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Fiber, Phytic Acid and Enzymology in Non-Ruminants' Productivity with Conventional Feedstuffs

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Abstract. The global population is still growing and as such would soon increase above the current levels. This is an indication that the demand for food, including animal proteins from the swine and poultry industries would also increase accordingly. This is also a clear indication that the feed industry, particularly for swine and poultry, is expected to also grow. This therefore requires that means of meeting this need be strategized for, such as improving digestive processes for better nutrients' utilizations and retentions by swine and poultry, since their abilities to digest their diets are not 100% efficient. The major problems relate to the presence of anti-nutritional factors impeding nutrient digestibility. The major concerns are fibers and phytic acids. Fiber acts as a diluent of available nutrients and may also contain factors which can physically and chemically inhibit nutrient digestion, absorption and utilization resulting in high amounts of dietary nutrients in the excreted manure in addition to poor performance. Fibers also cause mineral adsorption thereby exacerbating poor nutrient retention. Pigs and poultry are deficient in cellulases and phytases (enzymes involved in the digestion of fiber and phytic acid) respectively. Overall, therefore, fiber and phytic acid not digested prevent the digestibility of nutrients thereby significantly reducing net energy intake. The inclusions of exogenous cellulases and phytases in diets of non-ruminants therefore greatly influence their productivity positively with improved performance leading to minimal nutrients' excretions in animal manure. Swine and poultry feeds are to date still are the largest proportion of feed compounded globally primarily due to increased consumer demand for cheap, safe and healthy meat and meat products from swine and poultry. These drawbacks can be overcome via the use of enzyme technology involving the use of exogenous enzymes.

Key words: Anti-Nutritional Factors, Nutrient Digestibility, Enzymes, Swine and Poultry

Introduction

Feed additives, such as antibiotics have been employed in the nutrition of non-ruminants at sub-therapeutic levels primarily to enhance growth and reproductive performances (NRC, 2012). With the advent of the bans on their uses researchers had sought for their alternatives. However, of more concerns presently is the presence of fiber and phytic acids in the diets of non-ruminants that are not digestible by swine and poultry. The swine and poultry industries are growing and expanding geometrically principally due to the increase in demand for safe and healthy pork and poultry meats (Hoffman, 1999). Furthermore, as the global population continues to increase above the current levels, the demand for food, including animal proteins from the swine and poultry industries would also increase. This is a clear indication that the feed industry for swine and poultry are bound to also grow and therefore require the means or strategies of meeting these needs, such as improving digestive processes for better nutrients' utilizations and retentions.

Digestive enzymes act as catalysts in food digestion without which digestion is impeded. Therefore, enzymes speed up or catalyze reactions by binding to their substrate and stabilize the entire reaction process through to product formation, such that far less activation energy is required to accelerate the reactions involved (NRC, 2012). Enzymes work efficiently under certain environmental conditions, such as pH. The essence for the use of enzymes in feeds of non-ruminant animals is to enhance the nutritive value of dietary ingredients and eventually

the compounded feed. Ingested feed is usually digested by endogenous enzymes produced by the animal. However, the efficacies or efficiencies of the endogenous enzymes are not 100% majorly because of the anti-nutritive factors, such as fibers and phytic acid contained in the diet (NRC, 2012). In non-ruminants feed cost accounts for about 65-70% of the total cost of production (Patience, Thacker & de Lang, 1995). This inefficiency in nutrient utilization of the feed often result in increase of cost to the farmer and the environment because of high contents of undigested dietary nutrients in the manure (Patience, Thacker & de Lang, 1995). This is where the enzyme technology is employed to improve and increase dietary nutrients' digestibilities. Therefore, there are three basic reasons enzyme technology is employed in diet formulation: to breakdown anti-nutritive factors in feed ingredients which are not susceptible to digestion by endogenous enzymes, thereby interfering with digestion leading to poor performance and digestive offsets especially with growers; to increase the availability of nutrients, including starches, proteins and minerals and to breakdown chemical bonds in feed ingredients that cannot be degraded by endogenous enzymes (NRC, 2012; Patience, Thacker & de Lang, 1995). Therefore, this paper dwells on how exogenous enzymes can be used to improve animal productivity in the presence of fiber and phytic acid. However, the modus operandi of how dietary fiber and phytic acid exhibit their anti-nutritional characteristics would be first examined as to also justify the need for exogenous enzymes to mitigate them.

Fiber and Nutrient Digestibility

Fiber components in feed ingredients were long identified as carriers of anti-nutritional factors that limit animal performance due to the fact that they do not allow animals to consume enough net energy to enable them to gain at a maximum and efficient rates (Fairbairn et al., 1999; Moeser et al., 2002). Fiber acts as a diluent of available nutrients and may also contain factors which can physically and chemically inhibit nutrient digestion, absorption and utilization resulting in high amounts of dietary nutrients in the excreted manure (Fairbairn et al., 1999) and poor performance of the animal (Moeser et al., 2002; Rotter et al., 1989). Pigs and poultry are deficient in cellulases and phytases; enzymes involved in the digestion of fiber and phytic acid, respectively. Overall, therefore, fiber and phytic acid not digested prevent the digestibility of nutrients in addition to diluting the diets thereby significantly reducing net energy intake. Thus, the inclusions of cellulases in diets of non-ruminant animals greatly influence their productivity positively with improved performance leading to minimal nutrients' excretions in animal manure as a result of enhanced nutrient utilization and retention by the animal. Swine and poultry feeds are to date still are the largest proportion of feed compounded globally primarily due to increased consumer demand for cheap, safe and healthy meat and meat products (Gill, 2000).

Fiber-Degrading Enzymes

As previously given, one of the major limitations of digestion in non-ruminants is due to the deficiency of enzymes that readily digest fiber. In most diets for these animal species, cereals form or constitute a greater percentage of their diets. Cereals are well-known to contain fiber in the forms of soluble and insoluble arabinoxylan and β-glucans (Bedford & Classen, 1992). Examples of such cereals often referred to as 'viscous' cereals include wheat, barley, rye or triticale.

Soluble fiber increases the viscosity of digesta in the small intestine thereby impeding and interfering with the digestion and absorption of nutrients of the ingested diet leading to reduced growth rate or poor performance of the animal. They are also implicated in the occurrence of digestive disorders, including non-specific colitis in swine and sticky litter/hock burns in poultry. Therefore, the use of exogenous enzymes such as xylanase to target and degrade arabinoxylans and β-glucanse to degrade β-glucans results in the reduction in

variability in the nutritional value of the diets leading to significant improvements in the performance of the feed resulting in consistencies of the animals' responses thereby eliminating the variability in the nutritional value of diets due to these fibers. Furthermore, these added exogenous enzymes significantly reduce the incidences of certain digestive disorders again with the overall benefit of increasing animal productivity (Bedford & Classen, 1992).

Phytic Acid and Nutrient Digestibility

One of the importance of adding exogenous enzymes to feeds, such as phytase by the feed industry is the environmental benefits of harnessing enzyme technology. As the animal capacity to utilize the dietary nutrients is increased, less nutrients are eventually excreted. These invariably result in manure volume being reduced by up to 20% and nitrogen excretion by up to 15% in pigs and 20% in poultry (NRC, 2012; Patience, Thacker & de Lang, 1995). The use of phytase in this way significantly offers nutritionists the opportunity to reduce environmental pollution due to high levels of phosphorus (P) in excreted manure. Phytic acid serves as the reservoir for P in plants and seeds. A variety of plants and plant materials including cereal grains, such as maize, barley and wheat as well as grain legumes, such as field peas and chickpeas that are commonly used as dietary ingredients have high phytic acid contents at approximately 0.25% of dry matter (Patience, Thacker & de Lang, 1995). As a result of the bulk use of cereals and meals in animal diets, on average conventional diets contains about 70% of total P in diets is phytic acid-P. Phytic acid-P chelates minerals as well as proteins and starches (Maga, 1982) thereby triggering environmental pollution due to high levels of these nutrients in the excreted manure resulting in the poor performances of the animals (Mallin, 2000).

Phytic Acid-Degrading Enzyme

The phytic acid degrading enzyme is phytase. Of all the phytases investigated, microbial phytase and particularly those of *Aspergillus niger* and *A. ficuum* demonstrated highest potencies with *A. niger* having higher potency compared with that of *A ficuum* (Volfova et al., 1994). To this extent, at present commercial phytase products are based on the phytase encoding gene originating from *A. niger* to dissociate phytic acid-P and reduce the reliance on supplemental phosphate in meeting the P and other minerals' needs of the animal. In addition to liberating phytic acid-P for animal's use other chelated minerals, such as calcium, zinc, iron and magnesium, including proteins and starches are also liberated for the animal. By these means animal performances are better enhanced as well as reduction in environmental pollution emanating from high levels of manure nutrients' levels (Maga, 1982; Mallin, 2000; Volfova et al., 1994; Lei & Porres, 2003).

Conclusions

The enzyme technology has been demonstrated to be a very practical, effective and efficient means for improving nutrient utilization and retention by monogastrics and thus increase the profitability of the farmer, animal performance and as well as reducing nutrient loads of the ecosystem, including P pollution thereby making commercial and intensive animal production more productive and eco-friendly.

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