Nitrous oxide prediction in manure from pigs given mustard x grapeseed oil cakes as a replacement for sunflower meal

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ABSTRACT

During the last century, the emission of nitrous oxide (N₂O) from the livestock sector increased significantly. N₂O is a greenhouse gas with 298-fold higher global warming potential (GWP) than CO₂. Pigs accounted for about 26% of N₂O emissions. The formation of N₂O occurs through nitrification and denitrification processes in manure. This study aimed to estimate N₂O production in the manure of growing-finishing pigs by using our experimental data in the model. The associative effects of dietary mustard and grapeseed oil cakes (MxG), as an alternative for sunflower meal (SFM), on performance and efficiency traits were also determined. Forty growing-finishing pigs were randomly allocated in two groups (2 replicates per group) fed two diets: C diet (based on SFM, 15 wt) and E diet (based on M and G mixture, 7:8 wt:wt). Our model includes as initial input data: body weight (BW), feed intake, nitrogen intake, dietary dry matter, and fibre intake. Using literature prediction equations, including total nitrogen output (TNO) as the main parameter, we established N₂O production expressed as equivalent CO₂ (E-CO₂). A decline with 3% for BW (P=0.44), respectively 9.0% for average daily gain (ADG, P=0.21) in pigs given MxG was recorded. Correlated with growth parameters, efficiency traits (feed intake, feed: gain ratio, N and fibre intake) were decreased as well (P>0.05). Dietary addition of MxG led to a 5% lower level of N₂O production in manure. The reduction of TNO was not significant (<7.14% in the E diet compared to the C diet). In our trial, a relatively low N intake percentage is retained in the pigs body (35.56% in the C group and 35.98% in the E group, P>0.05). Based on these results, we conclude that the inclusion of 15% MxG mixture in pigs diets, although slightly declining growth parameters,

is a valuable nutritional solution by their contribution to lowering N_2O and N output in the manure.

Keywords: pigs, rapeseed cake, mustard cake, sunflower meal, N_2O , nitrogen

INTRODUCTION

A diversity of interventions can be applied in livestock, including those that target to mitigate animal emissions. Feeding management is accepted as one of the most important tools to alleviate greenhouse gases (GHGs) production. Although many solutions to mitigate GHGs were implemented, a further step consists of using new practices to cover the knowledge gaps. The European Commission sets out the new growth strategy “*for a growth that gives back more than it takes away*” that covers all sectors of the economy, including the livestock sector. It highlights the importance of promoting efficient ways of using resources by redirecting to a circular economy, a clean environment, and reaching climate neutrality, restoring biodiversity and cutting pollution.

During the last century, the emission of GHGs from the livestock sector increased significantly. However, several studies considered the agricultural sector to have the capability to mitigate GHGs (Philippe and Nicks, 2014; Grossi et al., 2018; Lenerts et al., 2019; Castrillón et al., 2020; Habeanu et al., 2020). In the livestock sector, the GHGs represent losses of energy, nitrogen and organic matter (OM). The main type of GHGs from the livestock sector are CH_4 (25%), CO_2 (32%, from land use) and N_2O (31% from manure (Moran and Wall, 2011). Grossi et al. (2018) show that manure storage contributes 0.71 GT, which means 10% of the total GHGs emission.

CO_2 is the gas used as a reference, such as the GWP value is 1. The accumulation of CO_2 , N_2O and CH_4 are a cause of GWP, although, in livestock, the E- CO_2 does not contribute to GWP. N_2O has 298-fold higher GWP than CO_2 (Eq- CO_2).

Pigs accounted for about 26% of N_2O emissions. The synthesis of manure N_2O by-products occurs through nitrification and denitrification processes in anaerobic conditions and/or accumulation of nitrite. Oxygen favours N_2O accumulation (Philippe and Nick, 2014).

In one respect, animal husbandry is an important source of protein. Statistics show an increase in global consumption of animal products. But on the other hand, animals' husbandry also means pollution, although the impact is not major. The gaseous pollution generated by pig farms may be due to the decomposition of manure. That has implications for the atmosphere and the health of farmers and their neighbours. The European Parliament's resolution on a strategy for the long-term reduction of EU GHGs emissions under the Paris Agreement (2019/2582, RSP) states that net emissions must be reduced

close to zero in all sectors of the economy, which should contribute to joint efforts to reduce emissions. In this context, it becomes imperative to identify and valorise, at maximum potential, new or lesser-known alternative resources.

The question raised was how to contribute to reducing pollution in pig husbandry beyond the aspects already known and applied. Using by-products as production residues could lead to favourable outcomes in feed costs and the environment.

The purpose of this paper consists of using three by-products from oil industry mustard cakes x grapeseed cakes (MxG) and sunflower meal (SFM), respectively, to predict N₂O production in the manure of growing-finishing pigs. The associative effects of dietary MxG as an alternative for SFM on nitrogen (N) metabolism, performance and efficiency traits were also determined.

MATERIALS AND METHODS

The bioassay was done at IBNA Balotesti according to 7976/12/2020 protocol approved by the Ethical Committee of the IBNA Balotesti.

Experimental setup

Forty growing-finishing TOPIGS pigs [sows Large White × Hybrid (Large White × Pietrain) and boar Talent, mainly Duroc], 56±3 days old, with an initial body weight of 21 kg ± 3, were randomly allocated in two groups (2 replicates per group) given two diets: C diet (based on SFM, 15%) and E diet (based on MxG mixture, 7%+8%, Table 1).

The feed was provided twice as daily meals, and feed intake and leftovers were registered daily. In our diet, the association of M with G cakes was established to be 7% respectively 8% to ensure the pigs' nutritional requirements were at a similar level while fibre and their component had higher content.

The diets and by-product fibre composition were calculated using EvaPig ® software, version 2.0.3.2 (2020) developed by the French National Institute for Agricultural Research (Table 2).

The animals were individually weighed with an electronic scale on the 56 and 94 days after farrowing.

The gross chemical composition was determined by standardised methods according to Commission Regulation (EC) no. 152 (2009). The by-products (M and G cakes) were procured from 2E-Prod SRL.

Table 1. Compound feed formula (as-fed basis)

Ingredients (%)	C diet	E diet
Maise	53.91	53.91
Rice bran	15	15
Soybean meal	13	13
Mustard cake	-	7
Grapeseed cake	-	8
Sunflower meal	15	-
Corn gluten feed	-	-
Milk powder	-	-
L-Lysine-HCl	0.09	0.09
DL-Methionine	-	-
Calcium carbonate	1.64	1.64
Monocalcium phosphate	0.15	0.15
Salt	0.1	0.1
Choline premix	0.1	0.1
Phytase	0.01	0.01
Vitamin and trace mineral mixture	1.0	1.0
Calculated chemical composition (g x Kg feed⁻¹)		
ME MJ/Kg	12.49	12.43
CP	158.7	153.6
EE	30.3	39.2
Crude fibre	63.00	72.70
Lys	10.5	10.5
Lys d	8.9	8.1
Met +Cys	6.6	6.6
Met +Cys d	5.7	5.7
Ca	8.1	8.1
P d	2.0	2.0
Cellulose	52.5	59.3

Abbreviation: DM dry matter, ME metabolisable energy, CP crude protein, EE ether extract, Lys lysine, Met + Cys. Methionine + cysteine, Ca calcium, P phosphorus, d digestible.

*The vitamin-mineral premix (x kg feed⁻¹): 6000 IU vitamin A; 800 IU vitamin D3; 20 IU vitamin E; 1 mg vitamin K3; 1 mg vitamin B1; 3.04 mg vitamin B2; 10 mg vitamin B3; 6.3 mg vitamin B5; 1.5 mg vitamin B6; 0.03 mg vitamin B7; 0.3 mg vitamin B9; 0.02 mg vitamin B12; 30 mg Mn; 80 mg Fe; 25 mg Cu; 100 mg Zn; 0.22 mg I; 0.22 mg Se; 0.3 mg Co; 60 mg antioxidant.

The diets had similar content in energy, protein and limiting amino acids.

Table 2. Diets and by-products fibre and their fractions composition

Ingredients (%)*	C diet	E diet	Mustard cakes	Grapeseed cakes	Sunflower meal
Fibre	6.30	7.27	11.42	41.86	25.49
NDF	15.67	18.85	33.28	77.78	51.31
ADF	7.42	10.6	21.61	69.13	39.33
ADL	2.17	4.67	9.58	45.97	10.02
Cellulose	5.25	5.93	12.03	23.16	29.31
Hemicellulose	8.25	8.25	11.67	8.65	11.80

Abbreviation: neutral-detergent fiber (NDF), acid-detergent fiber (ADF), lignin (ADL).

N- Balance and N₂O production calculation

To predict the N metabolism parameters and concentration of N₂O, we developed a model that was included as initial input data: body weight (BW), feed intake, nitrogen intake, dietary dry matter, and fibre intake. For urinary and faeces, N calculation the Joergensen et al. (2013) equations based on N, protein and dry matter intake were used. Using literature prediction equations, including total nitrogen output (TNO) as main parameters, calculated the N₂O production expressed as Eq-CO₂. The indicators evaluated are described in figure 1.

Figure 1. Adapted from Rational Livestock Nutrition In Rural Areas. Chapter 3. Animal Feeding Systems in Europe (Dragomir, Hăbeanu, Gheorghe, 2016).

Statistical analysis

Data were analysed using of Software Statistical Package SPSS (2011). Shapiro-Wilk test was used to determine data distribution. The fixed factor

in the model was diet. Significant differences were considered at a P-value ≤ 0.05 .

RESULTS AND DISCUSSION

Growth parameters

Figures 2 and 3 show the effect of the MxG mixture on BW and ADG compared to SFM. No significant differences were noticed irrespective of the parameters assessed. However, a slight decline was observed on pigs fed E diet, respective final BW smaller with 3%, and ADG smaller with 9% compared to animals given SFM.

Figure 2. Pigs live weight and metabolic body weight

Figure 3. Average daily gain

Correlated with the growth parameters, the efficiency characteristics decreased in the MxG fed group, respective feed consumption <3.5% and feed conversion ratio <10.7%.

Nitrogen balance and N_2O estimation

GHGs are gaseous compounds that capture longwave radiation emitted from Earth's and re-send it to the Earth (www.britannica.com/science/greenhouse-gas).

Figure 4 shows the GHG cycle in pigs' farms. CO_2 emissions from manure management are considered biogenetic and are neglected when analysing total GHGs emissions. The Intergovernmental Panel on Climate Change (IPCC, 2016, 2019) states that CO_2 emissions from manure management are zero because plants reuse it through photosynthesis.

According to the IPCC (2019), improved agricultural practices and forest-related mitigation activities can significantly contribute to removing CO_2 from the atmosphere at a relatively low cost. The idea consists of stabilisation of the C in such a way as to avoid an atmospheric alert.

An alarm signal was issued when the emission of N_2O from the livestock sector increased significantly. N_2O is a GHG with 298-fold higher global warming potential than CO_2 (Eq- CO_2). Pigs accounted for about 26% of N_2O emissions. The formation of N_2O occurs through nitrification and denitrification processes in manure.

Figure 4. GHGs cycle for pigs.

Nitrogen is an important component of the dietary protein involved in many metabolic processes but is one of the most expensive nutrients. It was highlighted that 32-46% of N consumed is retained by pigs (Dourmad et al., 2017; Millet et al., 2018; Hăbeanu et al., 2020). 2/3 of nutrients released are N (Millet et al., 2018).

The feed represents one way to minimise the level of N excreted (Monteiro et al., 2010; Dourmad et al., 2017; Wang and al., 2018). In the traditional diets for pigs, the farmers used SFM associated with soybean meal. Using by-products as production residues could lead to favourable outcomes in feed costs and the environment. Our premise was that M and G residues delivered by the oil industry could replace SFM due to their nutritional composition. The N intake was 5% lower in the E diet (figure 5). Consequently, the concentration of N retained was 4.3% lower in the E diet than the classical diet based on SFM (figure 6). A relatively low N intake percentage was retained in the pigs body (35.56% in the C group and 35.98% in the E group, $P>0.05$).

Figure 5. N consumed by pigs fed differently

It is important to estimate, especially TNO, since this is the main parameter used to assess the N_2O . In our study, TNO was 7.14% lower in animals fed MxG mixture. The possible explanation consists of dietary higher concentration of fibre components in diets with MxG mixture addition. Fibre is considered an essential nutrient for pig feeding, involved in many physiological processes and producing gases (Jarrett and Ashworth, 2018).

Figure 6. N metabolism in (g/head/day) pigs fed differently. Abbreviation: TNO = total N output; NR = N retained; ND = N digested

Figure 7. The concentration of N₂O (g/head/day, Eq. CO₂) predicted in the pigs' manure fed differently

In this study, the concentration of N₂O expressed in Eq-CO₂ recorded a decline by 5% in animals fed MxG mixture. The data obtained in our bioassay are closed by that noticed by Dong et al. (2007), Li et al. (2011), Ngwabie et al. (2011) quote by Philippe and Nicks (2014).

CONCLUSION

MxG cakes increase dietary fibre levels. Compared to the classic SFM, the MxG mixture cause a slight performances decline. TNO from pigs given MxG mixture is reduced, possibly due to the higher fibre level and its fractions. The same trend was observed in N₂O, which decreases by 5% in fibre-rich diet-fed animals. Based on these results, we conclude that the inclusion of a 15% MxG mixture in pigs diets, although with reduced growth parameters, is a valuable nutritional solution that contributes to lowering N₂O and nitrogen excretion. However, in terms of performance, SFM remains an ingredient with valuable potential.

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