Part 1: Greenhouse gases produced in pig rearing

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- The environmental impact of livestock production is currently under intense scrutiny, often with a focus on ruminants but it is important to consider the contribution of monogastric animals too.
- In pigs, enteric emissions account for only 11% of GHG emissions, whilst manure produces 89%: 69% of which is methane 20% is nitrous oxide.
- Enteric emissions from monogastric animals are greatly reduced compared to ruminants due to significantly different digestive strategies.
- Feed production is often omitted from analyses but can account for 50-70% of GHGs produced during pig rearing.
- Diets based on homegrown proteins with low (14%) crude protein content and balanced with amino acids reduces environmental impact by decreasing the amount of ammonia and subsequently nitrous oxide in manure.

The environmental impacts of farming and livestock production have attracted increasing attention in recent times, with particular pressure being placed on reducing greenhouse gas emissions (GHGs). Generally, much of this attention is directed towards ruminant production as enteric fermentation carried out in the rumen is a major source of methane. The rumen contains a diverse population of microbes that enable the breakdown of plant material into usable nutrients for the animal, but in doing so, they produce large amounts of hydrogen (H_2) which is used to build methane (CH_4). Animal feed and emissions from manure management also make a significant contribution to GHGs stemming from agriculture, but what sort of contributions do pigs make? Currently, pork is the most widely consumed meat in the world and its production is expected to grow in tandem with the human population. China leads the way in terms of global pork production, followed by the European Union, although there are predictions that poultry may overtake pork in popularity in the coming years. As such, it is important to explore greenhouse gases produced by these systems, compare them to ruminant production systems and develop effective mitigation strategies. This article will focus on pigs and the pork industry and explore the contributions of enteric fermentation and feedstuffs to GHG emissions. A subsequent article will examine the contributions of manure and investigate associated GHG mitigation methods.

Sources of GHG emissions

There are three main sources of GHG emissions in the pig industry: enteric (from the digestion of food), manure and feed production. Enteric emissions are produced during food breakdown and comprise a relatively small amount (11%) of emissions produced during pig rearing. Whilst CH_4 from manure accounts for 69% and nitrous oxide (N_2O) for 20% of total GHG emissions. The largest contributor of GHGs in the pig industry is from manure, as such, most mitigation strategies focus on manure management – collection, transport, storage, treatment and utilisation. There is also a contribution from feed harvesting, processing and transport, but in many analyses, this is categorised elsewhere. Monogastric animals like pigs require easy to digest grains which often places pig feed in direct competition with human food production. Another caveat to bear in mind when examining GHG measurements is that carbon dioxide (CO_2) is often excluded as it is assumed that it's compensated for by CO_2 utilisation during photosynthesis in feed crops. However, these CO_2 emissions are not negligible and depending on the rearing system may well exceed that used by the feed crops.

Looking at the bigger picture, global emissions from pigs are similar to that from chickens, with pigs producing 819 million tonnes in CO_2 equivalents per year and chickens producing 790 t (Figure 1). However, this is eclipsed by cattle (beef and dairy) who produce 5,024 t, roughly 62% of the agricultural sector's emissions (Figure 1). In Europe specifically, 28-30% of emissions come from dairy, 28-29% from beef and 25-27% from the pork industry. This can be further broken down into the fattening period which contributes the majority of emissions (70%) and then into gestation, lactation and weaning, each of which contributes approximately 10%. These statistics suggest that emissions during the fattening period may have the most potential for mitigation.

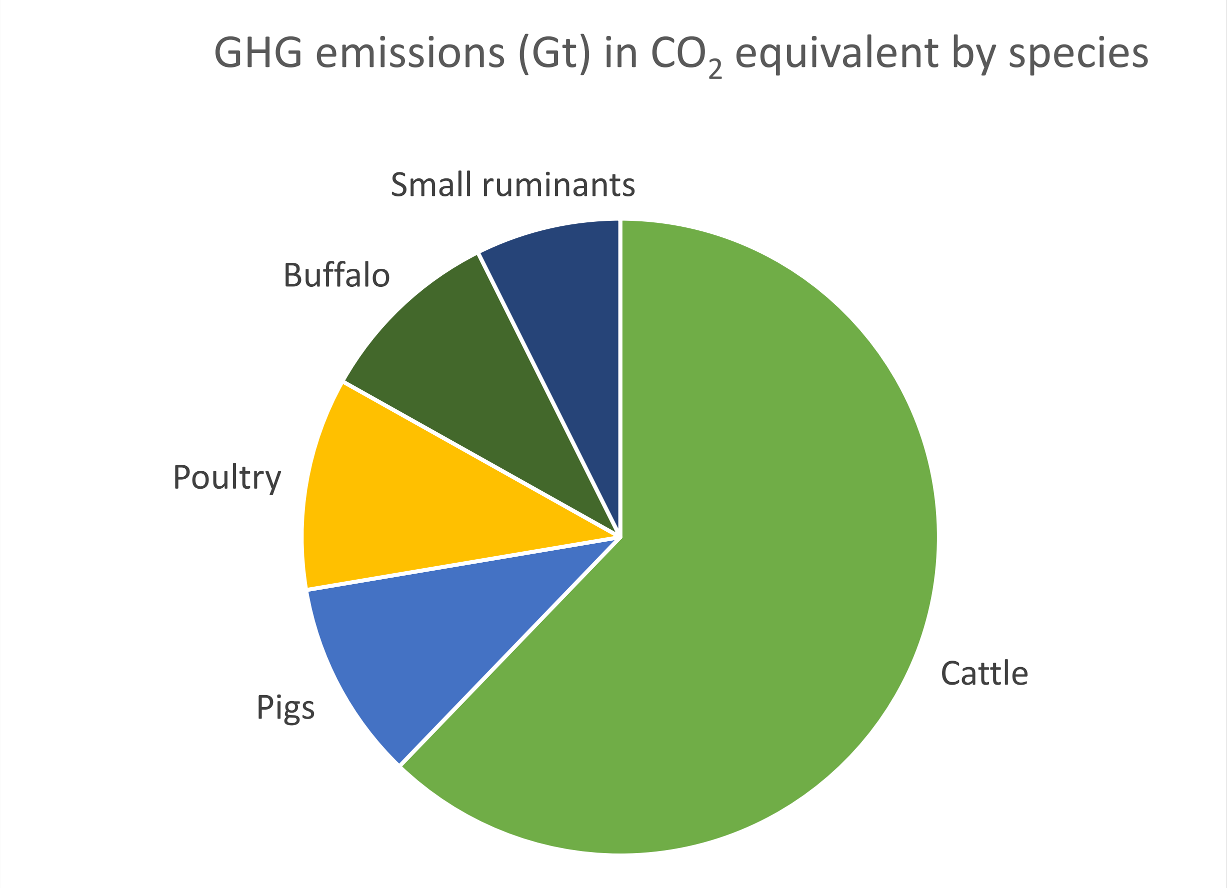

Figure 1: Graph showing greenhouse gas emissions in CO_2 equivalent gigatons per livestock species on a global scale (data taken from the FAO).

Enteric fermentation

Pigs are monogastric, meaning that they have only one stomach which is more comparable to the human digestive system (Figure 2). In the stomach, ingested food is mixed with enzymes and hydrochloric acid which begin the breakdown process, most protein is digested in the stomach by pepsinogen enzymes (Figure 2). The food then passes into the small intestine where carbohydrates and fats are digested and the majority of nutrient absorption occurs (Figure 2). The small intestine is well vascularised which allows nutrients to be carried away from the digestive tract and transported around the body. The large intestine is the site for fibre breakdown, however, pigs are poorly adapted to digest high fibre diets and instead need more in the way of easy to digest grains. Nutrient breakdown in the stomach gives rise to some H_2 and fibre digestion results in the production of several gases: CO_2, H_2 and

CH_4. On a global scale, pigs produce approximately 0.03 gigatonnes of enteric methane/year, very little compared to 1.64 Gt from ruminants – almost all of which is due to their different digestive strategies.

A certain amount of CO_2 is of course produced during respiration and exhaled as a waste product. Levels of CO_2 resulting from respiration depend upon the diet and the size of the animal, but a 70 kg pig will produce approximately 1.55 kg/day of CO_2. This equates to 186 kg if the pig is slaughtered at 6 months, a relatively small figure compared to emissions from manure and even enteric fermentation.

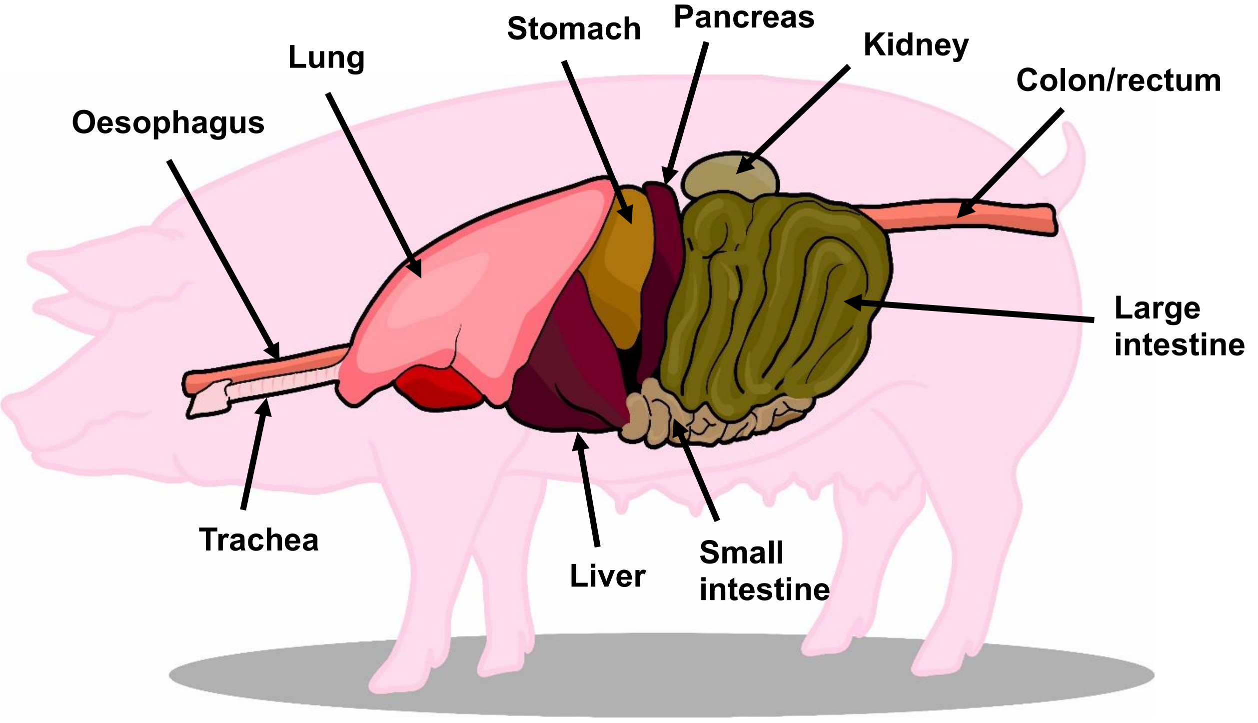

Figure 2: Diagrammatic representation of the pig's digestive anatomy.

Feed and diet

Feed composition has the potential to impact both manure-derived and enteric emissions as well as resulting in the direct release of GHGs during harvesting and transport of feed. These GHGs arise partly from the production and application of nitrogen fertilisers to crops and partly from soil processes – and if the diet contains imported soya this can result in even higher emissions. Whilst emissions from the production of feedstuffs are often not included in GHG analyses, when they are considered, they account for the majority of GHGs (50-70%), eclipsing the contributions of manure (20-35%). Ensuring optimum feed conversion efficiency is a key aim for all pig farmers to achieve optimum productivity.

Of particular interest is the reduction of crude protein (CP) in the ration formulation as this has the potential to significantly reduce N_2O emissions. In pig rearing, approximately 25–40% of all the nitrogen (N) contained in feed is converted into protein and used for growth, whilst the other 60–75% is excreted. The higher the levels of N in the manure, the greater the potential there is for ammonia (NH_3) emissions, which are then converted into N_2O. Studies have shown that reducing the CP level of the diet to 13-14% and supplementing with appropriate amino acids does not compromise performance but improves protein utilisation and reduces nitrogen levels in the faeces. The most commonly supplemented amino acids in pig feed are lysine, threonine and methionine as these are not only essential (meaning that the pig cannot synthesise them itself, so they must be provided in the diet) but in the shortest supply in an average dietary formulation. Lysine and methionine in particular play a key role in the immune system, so adequate supplementation of these amino acids in young pigs, especially during weaning, may support the immune system and reduce the need for antibiotics. Using modelling, one study looked at the environmental effects of a soy-based diet (reflecting current practice), an organic feed (in which synthetic amino acids and chemically extracted protein feeds were excluded) and a low protein diet supplemented with synthetic amino acids (excluding soya). The study concluded that the latter was preferable in terms of environmental impact for several key reasons: the exclusion of soya and use of domestic protein sources, low CP levels and balanced amino acids and the use of peas in the crop rotation which reduced the need for fertilisers. Current research suggests that the use of homegrown or domestic protein in a “low protein” ration (around 14%), supplemented with amino acids is likely the best way forward in terms of impact on the environment, pig nutrition and production efficiency.

It is also important to consider the feed/food debate as most pig production systems rely largely on concentrated feed produced outside of the farm. Most livestock require some sort of concentrate feed in their diet, although monogastric animals such as pigs require a more processed, grain-based diet than ruminants. This often brings their feed production into direct competition with land that might be used to grow human food and is termed “the feed/food debate”. If the land were used to produce plant-based human food, would this be more valuable than using it to feed the animal, which would generate a protein-rich human food source? As consumer perceptions and environmental concerns develop, answers to this question are continually changing and are hotly debated around the world. It is important to remember, that in addition to a nutrient-dense and valuable food product, animals also provide manure, additional commodities such as wool and leather and in some parts of the world, draught power. Whilst this debate applies to all livestock, it is perhaps more pertinent for monogastric animals, which unlike ruminants are unable to thrive on marginal land and require a grain-based diet. For ruminants, 1 kg of meat requires 2.8 kg of human-edible feed, compared to 3.2 kg for monogastric animals, but research suggests that improvements in feed efficiency and conversion could help prevent any further expansion. On a global scale, around 86% of livestock feed consists of residues and by-products that are not suitable for human consumption. If not consumed by livestock, these by-products could quickly become an environmental issue - such feeding strategies may be of interest to increase the sustainability of farming and to help mitigate (if only marginally) the burden that an increasing human population places on the planet.

Summary

The environmental impacts of livestock farming are under increasing scrutiny by the public and policymakers alike, with the view to moving towards more sustainable and environmentally friendly systems. Ruminants are frequently the focus of these debates due to substantial methane emissions arising from enteric fermentation, as such, the contribution of monogastric animals may sometimes be overlooked. This article has explored sources of emissions from pig production systems – enteric emissions, feed derived emissions and GHGs produced during manure management. This first part has focussed on enteric emissions which account for around 11% of total GHGs emitted in pig production and has also considered GHGs stemming from the feed. Enteric fermentation in pigs is an entirely different affair to that in ruminants and is in fact, more similar to the human digestive system. Enterically, pigs produce comparatively fewer GHGs than ruminants (particularly methane) but do still contribute. The contribution of feed to emissions is often erroneously excluded from analyses yet can contribute 50-70% of overall GHGs in pig production. Of particular interest is the effect of a low protein diet based on domestic or homegrown protein sources with targeted supplementation of essential amino acids. Such dietary strategies have proved beneficial, improving protein use within the animal without impacting production whilst also reducing ammonia content in the faeces, which leads to a reduction in N_2O emissions and overall environmental impact. Of great debate are land use and competition with human food crops, as pigs require a grain-based diet, unlike ruminants. This ongoing discussion examines the value of plants in the human diet in comparison to animal-derived protein, a topic that is hotly contested all over the globe.