Phytase use in pig feed: a real profitability boost

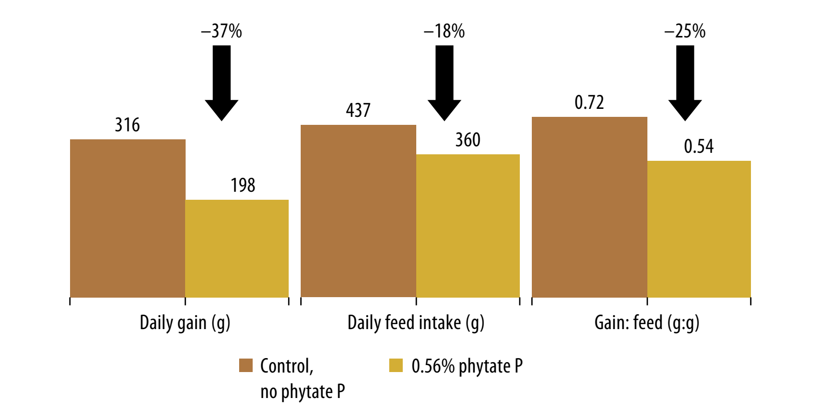
While phytase penetration in the poultry market is almost universal at around 90%, only around 70% of pig producers worldwide are using phytase. But the tide has started to turn and using phytase can give pig producers a true profitability boost.

By Bryan Rudolph,
senior technical services manager
North America, Danisco Animal Nutrition

Phytase's rapid growth has resulted mainly from its acceptance as an economically viable and scientifically proven replacement for expensive inorganic phosphates. While an increasing understanding of the impact of phytate on dietary amino acid and energy digestibility has also led to a greater appreciation of the value of phytase application beyond phosphorus and calcium release, this is still a very important phytase function, particularly for sows and piglets. The number of piglets born per litter today is around 12 for first litter gilts, increasing to around 15 in parities four or later[1]. Five parities are considered to be the optimum number to maximise sow profitability[2]. With this high level of productivity, it's not difficult to predict that such an intensive cycle, could result in dietary deficiencies.

Research comparing the bone mineral reserves of sows over three parities with non-reproducing gilts of a similar age demonstrated that most minerals - but in particular calcium and phosphorus - were reduced over time and particularly during late gestation and lactation[3]. Depressed sow milk production, growth rate, poor feed efficiency and reduced carcass muscle are just some of the effects of calcium and phosphorus deficiency, and all of these factors impact producer profitability. Most importantly, a deficiency of calcium and phosphorus will result in demineralisation of bones, which can lead to osteoporosis in sows and signs of clinical rickets in younger pigs. This in turn causes fractures or paralysis of the hind legs, as well as lameness and foot/leg problems[4], particularly in heavy milking sows during late lactation ('downer sow' condition). It has been shown that bone mineralisation issues can also indirectly cause reproductive failure, the largest cause of a sow being culled

Figure 1 - Phytate as an anti-nutrient decreases weaner pig (7.4kg) performance. Pigs were fed synthetic diets based on casein-corn starch supplemented with and without phytic acid additions (Woyengo *et al*, 2012).



from the herd[5]. All of these factors will increase replacement needs for breeding stock. Other trials[6] showed that there is a disease risk when introducing replacement animals into the breeding herd therefore potentially adding an unforeseen expense.

The phytase solutions

Phytate, which occurs naturally in raw feed materials, reduces the availability of essential nutrients such as calcium, protein/amino acids, iron and zinc to the animal because it forms complexes with these nutrients in various parts of the digestive tract. The pigs' own enzymes cannot degrade phytate, which in turn increases endogenous losses and further decreases the nutritional value of diet formulations. In addition, young pigs have immature digestive systems which make them particularly susceptible to anti-nutrients like phytate. Research[7] showed a significant reduction in growth performance (37%) when piglets were fed a synthetic diet based on casein-corn starch containing added phytate, versus a control diet with no phytate (*Figure 1*). Daily feed intake was also reduced by 18% and gain to feed ratio by 25%. Similar negative effects of phytate level in the diet on energy and protein/amino acid digestibility in growing pigs have also been shown in earlier research studies[8]. A high affinity for IP6 - the ability to remove one phosphate group from the intact inositol ring, reducing phytate's anti-nutritional power, is one of several key factors that impact the level of profitability achieved from phytase use. Improved phytate degradation achieved through phytase application in sow diets during the reproductive cycle has been shown to significantly increase the digestibility of vital phosphorus and calcium in pregnant sows against negative controls by 23.5% and 10.5% respectively[9]. It was also shown to be very effective during lactation, which is another critical time in terms of ensuring skeletal integrity not just for the sow, but also for its developing piglets[10]. Even for advanced, highly bio-efficacious phytases, there needs to be enough phytate substrate present to break down. Simply put, if there is no phytate, phytase can have no effect. The level of phytate in the diet, which varies significantly across raw materials is fundamental to optimising phytase dose rates and to quantifying the release of 'extra-phosphoric' nutrients e.g. amino acids and energy[11].

Activity at low pH

A high level of activity in the low pH conditions prevailing in the pig's upper digestive tract is another phytase feature that has been shown to impact the effectiveness of phytase application. The latest bio-efficacious phytases have been developed with a view to quickly achieving maximum phytate degradation thereby improving animal performance and producer profitability. *Figure 2* highlights the difference between *E. coli* and other phytases and the latest Buttiauxella phytase in terms of activity at low pH, where the Buttiauxella phytase shows a clear advantage over other phytases. Use of a highly bio-efficacious phytase during the post-weaning phase can help producers get around challenges caused by change of diet and environment that not only impact digestibility but also increase the maintenance energy requirements of the animal, leaving less 'spare' metabolic energy available for productive processes e.g. growth and lean gain. *Table 1* shows the results of a digestibility trial in weaner pigs with diets reduced in available phosphorus by 0.20%, calcium by 0.14% and a dietary phytate P level of 0.21%. A Buttiauxella phytase used in this particular trial was as effective as the *E. coli* phytase at half the dose in terms of phosphorus and calcium digestibility. In 14 trials with over 550 data points involving both weaner and grower-finisher pigs, using the Buttiauxella phytase instead of a commercial *E. coli* phytase resulted in a 34% improvement in phosphorus and calcium release and considerable digestible energy improvements (~35 kcal/kg feed (0.15 MJ)). These improvements translated into an economic advantage of around $1.00-1.30/tonne, over *E. coli* phytase use, even at 500FTU[12].

Using the right dose

There is a growing body of evidence that shows that dosing above the traditional industry standard of 500 FTU/kg, can have a beneficial effect on pig performance, depending on the type of phytase used. Two recent studies[13] evaluated the effect of a Buttiauxella phytase at 1000 FTU/kg on digestibility of calcium and phosphorus in weaner pigs (9-22 kg bodyweight). Based on bone ash and body weight gain data, the studies established that this phytase successfully replaced 0.2% available phosphorus in weaning piglet diets. A further study[14] evaluated the effect of varying doses of Buttiauxella phytase on ileal tract nutrient and total

Figure 2- Different types of phytase activity at varying pH.

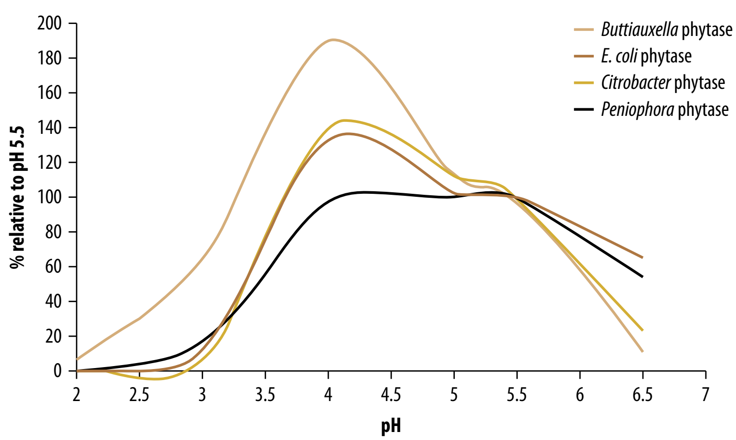


Table 1 - Effect of a Buttiauxella spp. phytase (2501000 FTU/kg feed) on phosphorus and calcium digestibility in weaner pigs (12-19kg) in comparison to an E. coli phytase (Schothorst Feed Research, Netherlands, 2012). Values without a common superscript are significantly different (P<0.005).

	Positive control	Negative control	NC + Buttiauxella 250FTU/kg	NC + Buttiauxella 500FTU/kg	NC + Buttiauxella 1000FTU/kg	NC + *E.coli* 500FTU/kg
Phosphorus digestibility (%)	50.0[d]	40.7[e]	55.5[c]	61.0[b]	64.9[a]	55.0[c]
Calcium digestibility (%)	59.7[d]	49.4[e]	64.8[c]	69.4[ab]	73.1[a]	66.2[bc]

tract digestibility in growing pigs fed a corn-soy based diet. Digestibility of calcium and phosphorus responded with increasing phytase dosing, with improvements of up to 33.8% in calcium uptake and 124.3% in phosphorus for diets supplemented with 2000 FTU/kg phytase. As phytase is increasingly used with other additives, it is also important for producers to have evidence not only of how these varying elements of the diet interact but also how this impacts phytase dosing. Take, for example, the addition of zinc oxide; studies show that zinc can bind to phytate, rendering it less accessible to phytase[15] and that the high zinc levels used in many post-weaning diets can compromise the efficacy of phytase at 'conventional' doses e.g. 500 FTU/kg feed[16]. Recent trials[17] have shown that the use of phytase at 1000 FTU/kg feed (and higher) gave good growth and feed conversion responses in phosphorus-adequate piglet diets containing 2500 mg/kg of zinc oxide and with a phytate P level of 0.28%.The best performance in this series of trials was achieved with a dose of 2000 FTU/kg feed.

Interactions with other enzymes

Understanding variation in substrate levels and their properties is also a prerequisite to understanding synergies between phytase and other enzymes such as carbohydrase and protease. Positive results in terms of nutrient digestibility have been seen with phytase and xylanase application in wheat based diets with low, medium, or high lysine levels for growing pigs, suggesting that savings could be made on expensive protein addition through use of the enzyme combination[18]. Additional trials have also shown that combining xylanase and phytase in diets that have high arabinoxylan and phytate content (e.g. wheat middlings) can dramatically improve nutrient availability by reducing anti-nutrient levels and improving nutrient utilisation[19]. These findings have implications not only in terms of the additional cost savings that can be made by using them in combination, but in terms of the impact on animal gut health. Many production factors can impact the balance of the pig's gut microflora, the type, amount and availability of undigested substrate is highly significant. In feed antibiotics have traditionally been used to overcome disease challenges in pigs[20], but growing concerns about residues in meat products and potential bacterial resistance to antibiotics has led to increased research into practically feasible alternatives[21]. Given that combinations of enzymes have been shown to tackle various substrates in the diet and thereby reduce the possibility of microbial proliferation, it's possible that they could help replace the in-feed antibiotics, which have the same role. Production profitability should be ensured through continuing research into the impact of substrates, and the great difference that phytase and other enzymes can make to digestibility and performance by tackling their negative effects. **AAF**

References are available on request from monica.hart@dupont.com