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Diet Formulation and Odour Control in Intensive Swine Production

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Abstract. Global population is increasing at a geometrical rate. This thus demands that food production particularly animal protein should also be increased to match the ever increasing world population. This trend has led to urban encroachment on farmlands leading to some concerns, especially pungent odour generations emanating from intensive animal productions, such as that of swine. However, it is required that animal production activities should be eco-friendly as it relates to neighbours living within the vicinities of production in order to continually sustain and support optimal animal productivity and profitability without environmental menace. Therefore, the production of pungent odours from swine production activities poses special scientific challenge to all stakeholders, including the feed formulators, animal nutritionists, producers and environmentalists as such odour nuisance emanating from intensive swine production has been implicated or involved in human-health related problems. Some of such health problems include: accelerated decline in pulmonary functions, bronchitis, sinusitis, inflamed nasal mucosa, throat irritation, headaches and other related problems. These usually lead to change of mood culminating in "stress". With these negative effects, it may be speculated that in the near future the interface of sustainable swine production and the society would experience more constraints ranging from animal well-being and health, quality of animal product and production system, utilization of nutrients and the environment/ecosystem. To this point therefore, feed formulation is to the rescue as the above stated problems principally originate from the ingested feed, animal bodies, faeces, urine and manure. This paper thus focuses on how feed formulation can be used to better manage odour generations emanating from intensive animal production activities, such as that of swine production, thereby making animal production eco-friendlier.

Key words: Feed Formulation, Intensive production, Odours, Ecosystem and Swine

Introduction

It is well-documented that odour generation in intensive swine production facilities originate or is mainly caused by the ingested feed of the animal (Le et al., 1995) and are associated with negative moods, leading to stress (Schenker, Christiani & Cormier, 1998; Donham, 2000). Additionally, it is caused by the amount of undigested or non-utilized dietary nutrients and endogenous products secreted in the gastro-intestinal tract (GIT) under anaerobic conditions entering the hindgut that are eventually released into the environment via the pig manure and urine. Here, the four main groups of odour based on their causative agents have been identified as: sulphurous compounds, phenols and indoles, volatile fatty acids (VFA), ammonia and volatile amines (Le et al., 1995). Therefore, the availability and level of these odour compounds, including their precursors in the GIT of the animal and in the manure are responsible for the malodour generation from swine production facilities. Consequently, for any nutritional strategy, such as feed formulation to be effective in minimizing odour production from swine production facilities it should be targeted at reducing these compounds and their precursors in the GIT, manure and urine.

Meanwhile, swine production activities are on the increase due to the rising demand from consumers for animal protein (Tamminga, 2003) with malodour production as a result of intensive production. As stated previously, malodour generations in swine production is dependent on the amount of undigested dietary feed ingredients and secreted GIT materials entering the hindgut of the animal that are eventually released by the pig in the manure leading

to malodour productions (Le et al., 1995). Furthermore, odour generations are also influenced by factors, such as the strain of the pig, health status, environmental factors and physiological status of the animal (Jensen, 2002). To this end, although nutrient losses in the manure are inevitable, nutritional strategies still remain the fundamental key in the better management of malodour generation in intensive swine production.

Since nutrition is to the rescue of the odour menace, some nutritional strategies tailored solely to minimizing odour production in intensive swine production need to be developed as projections support the fact that the rising in demand for animal protein, including pork and other swine products will continue (Tamminga, 2003). This paper therefore, explores some of the nutritional strategies in relation to diet formulation for swine with the main objectives of minimizing odour production from intensive swine production facilities are elucidated.

Nutritional Strategies to Minimize Odour Production in Swine Production

Matching Nutrient Supply with Animal Requirements

From nutritional standpoint, dietary composition and odour productions/emissions from swine production is as a result of a cause-and-effect relationship. To this point therefore, one of the major nutritional strategies that readily comes to mind when dealing with feed formulation to mitigate odour production is matching nutrient supplies with the requirements of the animal as it has been shown that the major compounds highly correlated with odours are products of the degradation of excess dietary protein intake. From the studies of Lenis and Jongbloed (1999) it was estimated that about 65 to 70% of dietary nitrogen intake by growing pigs is excreted. Therefore, it is nutritionally understandable that significant reduction in nitrogen excretion is achievable during diet formulation by ensuring that dietary supply is carefully and correctly matched with animal requirements (Sutton et al., 1999). Consequently, the use of more precise data on composition and nutrient availability for feed ingredients and better-defined requirements would enable nutritionists and feed formulators to formulate ‘ideal diets’ according to the needs of the animal for maintenance and production purposes for the various stages of the physiological states of the animal.

To be precise in matching nutrient supply with requirements it is important that feed formulator has good knowledge of the availability of the nutrients in the feed ingredients that are used in formulating diets for pigs and also more importantly know the specific nutrient requirements for the current pig genotypes being used in today’s commercial pork production. Here, for diet formulation to be used as one of the nutritional strategies in managing or controlling odour production from intensive swine facilities it is critical that swine producers will need to have a good understanding of the nutrient requirements of their pigs under their unique conditions so as to better manage their nutrients efficiently. This is true because many factors affecting production interact and influence the nutrient requirements of the pig. These include genotype, capacity for lean tissue growth, environmental conditions as well as the physiological state of the pig (NRC, 2012; House & Fletcher, 2003). This again emphasizes that it is important for the producer to know the requirements for his pigs as they differ within herds. Again, pharmacological levels of vitamins for strains of pigs should be determined and used accordingly in their diets (Stahly, 2007; House & Fletcher, 2003). This would ultimately enhance nutrient digestibility and utilization for improved animal performance (Stahly, 2007; House & Fletcher, 2003) leading to reduction of nutrients in manure and consequently aid in minimizing odour generation from pig production facilities, since NRC (1998) requirements tend to be obsolete for modern strains of pigs, particularly the vitamins (Stahly, 2007; House & Fletcher, 2003).

Formulation of Low-Protein Amino Acid Supplemented Diets

Another nutritional strategy closely related to matching nutrient supply with requirements to minimizing odour production is the formulation of low-protein amino acid supplemented diets for pigs to provide the animal with the 'ideal protein' for their maintenance and production purposes. Usually standard commercial pig diets are formulated to meet the minimum requirements for the key essential amino acids (AAs) to achieving the desired performance levels. However, this normally results in the diets being too rich in protein and consequently often contains excessive amounts of other AAs that end up in the manure (Jean dit Bailleul et al., 2001). The excreted nitrogen in the manure contributes significantly to odour generation as they are major precursors for odour formation (Le et al., 1995). The excreted nitrogen in the manure is further degraded to odour-generating products thereby elevating odour nuisance from production facilities. Here, feed formulation can be used to significantly reduce the amount of nitrogen excreted in the manure and consequently minimize odour production. In this regard, the feed formulation approach that has been developed to achieving reduction of nitrogen excretion is to formulate diet based on low protein status and supplement with synthetic AAs. Lenis and Jongbloed (1999) demonstrated that by reducing dietary crude protein (CP) content by 2 percentage units' excretion of nitrogen was reduced by 20%. Grandhi (2001a) and Grandhi (2001b) showed that feeding pigs low protein diets had no negative effects on pig performance provided the diets were well fortified with the key critical or limiting AAs, namely: lysine, methionine, threonine and tryptophan. Panetta et al. (2006) reported decreased ammonia emission rates from 2.46 to 1.05 mg min^{-1} with decreasing dietary CP levels from 17% to 14.5%. Conversely, Connell, Callan and O'Doherty (2006) reported increased ammonia emissions from slurry of pigs fed 22% CP diet compared with a 16% diet. These findings confirmed the nutritional authenticity of the strategy and interestingly the strategy has been shown to be effective not only in pigs but also in other non-ruminant species like poultry (Nahm, 2003).

Feed Ingredient Selection

Another diet formulation strategy that is used to better manage odour production is feed ingredient selection during diet formulation. In practical diet formulation, a mixture of different dietary ingredients is mixed to supply the animal required nutrients to optimize animal performance. Usually the concept is that the different ingredients contains different levels of nutrients and therefore their mixture is to ensure that animal nutrient needs are met by the final diet compounded for maintenance and production purposes of the animal. To this extent, ingredients that are highly digestible and consequently induce minimal endogenous nitrogen secretion are often used more as one of the excellent means of reducing nitrogen excretion in the manure as it is associated with odour production (Grandhi, 2001a; Grandhi, 2001b). For instance, the substitution of hulled barley with hulless barley in these studies reduced total nitrogen excretion in the pig manure by about 4%. Therefore, formulators need to properly evaluate this strategy more critically in order to effectively exploit its usefulness in minimizing malodour production. Furthermore, to maximally benefit from this strategy, formulation of diets should be based on available or digestible nutrient basis as to better match animal nutrient needs while avoiding excessive nutrients in the diets resulting in excessive nutrient excretion as the nutrient level is above the animal digestive capacity. In conclusion, nutritionist should be guided by routine analyses of feed ingredient sources and estimates of nutrient availability to accomplish accurate feed formulation of the animal. Additionally, the study of van Heugten and van Kempen (2002) showed that diets containing fishmeal and a high sulphur content, such as 12% of feather in the diet was highly odourous. They further reported that including feather meal more than 8% in the diet increased odour concentrations due to butyric, pentanoic and isovaleric acids in the faeces of pigs. Therefore, individual feed ingredient characteristics on

odour generations warrant further studies in order to expand our understanding of individual feed ingredient characteristics and their implications in odour production. Another means of using diet to mitigate odour generations in swine production is via ingredient processing.

Ingredient Processing

The strategy of processing dietary ingredients before use in the diet is another means of using diet formulation in mitigating foul odours in swine production. It has been shown that some technological processing of individual ingredients or complete rations enhanced the digestibility of AAs. In a study by van Kempen (2000), it was demonstrated that for every 1% improvement in digestibility, the amount of nitrogen excreted per kg of pork produced decreased by 1.4%. In further extrapolating this concept in odour reduction, finely ground and pelleted feeds have been shown to be better digested than those of coarser particle size (Wonder et al., 1995). In this study, fine grinding by reducing particle size from 800 to 400 µm resulted in the reduction of nitrogen excretion by 30%. This is principally due to the fact that grinding aided in the exposure of feed more to the activities of digestive enzymes. Phase feeding is also another dependable means of mitigating against odour generation in swine production facilities.

Phase Feeding

This strategy is hinged on the fact that as pigs grow mature, their nutritional requirements, such as dietary AAs decline especially as they enter the finishing phase. This therefore implies that a diet that is suitable for growing pigs with high demands for AAs for instance will not be suitable again for the pigs in their finishing phase because their AAs requirements are much more less in this phase (Lee et al., 2000). This justifies the phase-feeding strategy in nutrient management for profitability and additionally mitigate against malodour production. Implication of this is the fact that AAs needs of pigs is highly depended on their physiological status. This has led to the use of more than one diet type for pigs in the nursery as well as during their growing-finishing phase with special emphasis on the adjustment of protein level reduction in the diets to minimize excess nitrogen excretion. This phase feeding strategy has thus been demonstrated to result in 5 to 10% reduction in the total amount of nitrogen excreted in the pig manure (Lee et al., 2000). In an earlier study by Peet-Schwering et al. (1996) in which pigs were fed decreasing proportions of a mixture of a high and low protein diet on a weekly basis, urinary nitrogen excretion and ammonia emission was reduced by 15% and 17%, respectively. Conclusively, it should be known and adopted that pregnant, lactating and breeding pigs belong to different physiological states and therefore differ significantly in their dietary nutrient requirements. For instance, nutrient requirements for gestating sows are generally lower than those of lactating sows. This had been substantiated to by previous studies (Evert & Dekker, 1994) that using separate nutrient level diets for same sex but physiologically different pigs reduced nitrogen excretion by as much as 20%.

Conclusions

This paper highlighted how diet formulation strategies can be used to minimize odour production from swine production facilities. However, it was not intended to be exhaustive of all the possible portals diet formulation could be used to mitigate odour production. Nevertheless, the major nutritional management approaches or strategies were expatiated on. These range from matching nutrient supply with animal physiological requirements, practical handling or processing of dietary ingredients prior for use in diet formulations and reducing ammonia emissions. All these diet formations manipulation strategies are tailored mainly to reducing the amount and types of nutrients presented to the hindgut of the pig that are

eventually released in the manure, especially proteins, since they the major triggers of odour generations.

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