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Major Strategies of Reducing Phosphorus (P) Levels in Animal Manure

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Abstract. Animal production, including swine production, had been projected to be on the increase. However, the high levels of P released via pig manure into the environment are a major concern as it is associated with environmental deterioration and degradation leading to eutrophication. Nevertheless, the potential exists for the reduction of P levels in the pig manure as to reduce the damage done to the environment. This had led to the search for strategies to better manage the nutrition of P for swine as to reduce P levels release into the environment. The strategies are also required not to compromise animal performance and welfare. Additionally, they should not significantly alter the normal processes of nutrient metabolism and absorption. Furthermore, they should not significantly increase the total cost of production and be suitable for adoption via the available technology in the environment. More importantly, the strategies should trigger mineral synergies and homeostasis, including other nutrients thereby significantly reduce the formations of the insoluble-phytate-mineral-complexes that impede mineral solubility for absorption. This paper highlights the strategies that have been developed in dealing with P levels in the pig manure. These strategies are categorized into: the use of microbial phytase to release phytate-P, use of low-phytate crop varieties or cultivars, commercialization of the phytase enviropig™ and improving diets based on the use of true digestible calcium to true digestible P ratio.

Key words: Strategies, Phytate-P, P in Manure, Eutrophication and the Pig

Introduction

Environmental pollution emanating from intensive swine production activities is highly undesirable (Mallin, 2000). Although nutrient release into the environment is inevitable the potential exists for significant reductions in the degree of environmental pollution caused by P released via manure into the environment (Tamminga, 2003). Accordingly, therefore, one of the major goals of the agricultural industry in recent times had been the search for suitable strategies of reducing P level in the pig manure as to alleviate the negative impacts it has on our ecosystem.

In order for any strategy to manage P pollution to be viable and effective for adoption for use by the swine industry it needs to be efficient in reducing P and other nutrients, such as calcium and nitrogen levels in the pig manure (Aarnink & Verstegen, 2007). Also, the strategy needs to be simple and inexpensive and at the same time suitable for use by the existing technology in the environment. This is fundamental because the strategy should not unnecessarily increase the cost of production. Additionally, it should not also significantly alter or affect the normal process of nutrient digestibility as not to compromise animal performance and welfare (Donham, 2000).

Until a cost-effective applicable strategy of reducing P in the pig manure in order to minimize its negative impacts on the environment is available the food and agricultural industries will continue to experience the problems associated with P pollution (Mallin, 2000). This poses a serious challenge and threat to the swine industry and swine nutritionists in particular. To this point therefore, some strategies to better manage P levels in the pig manure have been developed. The strategies are categorized into: the use of microbial phytase, use of low-phytate crop varieties or cultivars, commercialization of the phytase

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enviropig^{TM} and improving diets based on the use of true digestible calcium to true digestible P ratio.

Use of Microbial Phytase to Release Phytate-P

Simple-stomached or non-ruminant animals such as the pig and poultry are deficient in phytase, the enzyme that degrades phytate-P. Most of the plant sources of P in swine diets are phytate-bonded P which is poorly digested by pigs and poultry. This has been one of the major causes of high levels of P in the animal manure. Therefore, the use of exogenous phytase in swine diets to make phytate-P bioavailable has been employed as to reduce P levels in manure (Simons *et al.*, 1990). In the study of Simons *et al.* (1990) it was found that addition of the microbial phytase increased apparent P digestibility by 24% that resulted in the reduction of P in manure by 35% with improved growth rate and feed efficiency. In the same study, the authors also noted that addition of phytase to low-P diets for broilers resulted in improved efficacy of P availability with improved significant reductions of P in poultry droppings. They also observed that as P availability improved that of calcium also significantly improved suggesting that P and calcium (Ca) metabolism are interwoven. The findings of Simons *et al.* (1990) were corroborated by the study of Emiola *et al.* (2009) that demonstrated that addition of phytase to pig diets improved animal performance, significantly improved P and calcium absorption which subsequently reduced P and calcium levels in the manure.

The Use of Low-Phytate Crop Cultivars

Concerns about how to combat P pollution of the environment had led to strategizing for solutions to the problem. To this end, another biological approach that has evolved and adopted for increasing P digestibility as to minimize P excretion is by the use of feed ingredients with low phytate-P contents. Here, the development of low-phyate crop cultivars has also evolved, such as the genetically modified low-phytate corn variety (Spencer *et al.*, 2000). This corn variety contains at least five times as much available P compared to normal corn with phytate-P. This corn significantly resulted in reduced amount of P excreted by pigs and poultry (Spencer *et al.*, 2000). These findings of Spencer *et al.* (2000) were substantiated to by the studies of Veum *et al.* (2002) that showed the use of low-phytic acid barley variety significantly improved P and calcium absorption and utilization resulting in minimal release of P and calcium in manures of pigs and poultry. Animal performances were significantly improved suggesting again that P and calcium are similarly metabolism, especially as it relates to the structural soundness of the animal (Han & Thacker, 2006).

Commercialization of the Phytase Enviropig^{TM}

The current challenge for improving agriculture and increasing production without polluting the ecosystem has led to the development of the phytase transgenic pig (Golovan *et al.*, 2001). Transgenic pigs are capable to produce and release the digestive enzyme phytase endogenously to digest P and thus improve its digestibility. In this way, it provides a relief from the current dependence on the inorganic sources of P in meeting P requirements for the animal. Golovan *et al.* (2001) reported that transgenic pigs produced salivary phytase that had enabled the pig to require no inorganic phosphate supplementation for its normal growth and development. More importantly, transgenic pigs digest more than 75% of phytate-P resulting in significant reduction of P manure by 75% compared to non-transgenic pigs without any negative effect on their health and performance. They concluded that the minimal levels of P in the manure would have come from endogenous sources that probably escaped digestion and absorption. Thus the use of transgenic pigs is a major breakthrough in the effective nutritional management of dietary P.

Improving Diets Based on the Use of Optimal True Digestible Calcium to P Ratio

From the fore-discussed, it is very clear that the problem of P in animal manure is mostly nutrition related. Since nutrition is at the core of it, nutrition would also be the fundamental principle to best deal with P nutrition for our farm animals. Therefore, the option of combining the benefits of the above highlighted strategies appears very plausible in using nutritional principles to address the problem. Combined supplementation with phytase and the use of low-phytate feed ingredients with improved or balanced diets based on the use of optimal true digestible Ca and P ratio would work synergistically together to improve the digestibilities of P, Ca, other macro-nutrients, such as proteins and energy as well as micro-nutrients, such as trace-minerals. Therefore, by fortifying diets with just its requirements, such as minimal crude protein intake and fortifying diets with adequate amino acids with optimal P and Ca ratio based on the physiological class of the animal, also known as phase feeding would no doubt reduce nutrient losses in the manure, particularly P. This nutritional principle results in presenting to the hindgut minimal amounts of dietary feed products or indigested feed materials that are eventually released in the animal manure (Dourmad & Jondreville, 2007; Aarnink & Verstegen, 2007). The use of low-Ca to low-P diet contents have very high potential for improving Ca and P solubility in the stomach thereby enabling their effective digestion and absorption in the small intestine, especially when phytase is involved (Kornegay, 2001; Brady *et al.,* 2002). It has been reported that by combining the currently available diet modification strategies in conjunction with other available technologies, such as the commercialization of the enviropig^{TM} it should be possible to drastically decrease the total P concentration in manure [Council for Agricultural Science and Technology (CAST), 2001] thereby making animal production eco-friendlier (Peterson, 2010).

Conclusions

The adoption and use of the highlighted strategies would effectively aid in addressing the nutrition of P in the livestock industry, particularly those of the non-ruminants thereby changing the negative narrative of the animal industry on the environment to a more environmentally-friendly gesture as prediction indices indicate that animal production is still on the increase and the trend is expected to continue in the future.

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