Pig Nutrition

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Ergot alkaloids **by Katia Pedrosa and Karin Grießler**

Ergot alkaloids of increasing concern

Ergotism can occur in all animal species and its impact on production should not be underestimated.

Cows in the shade suffering heat stress at 22C.

Hybrid rye contaminated with ergots.

Ergot is a fungal disease that primarily affects rye, triticale, barley and wheat, and which adversely affects the health and productivity of livestock.

The fungus in question produces the ergot responsible for the ergot alkaloid group of mycotoxins and parasitizes the seed heads of plants at the time of flowering. It is often seen in years where wet weather prevails in the spring and early summer, during the flowering stage of cereal crops or when low temperatures are present during grain fill.

Ergot infection reduces grain quantity and quality. It replaces grain kernels with poisonous alkaloid-containing ergot sclerotia - hardened bodies that are formed by the fungus.

Despite using cleaning techniques at mills, ergot alkaloids have been detected in surveys worldwide. Fungal endophytes (Neotyphodium coenophialum), which infect perennial ryegrass (Lolium perenne) and tall fescue (Festuca arundinaceous) also produce alkaloids that impair animal health and performance. Animals grazing these pastures can lose body condition, and have low conception rates and lower survival of offspring.

Additionally, body temperatures are elevated and reduced blood flow to extremities can result in death of these tissues. In mammals, ergot alkaloids affect immune and reproductive systems as well as the central and sympathetic nervous systems as some possess hallucinogenic properties.

Ergotism is one of the oldest known mycotoxicoses. Ergot alkaloids exert toxic effects in all animal species, and the most prominent toxic signs can be attributed to the interaction of ergot alkaloids with adrenergic, serotinergic and dopaminergic receptors. Recently, ergot alkaloids have gained considerable relevance due to, amongst other things, ergopeptine producing endophytes causing breeding problems in animals. The amount and pattern of alkaloids produced varies between fungal strains, the host plant and geographical region.

The term ergot alkaloid refers to a diverse group of some 40 toxins.

Toxicity in animals

Animals can be exposed to complex mixtures of ergot alkaloids in many typical production systems. This mixture results from the fact that the kinds of alkaloids present in grains and their levels can vary widely. Consequently, it is practically impossible to determine the exposure to individual toxins.

Due to the fact that animals are exposed to a multiplicity of alkaloids when consuming endophyte-infected tall fescue, a combined alkaloid effect has been suggested. In addition to vasoconstriction, other symptoms reported as typical include gangrenous changes, neurotoxic signs including convulsions, abortions and death. Moreover, reduced prolactin secretion and consequently agalactia are major adverse effects in animals.

Pigs

Negative effects of ergot alkaloids have been observed in sows fed sorghum grain infected with sorghum ergot (17% C. africana ergot sclerotia) before farrowing. Symptoms included shrunken udders, lack of colostrum production, signs of oestrus and dead piglets due to starvation. Sows fed the grain after farrowing showed severe reductions in milk production due to low levels of prolactin.

Moreover, agalactia (due to the interference in the release of prolactin), feed refusal and consequent reduced weight gain are classical signs of poisoning by rye ergot (C. purpurea). Other frequently noted symptoms include strong uterotonic effects, causing stillbirths and reduced pregnancy rate.

Other studies have reported negative effects on the cardiovascular and central nervous systems due to higher blood pressure causing vasoconstriction. Defining the tolerable level of ergot in diets for weaned pigs is important to help use infected grains safely. A trial with ergot alkaloids to evaluate the performance and clinical symptoms in weaned pigs found that the maximum tolerable levels of ergot in the diet were 0.10 and 0.05% based on average daily gain and average daily feed intake, respectively, which corresponds to 1.04 mg to 2.07 mg of total alkaloids per kg diet.

For a more detailed examination of ergotism, read: Ergot alkaloids – a tour through the complex family of mycotoxins of increasing concern. www.WATTAgNet.com/17359.html

Poultry

Trials in poultry have found that chickens fed contaminated diets (150 or 300 mg ergotamine/kg) exhibited poor feathering and developed gangrenous lesions on the toes when exposed to a continuous, temperature environment (22C). These birds consumed less feed and water and grew poorly, and these effects were exacerbated on exposure to a higher temperature (35C).

In birds, prolactin is involved in incubation behavior and broodiness. Ingestion of ergotamine results in reduced circulating prolactin concentrations resulting in reduced circulating concentrations of gonadotropins and thus ovarian regression. In layers, feed intake and egg production are significantly reduced when ergot sclerotia (2%), from rye or triticale are included in the diet. Other studies have found that chickens fed with diets containing 2.5 and 5.0% sclerotia exhibited respiratory difficulties, diarrhea, and death. Blackening of beaks, claws and feet, followed by necrosis of these parts were the most obvious signs.

Birds fed grains containing ergot´s sclerotia have been seen to be reluctant to move; their feet were uniformly dark, reddish purple, and they were slightly dehydrated. They also exhibited purplish-black claws, toes, shanks and beaks on several three day old chicks.

Cattle

Symptoms of ergot poisoning are more pronounced when animals are kept outside under varying weather conditions.

Adult ruminants are considered less susceptible to mycotoxins, since the alkaloids are metabolized quickly. The rumen microbes may be influenced in their activity in deactivating the alkaloids by varying feed intake and passage rates through the rumen. It has been found that approximately 94% of the alkaloids ingested by cattle grazing endophyte-infected tall fescue were found in urine and the remaining 6% was in the bile. Usual symptoms of acute poisoning are lameness and gangrene due to constriction of the blood vessels and occasional convulsions. Cattle fed ergot infected sorghum had reduced ability to shed heat, which in turn reduced feed intake and growth.

Poor reproductive performance or decreased pregnancy and calving rates have also been reported. Reduced testicular development and sperm production in males fed endophyte-infected fescue seed has also been reported.

Toxic effects from cattle consuming endophyte infected fescue are manifested by one of three main pathologic conditions: fescue foot, fat necrosis, or summer syndrome.

Fescue foot occurs mostly during cooler weather (<15C) and is characterized by rough hair coat, emaciation, limb swelling, development of necrotic tissue, and sloughing of tail and ear tips in extreme cases. Fat necrosis, or lipomatosis, results in deposition of hard, necrotic mesenteric fat around the intestinal tract, leading to impaired digestive function and sometimes death. Summer syndrome is the most prevalent and well-studied condition caused by grazing endophyte-infected fescue, where cattle suffer reduced feed intake and average daily gain. Chronic ingestion of low levels of the toxins may result in overall decreases in productivity through decreased milk production, reduced weight gain, diarrhea, reduced reproductive efficiency, spontaneous abortion and heat stress. Studies have reported that, in late pregnancy, abortions occurred 7-11 days following exposure to ryegrass pasture heavily infested with ergot.

Researchers have reported that feeding tall fescue hay containing a high level of

Ergot alkaloids

ergovaline can reduce the performance of lactating dairy cows even with relatively cool temperatures and at a relatively high dietary ratio of concentrate to roughage. In the rumen fluid, concentrations of isovalerate, propionate and ammonia nitrogen are significantly influenced as is the amount of protein ruminally undegraded; conversely, the fermentation of neutral detergent fiber, tends to increase with the ergot supplementation at higher levels of feed intake, which might indicate a modification in the microbial population.

Sheep

Lambs kept outdoors administered aqueous suspensions of milled ergot from C. purpurea (0.75 g sclerotia/kg body weight) have shown signs of dullness, inappetence, high pulse rate, diarrhea, edema of the hind legs and tail, as well as lameness.

Post-mortem findings have included inflammation and necrosis of the forestomach and intestinal mucosa. Ergovaline ingestion suppresses feed intake, reduces serum prolactin level, and reduces thermoregulatory function, which leads to increased body and decreased skin temperatures, elevated respiration rates and reduced live weight gain. Endophyte (Neotyphodium lolii)-infected perennial ryegrass causes high loss of ewes and weaned lambs and seriously disrupts breeding goals, increases lameness in sheep and cattle and elevates the incidence of pregnancy toxemia.

Quality feed is the first step to avoid problems

Ewes pastured on high endophyte-containing fescue before breeding take longer to conceive or have a reduced conception rate and experience embryonic mortality.

The effects of ergot alkaloids in animals are diverse and can impair the health and productivity of animals, and result in economic losses for producers. The total alkaloid content, as well as the level of individual alkaloids, varies; therefore, it is difficult to obtain specific data on exposure to individual toxins of certain animal species as well as to set safe levels. Despite that only a few countries have set limits for individual ergot alkaloids in food or feed, recommendations for levels of ergot sclerotium (dormant winter form of the fungus Claviceps purpurea) are being used. Thus, the limit refers to the weight of ergot kernels per total commodity weight, and not toxin concentration.

The use of high-quality feedstuffs to reduce toxicosis of ergot alkaloids in livestock is the first step in avoiding problems they can cause, but inclusion of a mycotoxin counteracting product could also be considered.

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Nutrition by Peter Best

Piglet nutrition: New targets for amino acids

The latest concepts in feeds for young pigs include formulating to optimise the growth and health of the animal's gut.

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Feeding the young pig both adequately and economically has never been an easy task, but the manufacturer of piglet diets is now being asked to take further factors into consideration. Among these are the birth origins of the animal and even the possibility that part of its feed supply should be for reasons other than body maintenance and growth.

This second aspect was raised in 2010 at the 21st International Pig Veterinary Society Congress, where Dr Douglas Burrin of the US Department of Agriculture's Agricultural Research Service presented a lecture on the role of nutrition and intestinal adaptation in the weaned pig. In his remarks, he introduced the rather novel concept of also formulating to meet gut nutrient requirements.

Fuels for gut function

"Historically, weanling pig diets have been formulated largely to overcome the limitations or immaturity in digestive function in order to maximise growth of the whole animal," he said. "However, with a new understanding of intestinal nutrient utilisation, it is now possible to formulate such diets with the specific goal of optimising the growth, function and health of the gut."

Although most swine nutritionists have an extensive knowledge of the pig's nutritional needs for growth, he told the meeting, research in recent years has extended the whole area of defining requirements so it also now includes nutrients needed specifically for the gut.

"Technical advances have enabled direct estimates of gut nutrient utilisation and the impact on whole animal nutrient metabolism," said Dr Burrin. "A major concept that has emerged from studies with young pigs is that non-essential amino acids are major gut fuels."

The research into intestinal nutrient utilisation has suggested that some of the most promising candidates for manipulation in a new-look formulation strategy are the amino acids glutamine, glutamate and threonine with aspartate. From in-vivo studies in pigs, roughly 70-80% of the glutamate, glutamine and aspartate provided by the animal's diet is taken up by the gut at the first pass and metabolised to carbon dioxide. "Glucose is also quantitatively an important oxidative fuel for the pig intestine. In absolute amounts, the intestinal utilisation of glucose is similar to the combined total from glutamate, glutamine and aspartate. However, the proportional use is lower, such that only about 20-30% of the dietary glucose is metabolised by the gut."

Intestinal metabolism

The implications of the research conducted to date seem to be greatest with regard to the supply and use of amino acids in young pigs, to judge from Dr Burrin's remarks. He described studies with piglets showing that the neonatal intestine played a key role in the metabolism of amino acids involved in the urea cycle, particularly arginine, proline, and ornithine.

There is extensive inter-conversion between these amino acids, he reported. The intestine represents an important site of net arginine synthesis in neonatal pigs. Moreover, the intestinal studies in pigs have demonstrated the extensive metabolism of other essential amino acids, including threonine, lysine, phenylalanine, branched-chain amino acids and methionine.

"It is generally considered that the primary metabolic fate of essential amino acids taken up by the gut is incorporation into tissue proteins. However, studies show that extensive irreversible catabolism and oxidation of amino acids occurs in the gut. Many of these essential amino acids are metabolised to other intermediates involved in intestinal function.

"For example, threonine is believed to be channeled into mucin synthesis and secreted by goblet cells, because mucin peptides are rich in threonine. Methionine may be converted to cysteine or s-adenosyl-methionine used in polyamine synthesis. Cysteine is used as a precursor for glutathione synthesis and maintenance of mucosal anti-oxidant status."

The oxidation of some essential amino acids, such as the branched-chains and lysine, in the gut may be nutritionally significant, Dr Burrin continued. The high essential amino acid utilisation rate by gut tissues can impact significantly on the systemic availability of amino acids for lean tissue growth.

Ideal protein

Current ideas from Europe and North America on the piglet's need for dietary amino acids were summarised at the end of last year in a presentation to the Society of Feed Technologists, SFT, in the UK by Lars Sangill Andersen, feed application manager for Hamlet Protein A/S in Denmark. Amino acid values to supply within a piglet diet tend to be defined according to their relationship to lysine in an ideal protein combination, he pointed out.

Typically, this could mean methionine at 33% relative to lysine or methionine + cystine at 57%. Threonine could be at 65%, tryptophan at 20%, valine at 70%, isoleucine at 58% and histidine at 33%.

Modern formulations in practice consider digestible amino acids per kilogram of feed according to the energy level of the diet and the weight of the piglet. But as Mr Sangill Andersen pointed out, not all requirements have been defined even today and particularly not those for the youngest pigs. The nutritionist therefore must still work mainly from values found for larger growing pigs, despite the certainty that the needs of small piglets will be lower.

From his SFT presentation, accompanying Table 1 sets out some standardised ileal digestible amino acid values at different piglet weights and levels of dietary metabolisable energy. They are based on data established in France, Germany and the US.

As he remarked, however, issues on how to formulate effective feeds for young pigs go beyond the specification of amino acids or other individual nutrients. Among the questions for formulators to answer is whether the right ingredients have been chosen and whether the concentration of crude protein in the early diet might lead to problems of piglet diarrhoea.

Classifying ingredients

It is possible to identify certain "good" ingredients in terms of their suitability for piglet starter feeds, he declared, and also some ingredients that can be rated as "bad" in this context. His own list under a classification of good included milk products such as skim milk power, lactose, whey and whey protein concentrate as well as spray-dried blood plasma, fishmeal, cooked cereals and protein concentrates processed from soybeans and potatoes.

Among "bad" ingredients, he indicated, would be soybean meal and raw (uncooked) cereals together with meals from other oilseeds such as rape and sunflower and also full-fat soy, in addition to red blood cells.

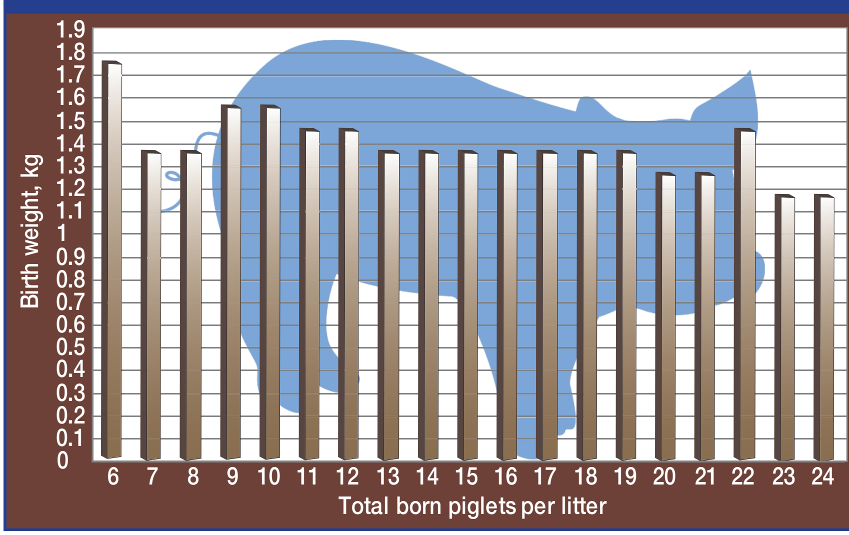
TABLE 1: Standardised ileal digestible amino acid values (grams per kilogram of feed) according to pig weight and dietary energy.

Metabolisable energy	14 MJ ME/kg	13.7 MJ ME/kg	13.5 MJ ME/kg	13.1 MJ ME/kg
Piglet size	6-9 kg	9-20 kg	9-30 kg	20-30 kg
Lysine	13.4	12.2	11.9	11.0
Methionine	4.3	3.9	3.8	3.5
Methionine + cystine	7.2	6.6	6.4	5.9
Threonine	8.2	7.5	7.2	6.7
Tryptophan	2.6	2.4	2.3	2.1
Isoleucine	7.8	7.0	6.8	6.4
Leucine	13.7	12.4	12.1	11.2
Histidine	4.5	4.1	4.0	3.7
Phenyl	7.7	6.9	6.7	6.3
Phenylalanine + Tyrosine	14.9	13.6	13.1	12.2
Valine	9.4	8.5	8.3	7.7
Crude protein (min)	193	176	171	160
Crude protein (max)	207	190	185	173

Source: Sangill Andersen, Society of Feed Technologists 2010, from European and US data.

Standardised ileal digestible amino acid values at various piglet weights and levels of dietary metabolisable energy.

TABLE 2: Danish results for average piglet birth weight when litter size is increased



Larger litters have tended to result in smaller piglets, according to a Danish study.

Piglet nutrition

Diet selection for young pigs before weaning must address changing farm productivity

These ratings are based on a combination of experience and measurables, Lars Sangill Andersen added. We can measure trypsin-inhibitor levels, for example, besides knowing where a particular ingredient has been ineffectual. But the central issue in each case is one of digestibility.

The first requirement in feeding the pig after weaning is to provide a highly digestible diet because of the animal's still-immature digestive system. When protein is highly digestible, its amino acids are readily available to the pig for use in healthy growth. By contrast, a protein source with poor digestibility not only wastes an expensive input, it also consumes extra energy in its disposal and it sends undigested amino acids into the colon where undesirable gut flora may develop so that the piglet suffers from diarrhoea.

Litter size effect

Diet selection for young pigs before weaning must also address changing circumstances brought by extra farm productivity, according to another Danish speaker to the SFT meeting. Dr Flemming Thorup, pig researcher with Denmark's Agriculture & Food Council, drew attention to data from breeding units showing that modern sows are giving birth to more piglets.

As an example, a research report from Denmark at the start of 2011 commented that the number of pigs born nationally in each farrowing had increased steadily for 15 years and was now at an average of 16.1 pigs per litter.

Although this may be a good basis for greater efficiency in pork production, the report commented, larger litters tend to mean smaller pigs at birth and therefore a bigger risk that they will die prematurely - either during the farrowing process or shortly afterwards.

Dr Thorup's presentation to SFT highlighted Danish investigations of another effect, which is the negative correlation between litter size and the weight of the pigs at weaning. This probe in Denmark found that each additional piglet in the litter was associated with a reduction on 150 grams in the weaning weight at 24 days old.

The relationship held true whether the size of the litter went from five pigs to seven or from 13 pigs to 15, he commented.

What is more, supplementary creep feeding of piglets did not seem to compensate for the slower growth of piglets in the larger litters.

Fighting edema in piglets with nutrition

Depending on market restrictions, there are various approaches that can be used to tackle edema in piglets.

Ioannis Mavromichalis, PhD

Edema, or oedema, disease is a complicated yet quite frequent gastrointestinal disorder affecting millions of piglets each year.

Major symptoms include disorders of the nervous system, puffy eyelids, sometimes diarrheas, lameness, loss of appetite, depressed performance, poor overall condition, and of course, elevated mortality.

The best advice that could be offered is veterinary intervention and a high level of health status throughout all farm operations. Nevertheless, even under the best veterinary and management care, edema still emerges in certain farms. In these persistent cases, a number of nutritional intervention strategies are available to at least alleviate the symptoms of this disease, if not completely prevent or cure it.

It must be emphasized here that not all such nutritional strategies work in every farm, so their employment should be considered as part of a greater overall program against edema.

As edema disease is thought to be triggered by certain serotypes of *Escherichia coli* bacteria, any dietary measure effective against normal colibacteria (causing piglet diarrhea) are usually effective against serotypes causing edema disease.

TABLE 1: Comparison of piglets with edema fed egg immunoglobulins

	Control	Immunoglobulins
Mortality (%)	10.0	5.2
Medicine cost (Euro/pig)	11.5	7.0
Weight gain (g/day)	402	442

Source: EW Nutrition, Germany.

Piglets fed egg immunoglobulins fared better under an edema disease attack.

Edema can lead to depressed performance, poor overall condition and elevated mortality.

Zinc oxide

Edema disease is more prevalent in areas of the world where antibiotics and other antimicrobial agents are restricted in their use.

For example, piglets imported from southern Denmark to be finished in northern Germany (literally a cross-border transfer) are almost invariably without any symptoms. But, they quickly break down with edema disease once in Germany, something not mirrored in Denmark when similar pigs are transferred to finishing facilities there.

This has been attributed by many field experts to the lack of zinc oxide in German piglet diets, due to a ban of this ingredient. Thus, where allowed, zinc oxide is considered a good supplement to be used against edema disease. Usually, 3,000 parts per million of Zn are considered adequate to treat Escherichia coli infections.

Antibiotics

In a recent study in Denmark, 27 isolates of *E. coli* O139, which triggered edema, were evaluated against their resistance to well-known antibiotics. All 27 isolates were sensitive to colistin, gentamicin, apramycin and amoxicillin/clavulanic acid. Resistance to sulphonamide was found in 80% of the isolates.

Clearly, in many areas of the world where antibiotics are still allowed, their use greatly helps against the occasional flare up of edema. The correct antibiotic to be used should be left at the discretion of the attending veterinarian.

Dietary protein

Most pathogenic bacteria, including *E. coli*, feed on protein and, it makes sense to offer them less of a substrate to proliferate. To this end, the dietary protein level in diets for piglets suffering from edema disease should be lowered by 2-4 percentage points, while rebalancing the amino acid profile. To the same effect, increasing dietary protein digestibility also helps reduce undigested protein reaching the hind gut. The use of crystalline amino acids and highly digestible protein sources greatly help in this direction.

Alternatively, a lower-density diet may be offered, but this might also result in depressed performance due to lack of nutrients for growth and development. In this case, the least worst case scenario should be weighed against financial losses.

» Fighting edema

Other minerals

Apart from zinc oxide, copper sulfate, if and where still allowed, up to 250 ppm of Cu in the complete feed is also beneficial against bacterial infections, especially during the later stages of the nursery period.

It has also been shown that reducing the amount of calcium in the diet (for example a maximum of 0.8% Ca in the first post-weaning diet is recommended) improves stomach pH conditions, creating a less favorable environment for bacterial growth. Finally, it is important to keep in mind that *E. coli* thrive on an iron-rich substrate, and it might be beneficial to limit this nutrient to minimal levels required for growth.

Ingredients

It is quite widely accepted that reducing or removing soybean meal from piglet diets greatly reduces the incidence of gastrointestinal disorders, including edema disease.

» Limiting feed intake during the first four to five days is advocated «

Although replacing soybean meal with other more digestible protein sources markedly increases feed cost, this is strongly recommended in the case of piglets suffering from edema disease. Organic acids, and perhaps some plant extracts, are also quite helpful against bacteria as they tend to create an environment unsuitable for bacterial growth throughout the gastrointestinal tract, and especially in the stomach. Blends of organic acids with or without plant extracts are usually better than straight acids.

Enteric acidocis

Dutch researchers recently examined affected and healthy pigs from the same herd and concluded that although edema disease is closely associated with the presence of *E. coli*, dietary factors usually contribute or aggravate this disorder.

Affected pigs in this study exhibited symptoms of metabolic acidosis, evidenced by higher blood and intestinal acidity. It was speculated that toxins produced by *E. coli* in the gastrointestinal tract had a greater chance to cross the intestinal barrier in pigs suffering from metabolic acidosis, because increased intestinal acidity is associated with increased permeability. Therefore, nutritional intervention strategies in the face of an edema disease outbreak may be beneficial. The optimal dietary electrolyte balance (Na+K-Cl) for diseased piglets may be different than that for healthy piglets, because a higher dietary electrolyte balance may prevent metabolic acidosis.

Feed management

Beyond the obvious suggestion of enhancing biosecurity, sanitation, and overall animal housing conditions, there are a couple of less known strategies for fighting edema disease.

First, limiting feed intake during the first four to five days post-weaning is strongly advocated in cases of high infective stress as this strategy reduces the amount of undigested feed reaching the hind gut. Also, the use of coarsely ground cereals instead of fine ones, and only uncooked, has been shown to further increase the overall health of the digestive tract in cases of severe bacterial infections. In addition, feed in meal form is preferable to pelleted feed when pigs are known to suffer from enteric diseases. Although these intervention strategies are quite effective in controlling gastrointestinal disorders, they also have the potential of limiting animal performance, and as such they should be employed with care.

Fiber

Based on empirical evidence, increasing dietary crude fiber by 2-3 percentage points has been shown to help against many types of bacterial infections. To increase dietary fiber, barley and oats, often just coarsely ground, are quite effective while being more nutritive than other sources of fiber. Similarly, beet pulp has been effective in many cases, but not always, for unknown reasons. Other sources of purified fibers have shown mixed results so far, but research is ongoing in this area.

Egg immunoglobulins

This is the latest method of addressing edema disease and it is, in fact, the only direct intervention method. Immunoglobulins are obtained from eggs that have been produced by hens hyper-immunized against strains of piglet-specific strains of *E. coli* known to trigger edema disease.

These immunoglobulins are then added directly in the piglet feed and once ingested reach the gastrointestinal tract. There, they bind to the specific strains of colibacteria for which they have been produced, rendering them ineffective.

A recent trial evaluated the use of egg immunoglobulins on a farm with strong problems of edema disease. Results (Figure 1) suggested that pigs fed with egg immunoglobulins specific against edema disease were about 2.5 kg heavier at 68 days post-weaning, while mortality was just above 5% compared to 10% in piglets fed diets without this supplement. Furthermore, treatment cost for medicines was significantly reduced. PIGI

More information

For more on piglet nutrition read Piglet nutrition: New targets for amino acids www.pig-international.com/20521.html

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Increasing pig finishing weight for quality meat

Producing quality, cost-effective pig meat by increasing finishing weights in socially responsible production systems

Experts in the UK have suggested that a 10% increase in pig carcass weight could potentially cut production costs by up to £0.04 per kg (MLC Report 2003). Although this figure is based on experience from a non-castrating market with relatively low slaughter weights, the same principle applies to other pig rearing systems.

Some significant costs are incurred on a per-pig basis, so the heavier pigs at slaughter the more these particular costs can be diluted. A simple example is sow feed: A typical sow might produce 20 slaughter pigs and eat 1,200 kg of feed per year (60 kg per pig). At a slaughter weight of 105 kg, each kilogram of pig produced has 'cost' the equivalent of 0.57 kg of sow feed (60/105), in addition to what the pig ate itself. At a slaughter weight of 145 kg, this figure is reduced to 0.41 kg.

Higher weight production

From the pig processor's point of view, increasing carcass weight can have similar financial benefits because, depending on equipment, the cost of processing a heavier carcass may be no higher but would provide a greater yield of saleable meat.

However, before switching to higher weight pig production there are a number of factors that have to be taken into consideration, if the change is to yield the expected results. With greater maturity, there is a tendency for fat deposition to increase and feed conversion efficiency to get worse.

Before switching to higher weight pig production a number of factors must be taken into consideration.

Excess backfat is a particular problem in castrated male pigs that do not benefit from superior feed conversion rates and lean tissue gains that are typical of intact boars. If castrates grow too heavy, then the increase in P2 may reach a level that is less desirable to processors. For example, castrates slaughtered at 130 kg may have a P2 of 18mm (MLC figure).

An answer to the problem of maintaining acceptable productivity at higher slaughter weights would be to raise entire boars. However, in non-castrating markets, heavier weights are associated with different meat quality problems – principally the higher risk of boar taint – and behavioural issues associated with boar behavioural patterns.

These heavyweight factors can be put in two broad categories: those affecting the farm, and those affecting the supply chain.

On-farm factors

Bigger pigs need more room. This isn't just a result of the increasing interest in animal welfare by consumers and legislators: It's necessary if pigs are to achieve their full growth potential. Pushing up slaughter weights also means keeping pigs longer in the finishing barn and coping with larger variations between individuals.

Depending on the pig production system being used, this has implications for the management of animal throughput and stocking levels. Physically housing, feeding and moving larger pigs may require an investment in farm infrastructure. EU animal welfare legislation, for example, stipulates that pigs with an average weight above 110 kg should each have a minimum of 1m2 floor area per animal; that's nearly double the minimum for pigs in the 50-85 kg bracket.

Single-sex groups are highly desirable »

» Quality meat

to minimize the difference in performance within the group as weight increases and to avoid unwanted sexual activity. Transport to the abattoir may have to be adjusted to make sure pigs have sufficient room. Larger pigs are also likely to exert more wear and tear on the farm environment – especially non-castrated boars.

Even in single-sex groups, sexual and aggressive behaviour between non-castrated males can become a management problem, leading to injuries, leg problems and in some cases a significant animal welfare issue. In well-managed units, the risk period is at the end of fattening—removing heavier animals from pens can disrupt established social hierarchies and lead to fighting between those remaining.

Similarly, mixing with unfamiliar animals, for example, during transport or at the slaughterhouse, can lead to stress and fighting between males, which in turn can lead to carcass damage and meat quality defects. Depending on the timing, pigs that are stressed before slaughter are more likely to produce Pale Soft and Exudative or Dark Firm and Dry meat, both of which are undesirable.

» Special care is **needed to raise heavier** pigs for quality meat. «

Although attempts are being made to reduce these problems, particularly the risk of boar taint by genetic improvement, an anti-taint vaccine Improvac from Pfizer Animal Health may reduce boar-like behaviour in the late fattening stage.

In addition to sex differences, genetics are important when considering slaughter weights. Both lean growth and feed intake are partially genetically determined and differences in performance between genotypes can increase at higher weights. Early maturing genotypes, for example, may show a significant fall in growth rate at higher weights and a rapid increase in P2.

Optimal feeding regimens and slaughter weights for heavy pigs have been the subject of much research. The ideal feeding regimen will vary from herd to herd and even between individual pigs: If you feed to suit the average pig, then by definition some will underperform.

Computer modelling programmes can assess the effect of different variables on production costs and output; remember that every farm and herd is different and you should find out what works best for you.

Areas to consider when raising heavier pigs

Clearly, the benefits of raising heavier pigs can be fully realised only if a number of factors are taken into consideration. These include:

- Do changes need to be made to the farm infrastructure?
- How can carcass quality be maintained in heavier castrates?
- In non-castrating systems, how will boar behaviour and boar taint be controlled?
- Do supply contracts need to be re-defined?
- Is the abattoir able to process bigger carcasses?
- Do waste management procedures need to be altered?

External factors

Bigger carcasses present a number of value opportunities for the pig processor. Seam butchery becomes easier, cutting along and between muscles and removing unwanted fat and gristle, to produce lean, well-trimmed cuts that are attractive to consumers. New cutting techniques allow a wider and more diverse range of products to be produced, and increased muscle bulk also facilitates the production of larger boneless joints and steaks. Meat tends to become more tender and juicier as the animal gets older, principally as a result of increased intramuscular fat deposits.

On the downside, castrates tend to lay down more fat as they get older. Unless the excess fat is trimmed, the result could be a less appealing product for consumers in many markets. Fat deposition can be limited by restricting feed intake, but this needs to be done with care as it can also affect other aspects of growth performance and meat quality.

In cases where pigs are sold to a buyer contract, the specifications will have to be re-defined if carcass size is increased. Likewise, the slaughterhouse needs to be equipped to accept bigger animals. If vaccination is used to facilitate the production of larger boars, the abattoir staff must be prepared to see pigs that behave like castrates but with testicles that will need to be removed on the line. It is essential to check that heavier animals are acceptable to the abattoir before implementing any changes.

Legislators and consumers are increasingly aware of environmental issues and in some markets these are being actively targeted for control. Several EU states have already introduced legislation to limit the amount of pig manure used per hectare of land – although these vary considerably.

Raising heavier weight pigs also has implications for waste handling. Heavier pigs eat more feed and create more waste, but this can be balanced by the reduced number of pigs required to produce a given amount of meat and the fact that the environmental impact is spread over more meat production. The particularly poor feed conversion rates of castrates means that the amount of waste that has to be dealt with per kg increases even more if such animals are reared. Waste management and the environmental impact need to be considered on a broad basis if pigs are to be raised to higher finishing weights.

Another problem attracting attention from both consumers and governments is animal welfare. In terms of heavier pig production, stocking levels, transport and castration are key areas of concern. In some markets, physical castration is being phased out and in others the compulsory use of anaesthesia is a possibility.

Special care is needed to raise heavier pigs for quality meat. PIGI

Improving piglet gut health with nutrition

Strategies for maintaining intestinal health after weaning

By Dr. Albert van Dijk, DVM

An important way to improve piglet intestinal health is with nutrition. In general, pig health is closely related to their nutritional status.

Nutritional deficiencies can result in intoxications, hypogalcatia, leg weakness, gastric ulcers, oedema disease and diarrhea. In pigs, the most important nutrition-related disease is post-weaning diarrhea and oedema caused by pathogenic *E. coli* bacteria. Improving health with nutrition is becoming increasingly important, as the use of antibiotics is becoming more restricted. For example, in the EU, antibacterial growth promoters were banned in 2006.

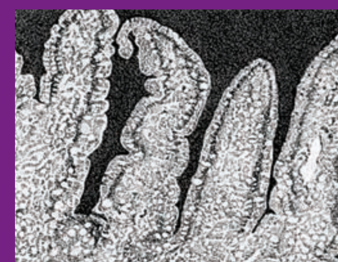

FIGURE 1: *A healthy intestinal wall has long, finger-shaped villi that provide an enormous surface for digestion and absorption of nutrients. In case of intestinal damage the villi are shortened, which impairs digestion and absorption. The nutrients are left over in the lumen as a substrate for bacteria, causing bacterial overgrowth and disease.*

» The intestine has the challenging task of absorbing nutrients while at the same time keeping bacteria, viruses and toxins at bay. «

How nutrition influences health

The surface of a pig's intestine is comparable to a tennis court. It is formed by villi and microvilli, enabling the pig to digest and absorb valuable nutrients from its feed (see **Figure 1**). However, this surface can also be used by pathogenic microorganisms to adhere to and enter the pig's body. The intestine has the very challenging task of absorbing nutrients while at the same time keeping bacteria, viruses and toxins at bay. To keep pathogens out, the intestine is equipped with the largest immunological organ of the whole body: the Gut Associated Lymphoid Tissue.

Because the intestine plays a crucial role in keeping pathogenic microorganisms at bay, it is important to maintain the integrity of the intestinal wall. The supply of all normal nutrients must be sufficient, because the intestinal cells are renewed every three days. The intestine takes its nutrients directly out of the intestinal lumen, which is called luminal nutrition. After weaning, it is essential that feed intake is kept at a maximum level. If not, the integrity of the intestine will be disrupted.

Certain nutrients, such as glutamine, butyric acid and propionic acid, are used as an energy source by the intestinal cells. Adding them to the feed can help keep the intestine in optimal shape. Also, antioxidants like vitamin E protect intestinal cells against oxidative damage caused by immunological reactions against pathogens.

Antibiotic alternatives

Several alternatives for antibiotics have been developed in the past decades. Antibacterial growth promoters suppress bacteria in the intestinal tract, leaving more nutrients for the pigs to grow. In fact, the alternatives for antibiotics do the same. Worldwide organic acids are used on a large scale because of their antibacterial properties. These acids, such as formic, lactic, propionic, benzoic and butyric acid, directly inhibit or kill undesired bacteria.

Essential oils are natural compounds a plant produces to protect itself against bacterial infections. They can be successfully applied as an antibacterial additive in feed. Essential oils penetrate the bacterial cell wall and prevent flaggelae from being formed (see **Figure 2**). The effectiveness of organic acids can be boosted by combining them with essential oils. In a challenge trial, weaned piglets were infected with *E. coli*. After infection, the faecal excretion of *E. coli* was measured daily. It was found that formic-lactic acid inhibited the *E. coli*, but combining these acids with an essential oil killed off the *E. coli*.

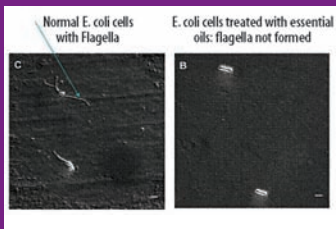

FIGURE 2: ***Microscopic picture of E. coli in a culture medium without additives (left) and with the essential oil carvacrol (right). Burt et al. 2007.***

Indirect suppression of bacteria

Undesired bacteria can be suppressed by preventing them from adhering to the intestinal wall. If bacteria like *E. coli* cannot adhere to the intestine, they cannot multiply and will be flushed out of the intestinal tract. One way to achieve this is to block the bacteria's binding sites with which they bind to receptors on the intestinal wall.

Bacteria need these receptors to adhere. The binding sites are located on the fimbriae of bacteria and are very specific (see **Figure 3**).

Specific antibodies that are present in spray-dried plasma can block them (see **Figure 4**). Certain mannan oligosaccharides also can block bacterial adhesion and colonization in a similar way.

Probiotics are beneficial bacteria that suppress pathogenic bacteria. Prebiotics are specific substrates for these beneficial bacteria. Too much Non Digestible Oligosaccharides and Non Starch Polysaccharides in feed can cause bacterial overgrowth leading to diarrhea. By lowering NDO and NSP levels in feed, diarrhea can be prevented.

Too much crude protein in feed creates undigested protein that reaches the large intestine where it is fermented by bacteria. These bacteria produce biogenic amines from the protein, and ammonia-like compounds irritate the intestinal wall causing diarrhea. By lowering a feed's crude protein level diarrhea can be prevented.

Influence immunity

At first sight, it seems appropriate to maximize the immune response of the intestine. This can be done by several immunostimulants like peptidoglycans and zinc. However, triggering the immune system requires quite some energy and amino acids (to produce immune cells and immunoglobulin), and in the worst-case scenario it could lead to undesired inflammation. Also, cytokines can be released leading to a drop in feed intake. In some cases, it may be better to temper the immune system rather than to stimulate it.

FIGURE 3: ***Schematic representation of an E. coli bacterium (below) binding specifically to the intestinal wall (upper part).***

The immune system can be tempered by lowering the contact of pathogens to the intestinal wall, and adding blood plasma to feed. The antibodies in the blood plasma bind to the bacteria and viruses, preventing them from coming into contact with the intestine. In addition, omega-3 fatty acids from fish oil reduce inflammatory processes.

Nutrigenomics

Nutrigenomics is the study of molecular relationships between nutrition and the response of genes. It determines the mechanisms behind the effects that nutrients have on health and performance. The goal of nutrigenomics is to make the beneficial genes work harder and better. For example, it has been found that in case of the intake of colostrum, sialidase mRNA is 'up regulated.' Sialidase makes holes in the bacterial cell wall. This may be an explanation of the positive effects of colostrum on health.

The challenge is to find out what other compounds have the same effect. Butyric and propionic acid are naturally produced by intestinal flora and play a key role in triggering beneficial genes or suppressing harmful genes. These acids reduce the invasiveness of *Salmonella* in poultry, and can stimulate the intestine to produce antibacterial peptides (defensins).

The intestine plays a key role in piglet health. Because antibiotics are more and more restricted, alternative concepts to suppress intestinal pathogens are needed. Measures such as increasing feed intake after weaning and lowering NSP, NDO and crude protein all have a positive influence on intestinal health. Main additives that have proved their effectiveness are organic acids, MCFA's, essential oils, blood plasma and vitamin E. PIGI

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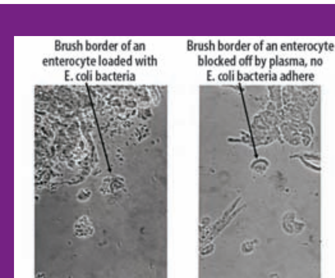

FIGURE 4: ***Microscopic pictures of piglet intestinal cells incubated with E. coli. In the right picture plasma is added which blocks the adhesion of E. coli. Van Dijk 2001.***

Feed strategies to protect sows from heat stress

Certain additives can help pigs cope with high temperatures

By Dr. Ioannis Mavromichalis

Because hot weather reduces feed intake, animal feed nutritionists and pig producers need to review sow feed formulas to better prepare them for high temperatures.

Pig producers usually reduce crude protein and fiber in feed, because these nutrients emit more heat during digestion and metabolism, compared with carbohydrates and fats. Lipids, fats and oils are added to formulations to increase dietary density, so pigs and livestock consume more energy, even though they reduce their overall feed intake when stressed. Synthetic amino acids are also included to maintain the ideal energy-protein balance to keep pigs growing.

But, none of these feed formulas fully restore animal performance back to normal, because for livestock to be able to consume the same amount of nutrients and produce the same quantity of "usable" product (meat, milk, eggs) would mean certain death from apoplexy due to heat stress.

While all of these feed formulas are used on most pig farms today, little consideration is given to additives that could equally help pigs and livestock cope with heat stress.

Effects of heat stress

Heat stress causes increased respiration rate. This leads to increased losses of carbon dioxide from the lungs, which reduces the partial pressure of carbon dioxide, and consequently the concentration of bicarbonate in the blood.

The ensuing lowered concentration of hydrogen ions causes a rise in plasma pH, a condition widely known as alkalosis. Blood alkalosis is considered partially responsible for depressed feed intake and the consequent impaired performance in heat-stressed animals. To this end, certain additives are known to be beneficial in restoring blood pH.

However, certain additives can help pigs cope with acute high environmental temperatures. Of course, any product or nutritional strategy that reduces the amount of heat generated during digestion and metabolism will help.

Additives to reduce heat stress

Chronic exposure to high ambient temperatures reduces the effectiveness of these additives as the organism begins to adapt via a number of other mechanisms.

Sodium bicarbonate. This additive is used mostly for pigs because it can improve feed intake under heat stress. Feeding sodium bicarbonate to young pigs is strongly discouraged as this ingredient tends to buffer stomach pH, which is already outside required limits in weaned piglets, reducing protein digestion.

Chloride salts. Potassium chloride and ammonium chloride can improve growth performance, as well as reduced pig mortality. However, high dosages of potassium chloride can have adverse effects. These salts also can be used in drinking water.

Vitamin C. Ascorbic acid is not required by mammals under normal conditions, but several research reports have demonstrated that an increase in vitamin C can help alleviate heat stress by

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Feed additives could do more than a dip in the sea to help reduce heat stress on sows during the hot summer months

reducing cortisol and ADH levels. Because an increase in Vitamin C requirements cannot be met by internal synthesis, external supplementation is required.

In pigs, Vitamin C supplements are best reserved for lactating sows that are under the most stress during the summer months, as they need to be able to consume large quantities of feed to cope with the large litters produced today. Vitamin C also can be administered in a water supply system, where its dosage can be easily altered to reflect anticipated heat waves. This is usually combined with an electrolyte pack.

Betaine. Also known as trimethyl glycine, betaine, derived from sugar beet, is a known osmo-regulator that helps animals suffering from water dehydration. Betaine balances water levels inside cells and alleviates the negative effects of accumulated inorganic ions that destabilize cellular enzymes and other proteins. It is specifically beneficial in cases where animals only have saline water to drink as this accentuates their predicament.

Sodium zeolite. A natural clay and anti-mycotoxin agent, sodium zeolite can reduce the effects of heat stress on laying hens and is likely to have a similar effect in other monogastric animals.

Although the exact mode of action in which this product affects the ability of animals to withstand heat stress is unknown, it is believed to act as a buffer in the gastrointestinal system, reducing alkalosis associated with panting.

Enzymes. Carbohydrases and proteases can help heat stress in an indirect way. Because they increase feed energy and nutrient density, they can help animals receive more nutrients per unit weight of feed they consume. This is most relevant in the case of energy and protein, and not so in the case of phosphorus.

Breaking down non-starch polysaccharides also can reduce direct heat production, because these compounds being hardly digestible pass on the lower parts of the gastrointestinal tract where they promote bacterial fermentation (that emits heat).

Additives are integral

No single additive or nutritional intervention strategy can restore animal performance reduction during acute heat stress. Nevertheless, along with feed formulation and feeding management, a number of additives should be considered in an integral approach.

Not all additives work the same in all species, and even within species there are classes of livestock that benefit more from a certain approach. So, leaving the usual formulae (as being used in the rest of year) unchanged for the summer is not an option! **PIGI**

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