas yield. Improper the management of waste can decreases the concentration of volatile solids, unfeasible economically biogas plants.

The manure from Nursery House presented the highest methane yield followed by Farrowing Sows House, Finishing House and Gestation Sows House, respectively.

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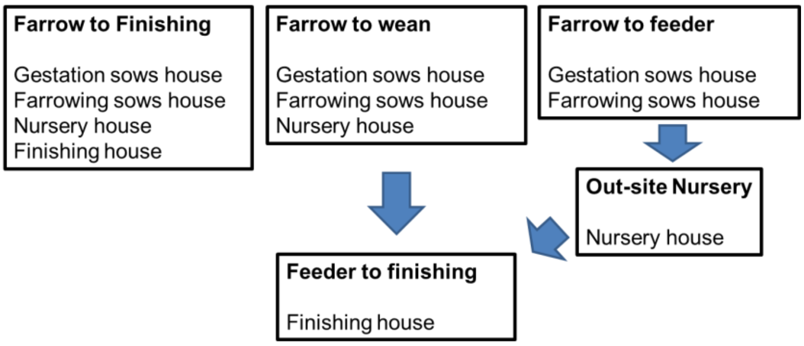

Figure 1. Typical Brazilian swine production system. Arrows indicate change of specialized production units.

Table 1. Total and volatile solids, ammonium nitrogen, biogas yield and methane percentage for different manure swine samples (Gestation sows house (GSH), Farrowing sows house (FSH), Nursery house (NH) and Finishing House (FH).

Sample	Total solid (g/Kg)	Volatile solid (gVS/Kg	Ammonium nitrogen ($gN\text{-}NH_3/L$)	Biogas yield ($m^3N/kgVS$)	Methane (%)
GSH	9.88	5.05	1.79	0.326[a]	52.0
FSH	9.29	6.06	1.29	0.865[c]	66.0
NH	5.10	3.81	0.34	0.970[d]	66.2
FH	31.57	21.22	2.36	0.474[b]	63.8

[a, b, c and d]: Means of biogas yield different superscript letters different ($p<0.05$) in columns.

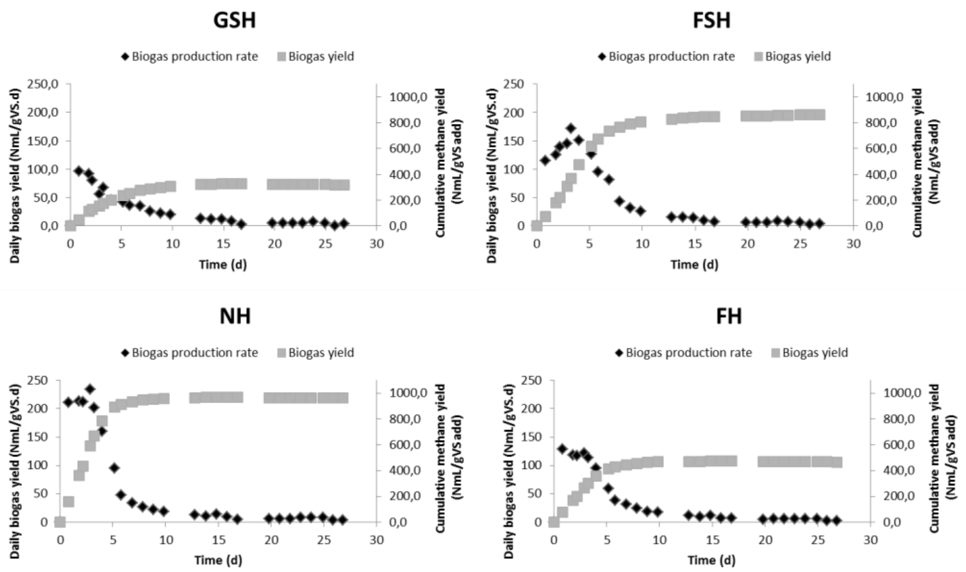

Figure 2. Biogas production rate and cumulative biogas yield of GSH, FSH, NH and FH.