

Optimising on Farm Feeding Strategies as a Means to Reduce Environmental Impact of Pig Pollution

Introduction

This research project will look at how the methods of feeding pigs could be optimised to increase efficiency and reduce environmental impact and sustainability. Current methods are inefficient as they do not optimise the different phases of feeding, increasing environmental impact. The project will be a chance to explore the scientific literature to enhance our understanding of alternative pig-feeding strategies, with the aim of recommending more environmentally friendly feeding strategies, while considering the capacity of farms to adapt to these suggested changes. The vision is to use scientific research to find the theoretically best option, while considering the logistics of implementing these changes in real life.

This literature review focuses on the method of phase-feeding, which is designed to meet the nutritional needs of the pigs more closely at each stage of their development. By altering the nutritional contents of the feed at different stages during the grower-finisher period, it is predicted that the nutritional needs of the pigs will be more closely met which will allow sufficient growth, while also minimising waste. As well as optimising the growth performance of the pigs, it is expected that the improved nutrient conversion rate should minimise both the environmental impact and the cost of production. This is because, if the pigs are only fed as much nutrients as they require, less nutrients such as nitrogen and phosphorous will be excreted into the environment, and less nutrients need to be supplied in the feed. Other alternative methods such as daily multiphase feeding, blend feeding and single diet, will also be explored in comparison with phase feeding.

Methods

I started my search by entering "phase feeding" AND "finishing pigs" into Web of Science, and looking through all of the papers that came up. There were 70 results at this stage, so my next step was to look briefly through each of these papers to see which were relevant to my research. My aim was only to select papers looking specifically at the effect of phase feeding compared to a non-phase-feeding control. I found that many of the papers in my search, despite using phase-feeding as a feeding method in their studies, they were not actually investigating the effect of phase feeding, and instead were looking at the effect of other factors on the performance of the pigs, such as crude protein levels. I also was looking out for what observations were made, as I was only interested in the performance of the pigs, and any environmental impacts of the feeding method. Hence some articles that were investigating other impacts of phase feeding, such as gut microbes or feeding behaviour. I saved the relevant articles to end note, as reference for later. I did the same search on Google Scholar to check that I hadn't missed any key papers, but I found there was a lot of crossover between the two search engines. I ended up with eight research papers, which I had saved in end note. These final eight papers were the ones used to produce the literature review and their findings are summarised in table 1.

Findings

Table 1 – summary of the literature

Title	Author, date	Performance outcome	Environmental impact	Number of phases studied	Additional info (eg. Cost, practicality)	Weaknesses/considerations
Effects of phase feeding on growth performance, nutrient digestibility, nutrient excretion and carcass characteristics of finishing barrow and gilt	Kim et. Al. 2000	0 (no sig diff)	+	1, 2	Decrease cost/ increase profit +	
An evaluation of the alternative feeding strategies, blend feeding, three-phase feeding or a single diet, in pigs from 30 to 100 kg liveweight	Moore et. Al. 2016	0	-- (blend feeding might be better)	3	Single diet might reduce cost compared to phase feeding. Single and blend diets might be more practical --	
COMPARISON OF CHOICE AND PHASE FEEDING FOR GROWING-FINISHING PIGS	D.S. Nam and F.X. Aherne 1994	0	/	3	3 phases may save money compared to 1 +	Older paper. Was largely in the context of comparing to choice feeding.
The impact of daily multiphase feeding on animal performance, body composition, nitrogen and phosphorus excretions, and feed costs in growing–finishing pigs	Pomar et al 2014	0	-- (DPF better)	3	Cost lower with daily multiphase feeding --	I think this is comparing just 3PF and DPF. Not really relevant
Effects of Phase Feeding and Sugar Beet Pulp on Growth Performance, Nutrient Digestibility, Blood Urea Nitrogen, Nutrient Excretion and Carcass Characteristics in Finishing Pigs	Ko et. Al. 2004	0	+	2, 3		Doesn't compare to 1 phase
The effect of phase-feeding on the growth performance, carcass characteristics and nitrogen balance of growing and finishing pigs	Garry et al 2007	0	-- Single diet with optimum lysine is better	1, 2, 4		
Blend-feeding or feeding a single diet to pigs has no impact on growth performance or carcass quality	Moore et. Al. 2013	0	--		Blend and single feeding appeared less costly than 3-phase --	

Quantifying the consequences of nutritional strategies aimed at decreasing phosphorus excretion from pig populations: a modeling approach	Symeou et al 2016	/	+ Reduced P secretion	1, 2, 3		
---	-------------------	---	--------------------------	---------	--	--

Key

+ phase feeding was better

-- Phase feeding was worse

0 phase feeding made no difference

/ no information found

Discussion

Several studies have examined the effectiveness of phase feeding and its benefits compared to other alternatives. Kim et al. investigated the impact of 2-phase feeding on performance, nutrient digestibility, excretion, and carcass characteristics in comparison to single-diet feeding. The study predicted that the ideal amount of crude protein in the diet should be 16% in the early finishing period and 14% in the late finishing period. It was found that in the late finishing period, nitrogen excretion with 2-phase feeding was reduced by 8.5% compared to single feeding, leading to a cost reduction of 9.1% in gilts and 3.19% in barrows. (Kim, Jin et al. 2000) Although there was no significant difference in performance, this study suggests that a 2-phase feeding system is a more cost-effective and environmentally friendly option than a single diet.

In a study by Ko et al., which also examined the effect of sugar beet pulp, they compared 2 and 3-phase feeding systems. The study found that neither the number of phases provided any advantage to the performance of the pigs. However, when comparing the 2-phase and 3-phase systems, pigs on the 3-phase diet had significantly lower blood urea nitrogen (BUN) levels, as well as lower levels of urinary nitrogen secretion compared to those on the two-phase diet. (Ko, Lee et al. 2004) While there was no difference in nutrient digestibility between these two feeding systems, this might suggest that nitrogen usage within the pigs is better with the 3-phase feeding method. Hence, according to this paper, if phase feeding is to be used to reduce nitrogen excretion, then 3 phases should be favored over 2.

Symeou et al. conducted a study examining the effect of sorting and phase feeding on phosphorus (P) excretion and found that phase feeding caused a decrease in P excretion as the number of phases increased. The pigs' diets either consisted of one, two, or three phases, and the results showed a large reduction in P secretion from 1 to 2 phases (7.5%), followed by a smaller reduction from 2 to 3 phases (2%).(Symeou, Leinonen et al. 2016) These findings support the notion that phase feeding can effectively reduce the environmental impact, and having 3 phases seems to be the optimal number for minimizing P excretion.

One study by D.S. Nam was mainly looking to see if choice feeding provided any advantage over phase feeding, in the context of both one-phase and 3-phase feeding regimes (Nam and Aherne 1995). The pigs were split into four groups, each with one of the following treatments: conventional

3-phase feeding (P3); 1-phase feeding (P1); 3-phase choice feeding (C3); 1-phase choice feeding (C1). Over the course of the study, the overall feed intake was lower in the phase-fed pigs and their feed efficiency was also higher, with no significant difference in weight gain. They found that the choice-fed pigs were not able to select their protein intake and hence overconsumed. While the study was mainly focused on comparing choice feeding to phase feeding, they did also look at the differences between the P1 and P3 pigs. They found **no significant difference between the P1 and P3 in terms of growth performance**, due to compensatory growth observed in the P1 pigs. However, they did find that P3 pigs consumed less feed than P1 pigs, and in doing so, could save 3.5 kg of dietary protein over the course of the growing-finishing period, which could lead to a **decrease in production cost** of \$2 per pig. Therefore, I think this paper suggests that the 3-phase feeding system is ideal, as it can save on cost, and also, although the paper didn't look into the environmental effects, it may be that the decrease in protein intake of P3 pigs may lead to a reduction in nutrient excretion, which would be better for the environment.

This is contrasted by a study by Moore in 2013 which looked at single diet and blend feeding in comparison to phase feeding, and seems to conclude that they have no difference in growth performance or carcass quality, and found the phase feeding method to be the most costly of all three techniques. (Moore, Mullan et al. 2013) However, as discussed in the study by D.S. NAM, the cost of different feeding methods may vary between studies for different variables as a result of the investigation process, and should not be taken as a conclusive indication of the cost of each method.

A 2016 study by Moore evaluated the three different feeding methods- blend feeding, 3-phase feeding and single diet, and suggested that phase feeding was a less favourable method than the other two in terms of both environmental impact and practicality. The paper concluded that phase feeding has no benefit to growth performance over the other two methods as none of the feeding methods showed any difference in daily gain, feed intake or feed conversion ratio (FCR). (Moore, Mullan et al. 2016) The paper discusses the inconsistency in the literature around the subject of which feeding method is the least costly, and suggests that this may be due to factors such as lysine levels in the feed, as well as the price of raw materials at each time, both of which may vary between studies. Therefore, I think more research must be done in order to come to a solid conclusion on which feeding method is actually the least costly. The paper mentions the **environmental benefit of blend feeding**, saying it could reduce the N excretion by 12 % compared to the conventional phase feeding method, as it enables the nitrogen requirements of the pigs to be more accurately met. Although blend feeding requires significant infrastructure, this study suggests that it might actually be a more practical method than phase feeding. Also, the **single diet was said to be a very practical alternative** in terms of manufacture, storage and delivery, and seems to be the favoured feeding method in this paper.

A study by Garry supports this idea that phase feeding might not be the best solution for reducing environmental impact. They were looking into how performance and nitrogen excretion of the pigs might be effected by the lysine concentration in diets and by giving this as a single diet or 2 or 4 phases. To investigate this, the pigs were given either a single diet high in lysine, or the same mean lysine concentration was split over 2 or 4 diet phases with different concentrations. The diets are as follows: one with total lysine from day 0 to slaughter (SHD), one with 2 phases of lysine level (DFD), one with a lower level of nitrogen from day 0 to slaughter (RFD), and one with 4 different phases of lysine level (PFD). (Garry, Pierce et al. 2007) They concluded that feeding a single high lysine diet led to an increase in nitrogen secretion and worse nitrogen utilisation, but that a single lysine diet based on the requirements of the pigs (as with the RFD diet) being fed was likely to be the best option for N excretion and utilisation levels, compared to the phase feeding diets. The single diet is favoured here

on the basis that optimising lysine levels is the most effective way of minimising nitrogen excretion, as well as only requiring one storage bin for the feed. It does mention that phase feeding might be good in an all-in all-out system, since this method requires the pigs to be of similar live weight.

Equally, a study by Pomar suggested that daily multiphase feeding might be a better alternative to phase feeding. When comparing the 3 phase feeding system with daily multiphase feeding, they found that by the end of the growing period, both sets of pigs had a similar body protein mass, but the DFP pigs had 8% more body lipids. They also found that daily phase feeding led to a 12% reduction in nitrogen excretion, (although there was no significant difference in phosphorous excretion), as well as a 1% decrease in feed cost (Pomar, Pomar et al. 2014). Hence this study supports daily phase feeding as a cheaper and more environmentally friendly alternative to traditional three-phase feeding. However, it is worth baring in mind that this type of diet might be less practical in reality due to the challenges of regularly altering the feed.

Conclusion

After having looked at the literature that compares phase feeding to alternative pig feeding methods, it appears that we currently do not know enough to declare one feeding method as definitively better than the others. The environmental impact of pig feeding is a complex topic that depends on various factors, from feed ingredients to the genetics of the individual pigs. There is evidence to support the notion that 3-phase feeding allows for the more precise matching of the nutrient requirements of the pigs at different growth stages, which can potentially reduce the over supplementation and excretion of nutrients like nitrogen and phosphorous.

Other aspects such as cost and practicalities should also be taken into account before making decisions about which feeding strategies to implicate. Feeding pigs a single diet would be more practical, especially on smaller farms, as only feed needs to be made, and only one storage bin is required. However, if nutrient utilisation and environmental impact are compromised then the impracticalities of phase feeding might outweigh this in the long term. While there is evidence to suggest that phase feeding could be beneficial to the environment, much more research needs to be done to confirm that it does actually reduce nutrient excretion compared to other feeding methods.

Citations

Garry, B. P., et al. (2007). "The effect of phase-feeding on the growth performance, carcass characteristics and nitrogen balance of growing and finishing pigs." Irish Journal of Agricultural and Food Research **46**(1): 93-104.

Kim, Y. G., et al. (2000). "Effects of phase feeding on growth performance, nutrient digestibility, nutrient excretion and carcass characteristics of finishing barrow and gilt." Asian-Australasian Journal of Animal Sciences **13**(6): 802-810.

Ko, T. C., et al. (2004). "Effects of phase feeding and sugar beet pulp on growth performance, nutrient digestibility, blood urea nitrogen, nutrient excretion and carcass characteristics in finishing pigs." Asian-Australasian Journal of Animal Sciences **17**(8): 1150-1157.

Moore, K. L., et al. (2013). "Blend-feeding or feeding a single diet to pigs has no impact on growth performance or carcass quality." Animal Production Science **53**(1): 52-56.

Moore, K. L., et al. (2016). "An evaluation of the alternative feeding strategies, blend feeding, three-phase feeding or a single diet, in pigs from 30 to 100 kg liveweight." Animal Feed Science and Technology **216**: 273-280.

Nam, D. S. and F. X. Aherne (1995). "A COMPARISON OF CHOICE AND PHASE FEEDING FOR GROWING-FINISHING PIGS." Canadian Journal of Animal Science **75**(1): 93-98.

Pomar, C., et al. (2014). "The impact of daily multiphase feeding on animal performance, body composition, nitrogen and phosphorus excretions, and feed costs in growing-finishing pigs." Animal **8**(5): 704-713.

Symeou, V., et al. (2016). "Quantifying the consequences of nutritional strategies aimed at decreasing phosphorus excretion from pig populations: a modeling approach." Animal **10**(4): 578-591.