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MODALITIES TO REDUCE NITROGEN EMISSIONS IN SWINE FARMS: REVIEW

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Abstract

The gas emissions have increased in recent years, which has exacerbated the greenhouse effect. In the livestock sector the main sources of emissions are considered to be the production, processing and transport of animal feed, manure decomposition, processing and transport of animal products (post-slaughter transport, refrigeration and packaging of animal products). A significant emission reduction, including nitrogen, are within the reach of animal producers. Adopting current best practices and technologies for feeding, raising and maintaining animal health, manure management, and greater use of biogas and energy-saving technologies would help the livestock sector to grow. reduction of greenhouse gases. This review aims to highlight the possibilities that pig farmers have in order to adopt strategies to reduce nitrogen emissions from farms.

***Key words**: greenhouse gas, nitrous oxide emission, pig farm.*

INTRODUCTION

This study looks over a number of nutritional and management strategies that have highlighted the dietary impact on the nitrogen (N) excreta. Environmental pollution adversely affects the ecosystem. For many years, pig farming raises a lot of policy concerns in terms of economic, environmental, and social aspects of sustainable agriculture (Habeanu et al., 2020). As a consequence, the pig farm management are directed to decrease the pollutant level by nutritional techniques and manure management. As previously stated by Petersen (2018), two nutrients such as N and phosphorus (P) contaminate water, and pig manure contribute to this large-scale pollution (Figure 1).

In pigs manure the N compounds can generate nitrous oxide (N_2O) as result of nitrification and denitrification processes (Zhao, 2017). Thus, from N derive nitrate and nitrite, N_2O etc.

In 2019, it was anticipated globally that about 40 percent of total N_2O emissions come from human activities, respectively nitrous oxide is emitted from agricultural soil management, wastewater treatment, stationary combustion, industry or chemical production, manure management, transportation and other activities, (U.S. Environmental Protection Agency).

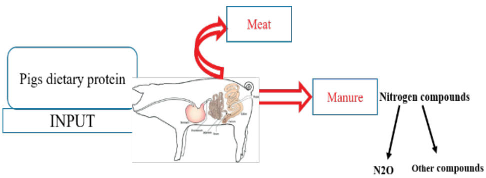

Figure 1. Nitrogen balance (adapted from Habeanu et al., 2021)

One of the most expensive nutritive substances is dietary proteins. Nitrogen is necessary for protein synthesis, as well as the synthesis of amino acids and nucleotides (Habeanu et al., 2020). Despite the fact that N is involved in a variety of metabolic processes, its detrimental environmental impact is a subject of concern. In the manure 2/3 of total nutrients is nitrogen (Millet et al., 2018). A great quantity of feed intake is excreted. The nitrogen coming from pigs' diet is converted into meat in a lower proportion than that excreted.

This paper intends to present some of the current information and concerns about climate change, as well as highlight the available nutritional options and determine which are the most cost-effective (N_2O mitigation vs. diets) for reducing greenhouse gas (GHG) emissions.

MATERIALS AND METHODS

In livestock production systems, there is a strong relationship between resource efficiency and GHG emissions. The potential for achieving emission reductions lies in providing all facilities for animal producers to use the practices already used by the most efficient operators in the field.

Taking into account these aspects, the bibliographic sources published in online scientific databases have been analyzed and presented, because many of the actions to improve efficiency and reduce greenhouse gas emissions also improve the production process, resulting in a quantitative and qualitative increase in food and higher incomes, with benefits for food security.

For livestock production systems, emissions of nitrogen oxide, methane gas and carbon dioxide are losses of nitrogen, energy and organic matter which reduce their efficiency and productivity. Possible interventions to reduce emissions are therefore largely based on technologies and practices that improve the efficiency of animal and livestock production.

RESULTS AND DISCUSSIONS

Climate change indicators

GHGs are gaseous compounds that, according to their molecular structure, trap heat or longwave radiation produced in the atmosphere and re-emit it back to the ground. This heat trapping phenomenon is known as the greenhouse effect that mean a natural phenomenon that allows life on Earth by maintaining the temperature of the planet at 15°C.

Climate change refers to a larger spectrum of changes that are taking place on our planet than just global warming. Global warming potential (GWP) is one aspect of climate change. In comparison to the mid-20th century baseline (of 1951-1980), the average surface temperature has risen roughly 1°C (nearly 2°F) since 1880 (Earth Observatory, 2020).

Agriculture is one of the key sectors impacted by climate change, according to recent climate assessments (National Climate Assesment, 2014; Melillo et al., 2014; Hartfield et al., 2020). Livestock products account for 17% of world calorie consumption and 33% of global protein intake, making them an important agricultural commodity for global food security (Rosegrant et al., 2009; Rojas-Downing, 2017). These assessments highlight many of the components vulnerable to climate change, requiring robust indicators to determine if the impact is increasing and our food and natural resource security is at risk.

Various models have been designed in order to assess indicators that providing information on climate change. Carbon dioxide (CO_2), total N outputs, N_2O, methane (CH_4 enteric or in manure) emissions are direct climate indicators for livestock sector. Carbon (C) sequestration mean carbon capture and storage which may become CO_2 gas.

GHGs emissions are calculated using the methodology presented in the Guide to the National Greenhouse Gas Inventory (IPCC 2006, respectively updated version in 2019) by the United Nations Environment Program, Intergovernmental Panel on Climate Change

According to the IPCC (2019), improved agricultural practices and forest-related mitigation activities can make a significant contribution to the removal of CO_2 from the atmosphere at relatively low cost. The idea is to stabilize the C in such a way as to avoid an atmospheric alert. These indicators are linked to the amount of feed consumed and the amount of excreta produced.

As part of attempts to mitigate climate change and enhance air quality, changes in farming methods (feed, types of livestock buildings, emission treatment systems, waste management practices, and so on) must account for these emissions (Hassouna et al., 2016; Garcia et al., 2016).

Contribution of pigs to greenhouse gas emission

The main type of GHGs from livestock sector account 25% for CH_4, 32% for CO_2, 31% for N_2O (Moran & Wall, 2011). Fluorinated gases from livestock have a lower fraction of GHG.These gases are expressed in CO_2 equivalent (CO_2 eq,) that mean their GWP.

Pigs consume feed and water in appreciable quantities, thereby their excreta is quite plentiful as well. Any protein surplus in feed that cannot be used for protein synthesis and is excreted in the urine, resulting in a high energy cost for animals and a financial loss for farmers. In addition, to being financially effective, determining the appropriate protein and energy intakes for pigs would have positive environmental repercussions by reducing pig farm nitrogenous excretions (Habeanu et al., 2019; Aquilani et al., 2019).

According to the Statistical Reports on the number of live animals on holdings transmitted by the National Sanitary Veterinary and Food Safety Authority (ANSVSA), the total number of pigs registered at the national level was 1,924,696 head on December 31, 2019 and 1,697,809 head on December 31, 2020.

The feeding strategies are designed to make the most efficient use of the fodder included in animal feed by: determining the nutritional value of pig feed with the greatest accuracy; using of the optimizing compound feed for each productive category, adapted to physiological conditions; developing recipes based on optimized nutrient structures; using recipes in such a way as to minimize waste and refusal of consumption; ensuring an adequate climate in the accommodation space.

Nitrogen cycle

Emissions from animal systems have been a significant concern for all livestock operations, according to Harper et al. (2004). The goal of this term influence on compromising surrounding and distant research was to determine the relationship between N emissions, ecosystems, and the environment.

Due to plant relationships, N reactivity and leachability, bacterial alteration (nitrification and denitrification) the number of N forms that can be found in the soil (urea, NH_4, NO, NO_2, N_2O, and various amines) and the large number of N forms that can be transported through the atmosphere (use and release; NH_3, NH_4 aerosols, N_2, NO, NO_2, N_2O, and various amines), obtaining a measured system analyses is difficult to found for all forms of N transport.

Pigs use feed protein nitrogen to restore deteriorated and lost digestive enzymes and other components. It has long been recognized that we should reduce the amount of pollution in our diet that is excreted as much as feasible. Many earlier investigations have shown that nitrogen output can be reduced, especially by dietary changes (Habeanu et al., 2019; Moreira et al, 2004; White et al., 2015).

Pigs retain only 32-46% of the N they consume (Dourmad et al., 2013; Millet et al., 2018). In contact with air on a manure storage platform, NH_3 is formed, which volatilizes in small volumes. One essential component is that which is stored in the soil and groundwater.

Diet is one approach to reduce N excretion (Monteiro et al., 2010; Dourmad et al., 2017; Wang and al., 2018).

Nitrogen balance

The nitrogen balance experiments provide information on net protein use, the relationship between protein intake and losses, and the relationship between protein and energy balance.

It is well recognized that N losses have an impact on the ecosystem, with the livestock sector accounting for 70% of NH_3 released into the environment (Habeanu et al., 2019; Kohn et al., 2005).

Protein-derived N is the most major source of N in animal metabolism. It shows us how much protein is being made and how much is being degraded. About 5 to 30% of N turned to food for human consumption, with the remainder being excreted by animals. Furthermore, too much N will sabotage efforts to achieve the Sustainable Development Goals.

Many previous studies had as main objective to evaluate N output level by using different feed formula (Dourmad et al., 2013; Mariscal-Landín et al., 2014; Untea et al., 2017; Habeanu et al., 2019, 2020 and 2021).

Thus, in 2013, Dourmad et al. presented an overview of the nutritional options for reducing pig N, P, Cu, and Zn excretion, as well as ammonia and GHG emissions, and discuss the methods that could or are now being used in practice. Their study has shown us that by improving animal nutrition efficiency the slurry excretion can be reduced. This can be an effective technique to limit the import of nutrients from outside the farm, particularly N, P, and trace elements, from a whole-farm perspective. Furthermore, due to variations in the chemical composition of the effluents, gaseous emissions from animal housing, as well as during the storage and spreading of manure, are influenced whenever livestock diet is modified.

One year later, Mariscal-Landín et al. conducted a trial in order to compare the energy metabolizability and nitrogen balance of new types of maize such as quality protein maize (QPM) to those of yellow and white maize, and to assess the apparent and standardized ileal digestibility (of protein and amino acids in QPM hybrids to those of yellow and white maize. They found out that the energy provided by QPM was utilized inefficiently compared to the energy provided by regular maize. The apparent ileal digestibility of lysine was larger in QPM than in regular maize, while the standard ileal digestibility of lysine was identical in both. The current study adds to our knowledge of QPM's nutritional content, amino acids digestibility, and N usage.

Untea et al. (2017) aimed to see how Cr as picolinate affects growth, plasma metabolites, N and fat digestibility, and pork quality (amino acids and fatty acids content of different tissues) in growing pigs. According to their findings, Cr supplements (200 ppb) increased nutrients balance and pork quality. The levels of important amino acids in tenderloin and ham samples from the Cr supplemented group were higher, showing that Cr might be used to make food functional. The mechanisms underlying these effects are unknown, and more research is needed to assess the consistency of these findings.

Habeanu et al., from 2019 to 2022, devised an experimental program with the goal of identifying and establishing the optimal nutritional solution to reduce nitrogen output and its interaction with N_2O. Thus, in 2019, Habeanu et al. assessed changes in performance, N metabolism, and composition of several tissues (*Longissimus dorsi* and semitendinosus muscles, heart, spleen, liver, and cecum) by combining two sources rich in n-3 fatty acids particularly alpha-linolenic fatty acids (extruded linseed and walnut meal, LE:WM, 50:50 wt/wt). Overall, their findings suggest that a diet high in n-3 fatty acids has a considerable effect on N metabolism. The addition of the LE:WM mixture decreased N excretion as well as net protein utilization. More than 40% of N was retained, resulting in increased nitrogen usage efficiency. The same team, one year later, estimated N_2O production in the manure and on N metabolism of growing-finishing pigs by using three different by-products from the oil industry: mustard cakes x grapeseed cakes (MxG) and sunflower meal (SFM). Their results showed that MxG cakes are high in dietary fiber than SFM. The MxG mix determine a slight decline of performance when compared to the standard SFM. However total N output levels in pigs fed MxG mixture are lower, presumably because to the greater fiber content and fractions. The same pattern was seen in N_2O, which decreased by 5% in pigs fed a fiber-rich diet. The inclusion of a 15% MxG mixture in pigs' diets, although reduced growth parameters, can be considered as a valuable nutritional solution that contributes to lowering N_2O and N excretion. However, in terms of performance, SFM remains an ingredient with valuable potential.

Another experiment was conducted by Habeanu et al., in 2021, in order to determine the effects of three different diets on N excretion in relation to other N metabolism indicators such as N retained (NR), N digested (ND), N digestibility, total N output (TNO), biological value of feed protein (BVFP), net protein utilization (NPU), coefficient of metabolizability (CAM), N clearance rate (CR), and blood urea N (BUN) and their correlation in males pigs. The authors look at the impact of different diets on performance and feeding efficiency, as well as enteric CH_4 and CO_2 emissions through manure. Based on the findings of their study, both peas and linseed have the ability to replace a part of soybean meal. Peas combined with soybean meal resulted in a decrease in growth performance due to a higher intake of some carbohydrates fractions. Even yet, a combination of peas, soybean meal, and linseed seemed to wipe out the discrepancies. It's worth noting that, regardless of the diet, the dietary protein level was guaranteed to be at the minimal threshold corresponding to nutritional requirements. Despite this, in pigs group fed peas diet, dry matter and organic matter intake were higher. Although peas incorporated in the diet increased significantly the total concentration of BUN, the N metabolism indicators were not significantly altered.

Nitrous oxide emissions

N_2O is a major contributor to global warming and one of the factors which affects the earth's atmosphere When N_2O emissions from the livestock sector climbed dramatically, an alarm signal was issued. N_2O is a greenhouse gas with a 298-fold higher GWP than CO_2 (CO_2 eq.). Pigs are responsible for about 26% of total N_2O emissions.

When there is a lack of o of oxygen and/or a nitrite accumulation during nitrification, N_2O is produced as a by-product. Denitrification is the process of converting NO_3 to N_2, with various intermediate molecules (NO_2, NO, and N_2O) created along the way. Denitrification in manure is primarily carried out by heterotrophic facultative aerobic bacteria. In the presence of oxygen and/or a low quantity of degradable carbohydrates, the formation of N_2O in manure is favored (Poth & Focht, 1985, Philippe & Nicks, 2015).

Therefore, it is critical to uncover the processes of dietary protein metabolism and the regulatory mechanisms that will aid in the reduction of N_2O emissions. Feeding low N rations and supplementing essential amino acids such as lysine and methionine to balance the amino acids profile of pig are two nutritional approaches for reducing N excretion from animals and, as a result, N_2O emissions. Other strategies include increasing fibber level into the diets.

Since 2006, Yasuyuki et al. added nitrite-oxidizing bacteria NOB to prevent NO_2 accumulation by boosting NO_2 oxidation till NO_3, i.e. complete nitrification, and its effect on N_2O emission during pig manure composting. Such as the authors indicated in this study, NO_2 accumulation resulting from an unbalanced composition of nitrifying communities appeared to have a significant role in N_2O emission. It was also demonstrated that improving nitrifying communities, by adding nitrite-oxidizing bacteria, could limit NO_2 accumulation and N_2O emission.

Philippe & Nicks (2015) reviewed the mechanisms responsible for the manure production of CO_2, CH_4, and N_2O by pigs. Literature emission factors are reviewed as well according to physiological stages of pig development, and an overall emission factor for the entire pig production process is provided. The impact of pig rearing conditions (including nutritional parameters) on emissions was investigated, as well as various mitigation approaches.

CONCLUSIONS

Of the many solutions proposed to reduce nitrogen emissions, strategies based on feed solutions are the most effective in the pig farming sector.

In most cases, the benefit is twofold, namely limiting the greenhouse effect and improving animal production.

In practice, a reduction in gas emissions in the future is possible as long as farmers are aware of the need to invest in order to ensure this food adaptation to the new recommendations of researchers in the field.

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