SEPTEMBER 2015

Feeding young animals

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ALL ABOUT FEED
PIG PROGRESS
WORLD POULTRY

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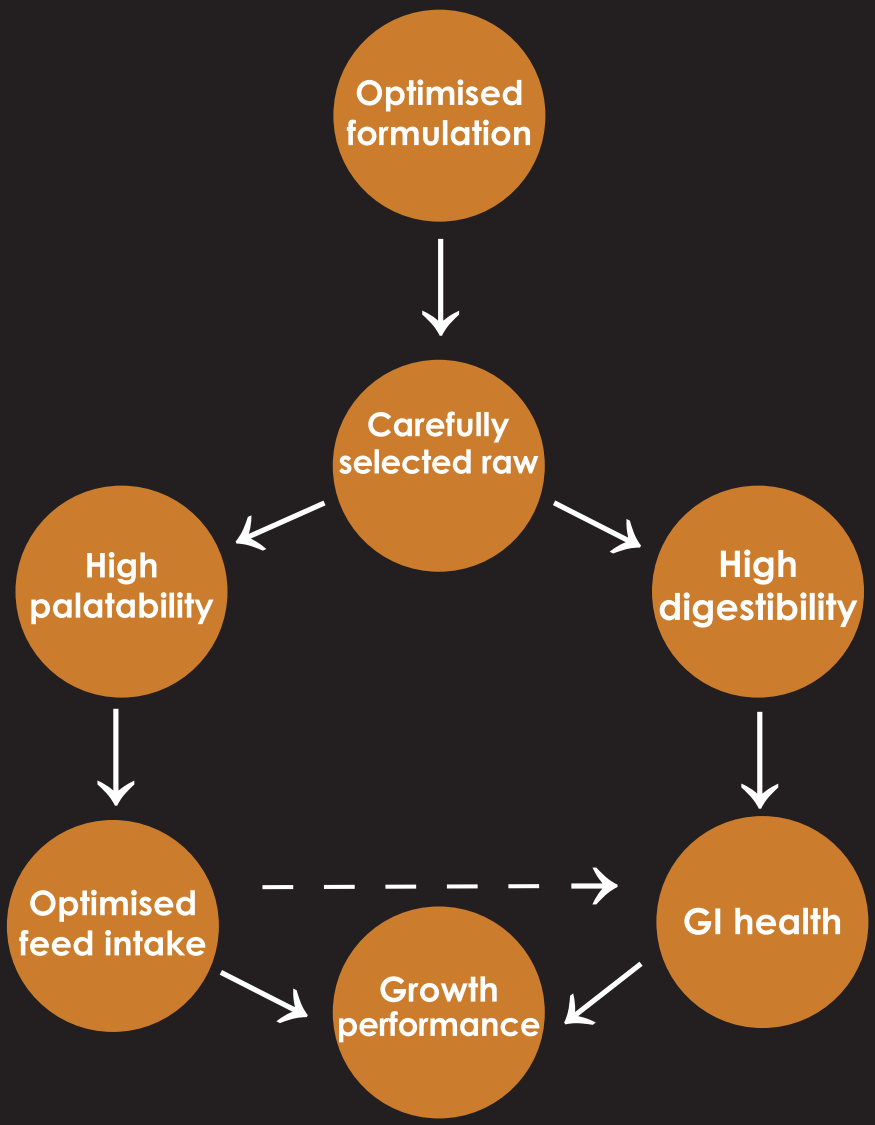
Fundamental criteria for successful weaning



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Neonate nutrition: A real game changer

How a farmer feeds the newborn calf, piglet or chick (neonates) should be the most important decision he or she makes. With an informed decision, the farmer will profit from giving the young animal a healthy start in life. The advantages of a good start in life is the basis and facilitates a healthy and profitable production period of the animal, hence literally having an effect on the profitability of the farm. For example: feeding a calf four litres of colostrum in the first six hours leads to cows that can be inseminated half a month earlier. This also results in 5% more cows reaching the third lactation. In pigs, farmers can reach slaughter weights earlier and poultry farmers experience improved egg production and meat production. Above all: good neonate nutrition facilitates a stronger and healthier animal, equipped with better protection mechanisms to fight pathogens and other challenges that it will encounter in life. This is partly due to the fact that proper feeding in the first days or weeks triggers the complex and dynamic ecosystem called the gastrointestinal microbiota. Hence, it can activate certain immune responses and promote feed intake. The importance of neonate feeding can therefore be a real game changer and is therefore a topic of intense interest. Luckily, our industry is acknowledging this and confirms that investments in strategies and supplements in FEEDING YOUNG ANIMALS are paying off. This in turn has been reflected in more research among them to further fine tune the neonate feeding practises. We have tried to capture a selection of this ongoing and exciting research, done by major players in the animal feed industry, in this special magazine. Enjoy!

Emmy Koeleman, editor *All About Feed, Dairy Global*

COLOPHON

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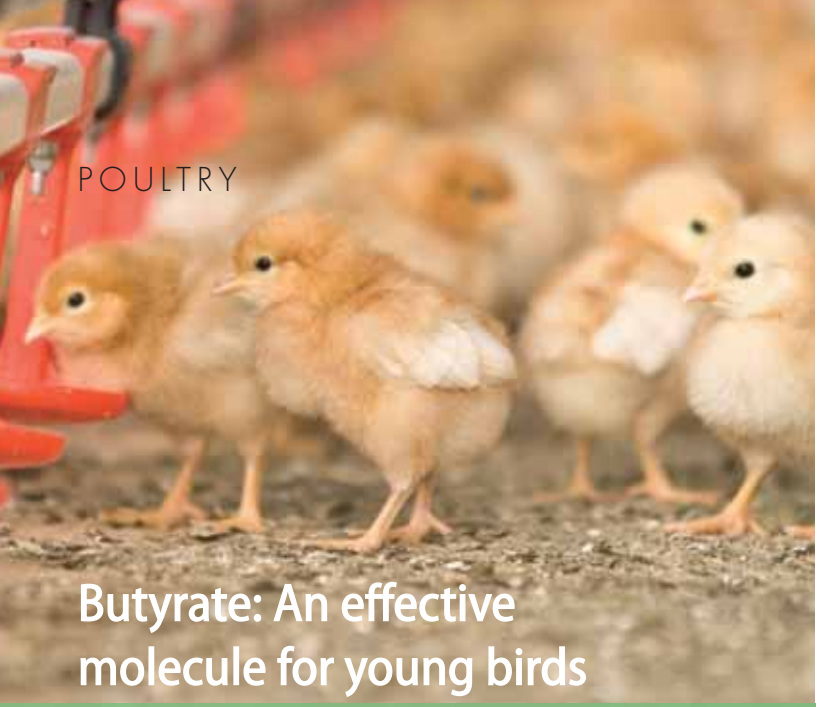

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Getting off to the healthiest start possible

PHOTO: DREAMSTIME

Nutritional programming is an extensively studied concept in human nutrition. It means that nutritional choices during pregnancy and after birth can make significant changes for the human being later in life. And this is true for animals as well.

By Emmy Koeleman

New parents are subjected to all kinds of contradictory advice regarding feeding their newborn child. Although the advisers may not always be right, their intention is good; getting the infant off to the healthiest start. What a human eats as a baby and child strongly affects the long-term body weight, health, metabolic programming, immune system, and overall aging. Experts in the field of human nutrition often refer to this concept as 'nutritional programming'. In human nutrition, this concept is widely studied with regards to programmed changes in the child's body and the effect on the health status as an adult. According to dairy food company and infant food producer Danone, it is all about getting the first 1,000 days of the child right. "This is the time in a young life when nutrition can have an impact that lasts a lifetime. Early life nutrition has a significant role on the brain and immune system development, as well as how the body metabolically reacts to foods or nutrients that in turn may influence the likelihood of developing conditions such as obesity, allergy, heart disease and diabetes in later life," they state in their communication to new parents.

Meta-study in Dutch women

Nutritional programming (or metabolic programming) is an intriguing phenomenon. And whether you talk about humans or animals, the concept remains the same. Some of the human nutrition studies regarding this topic show interesting results. A study in the early 1990's for example showed a strong correlation between low birth weight and the risk for chronic diseases such as type 2 diabetes. Babies below a birth weight of 2.5 kg showed to have more changes to develop this disease at a later stage of life, compared to babies that are heavier at birth. Another great study was done in the Netherlands, where they looked at Dutch women during the Second World War that gave birth in these harsh conditions. Despite this historical disaster, this group of women provided a unique opportunity to study effects of undernutrition during gestation in humans. These women clearly experienced undernutrition: In September 1944, there was an embargo on all food transports to the Western part of the Netherlands. Between September 1944 and April 1945, a harsh winter with an extreme shortage of food was experienced. The researchers found indications that undernutrition during gestation affects health in later life. The effects on undernutrition, however, depend upon its timing during gestation and the organs and systems developing during that critical time window. Furthermore, these Dutch findings suggest that maternal malnutrition during gestation may permanently affect adult health without affecting the size of the baby at birth.

Spreading to the animal feed sector

Although nutritional programming is becoming a real hot topic in human nutrition, the interest to apply this to young animals is gaining interest as well. And some of the results seen in humans and rodents might be useful for animal nutritionists as the correlation between infant nutrition and obesity might be comparable with young animal nutrition and its effect on weight gain or fertility in adult farm animals. Although many studies have been done on farm animals, it seems that feed companies have only recently started to acknowledge that young animal nutrition is a big part of successful farming. Getting the right amount of feed and nutrients to the young animals (before and after birth) will facilitate that they perform better later on in life. And it is not only about having the right genes (considering that cows do not use 30-40% of their genetic potential for milk yield). Proper nutrition can have a significant impact and can trigger animals to use their genetic potential better. At a recent feed symposium in the Netherlands, Swiss veterinarian Martin Kaske stated: "We should invest more in feeding the young calf, as this has a huge impact on subsequent performance in later life. At the moment, this is not the focus of the farmer (yet)." He also explained that higher feeding intensity in the first weeks of life has both short time as long term effects. The short term effects include better growing and healthier animals. On the longer term, effects are seen in better milk production, better mammary development and younger breeding age. For example: feeding a calf four litres of colostrum in the first six hours leads to a cow that can be inseminated half a month earlier. It also leads to 5% more cows reaching the third lactation. In swine, a strong correlation has been observed between low birth weight and lower live weight at slaughter. Also postnatal feeding intensity seems to affect subsequent fertility in pigs and piglets that drink less colostrum have a higher risk of dying.

Financial implications for farmers

Based on the results from human studies, combined with the challenges faced in the animal production sector (e.g. higher feed costs, tighter margins for meat, increased demands from consumers), we can certainly state that neonate nutrition deserves even more attention than we did before. When seeking to maximise animal performance, efficiency and intestinal health, it's critical to focus on proper feeding of young animals so as to deliver greater returns. It's all about increased incomes for the farmers from such things as reaching slaughter sooner, heavier animals or more milk production. In other words, the neonate phase in an animal's life can have a significant effect on growth rate, feed conversion and milk production all of which have financial implication. A good start is half the battle won.

References are available on request.

Malnutrition early in life may increase the risk of developing conditions such as obesity, allergy, heart disease and diabetes when the child reaches adult life. The concept of early nutrition and its effect later in life also accounts for animals.

Raising the genetic potential

How an animal is managed in early life has an effect on the expression of its genetic potential for the rest of its productive life. That, in short, is the basis of the recently launched LifeStart program philosophy. How does it work in practice?

By Leonel Leal, Cibelle Torres and Sandra Paredes,
Trouw Nutrition R&D

Since its inception, the LifeStart programme has been associated with attaining high performance in animal production, helping farms make the vital connection between neonatal animal nutrition and increased health, performance and convenience. As a science-based company, Trouw Nutrition is extending the benefits of its programme performance to a number of species. =Behind this progress are innovations and insights related to the specific metabolic functions of animal species including ruminants, swine and poultry, confirming along the way that the theoretical underpinnings of the concept translate to real advantages on farm.

Explosive population

One need only look at the explosive global population growth and the direct, and indirect, pressures it brings to people and the planet to understand the need for more efficient and sustainable farming practices. Over the next 40 years, the world will have to produce more food than it has over the last 8,000 years combined.

What is more, each year, we consume 50% more resources than the planet can replenish. Even if the farming industry could keep up with this growth through traditional farming methods, environmentally it would be unsustainable. To meet the growing food needs, the industry must find ways to double food production while halving the impact on the planet.

The good news is, for much of the world, agricultural productivity is growing. For the last 20 years, this growth has come not from the intensification of inputs (increased labour and investment per ha), but from getting more output from existing resources. The chart (*Figure 1*) shows the sustainable advances reached in the Netherlands. In spite of these gains, the full genetic potential of livestock remains an untapped resource. Presently, the productivity of farm animals is estimated to be 30-40% below their genetic potential due to sub-optimal conditions and health status. Innovations aiming to narrow the gap between genetic potential and performance, on farm level, are needed. LifeStart is dedicated to reducing the gap to 20% by providing farmers with natural and sustainable solutions to help improve the health and performance of animals.

Practice meets science

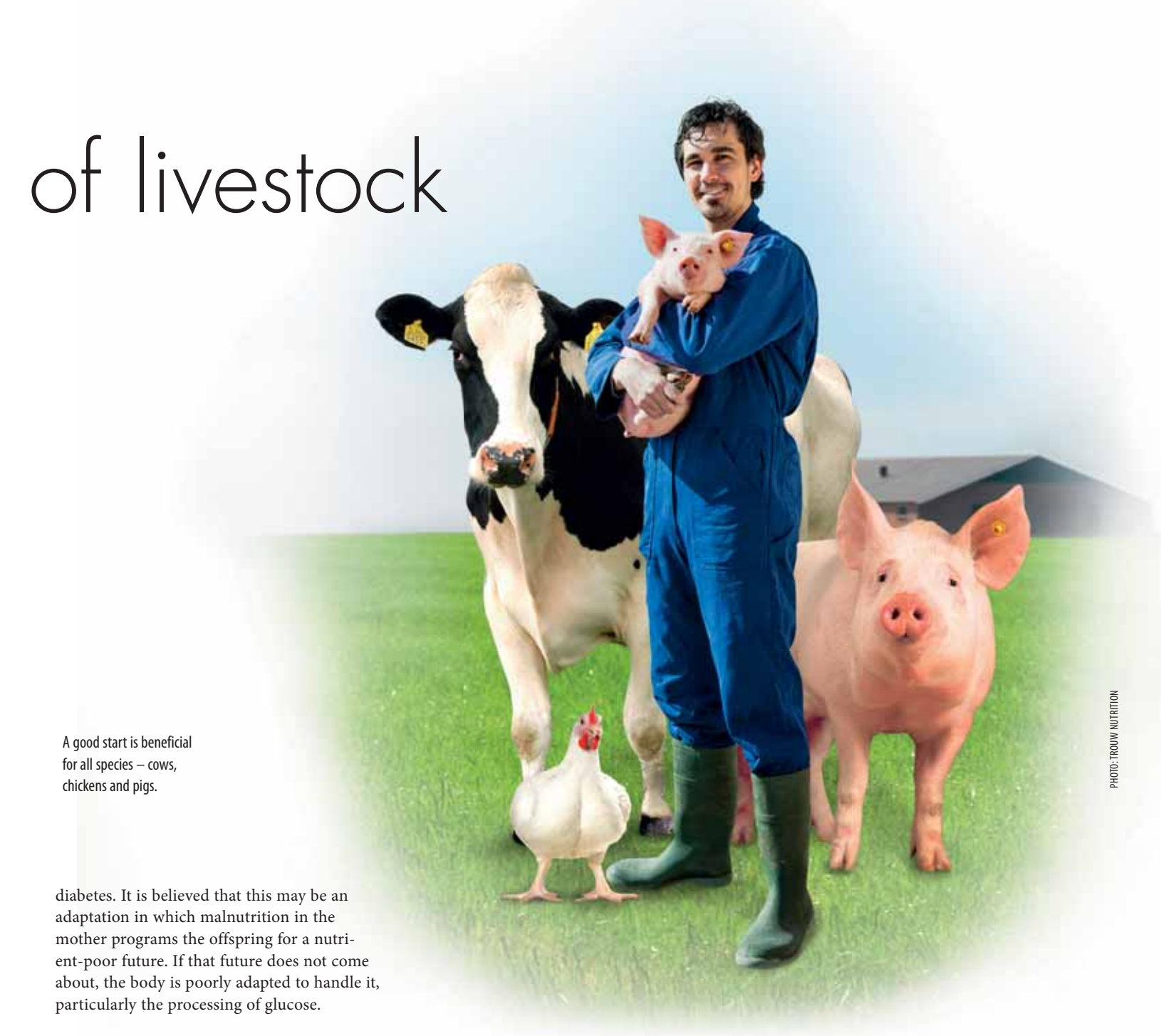
How can the industry tap into this potential? In many cases, it is a matter of practice catching up with science. Take the example of dairy farming. For many years typical calf rearing practices consisted of putting newborn calves on a restricted liquid feed diet up until weaning. This helped the farmer to reduce feed costs while facilitating the transition to dry feed. It was considered, and continues to be considered in many places, if not a best practice, at the very least a 'best compromise'. In the 1960s, however, research began to emerge suggesting that restricted diets could actually have a life-long negative impact on an animal's overall productivity. In this new light, restricted feeding was actually creating an undetected negative trade-off for the farm. Parallel situations can be found in the case of swine, poultry and other livestock – that is, nutritional shocks that were the result of logistical, economic or other external considerations were deemed acceptable, often with the notion that any early losses could be compensated for later in the animal's life.

Today, the relationship between neonatal nutrition and genetic potential has been established. Nutritional insults that were once tolerated as an inevitable part of the livestock farming process now provide us with a GPS indicating where practices must change in favour of early nutrition.

The rise of epigenetics

In different species, numerous research studies show that increasing nutrient supply in early life results in increased first lactation milk yields, improved performance and life span. The answer to this lies in the science of epigenetics, which refers to changes in gene expression that do not involve changes to the DNA sequence. An epigenetic change is a common and natural phenomenon induced by environmental factors. In simple terms, how an animal is managed in early life has an effect on the expression of its genetic potential for the rest of its productive life. The studies underpinning these conclusions are part of a wider body of research drawn from a broad number of species including humans, rodents, bees, swine and ruminants. In numerous situations, early nutrition, either pre-natal or post-natal, can have a programming effect on the phenotype of the offspring. The so-called 'thrifty phenotype' hypothesis, a case of 'metabolic programming' that has been validated across a large number of studies, establishes the relationship between low birth weights in human babies and a heightened incidence of type 2

# of livestock



A good start is beneficial for all species – cows, chickens and pigs.

PHOTO: TROUW NUTRITION

diabetes. It is believed that this may be an adaptation in which malnutrition in the mother programs the offspring for a nutrient-poor future. If that future does not come about, the body is poorly adapted to handle it, particularly the processing of glucose.

Super powered organs in dairy

Those phenotypic changes can include modifications to the size and productivity of key organs in offspring. Dr Fernando Soberon of feed and health company Shur-Gain USA, part of Nutreco, suggests: "When we compare calves fed a specific diet that enables a higher plane of nutrition pre-weaning to calves fed at a normal feeding level we find a significant difference in the development of key organs." Animals benefitting from higher nutrition prior to weaning had larger livers, kidneys and mammary glands as a percentage of body weight. "Most significantly," says Soberon, "the weight of parenchyma, the essential functional elements of the mammary gland also increased, laying the permanent foundation for a more productive life as an adult."Indeed, in a calf study measuring the effects of liquid feed intake during the first 60 days, calves fed increased levels of milk replacer registered mammary parenchymal tissue weights that were six times greater than those of calves whose milk intake was restricted. This indicates a direct effect of nutrient intake with parenchymal proliferation in the first months of life.

High performance in pigs

Pig farming has provided an ideal test-bed for the systematic application of metabolic programming as the results are relatively easy to measure and compare. The pig industry faces unique challenges as farm and litter size expand in the relentless search for sustainable efficiency. The aforementioned LifeStart programme has the potential to help the global swine industry take a quantum leap forward by better preparing piglets for optimal growth. To start with, the uterine environment during gestation is fundamental to optimal development of a sow's offspring. This is reflected even during embryo development, as well as later, when foetal muscle development is affected by the dam's nutritional status. Nutrition of the peri-parturient sow, and her body condition,

Figure 1 - Development of energy use, carbon footprint and land occupation in the dairy, pig and poultry sectors.

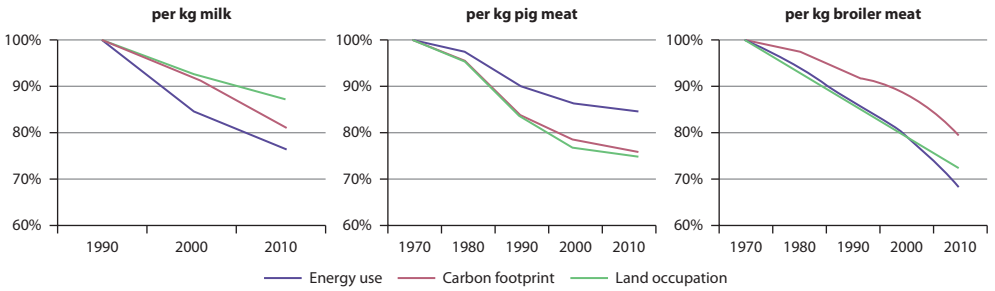
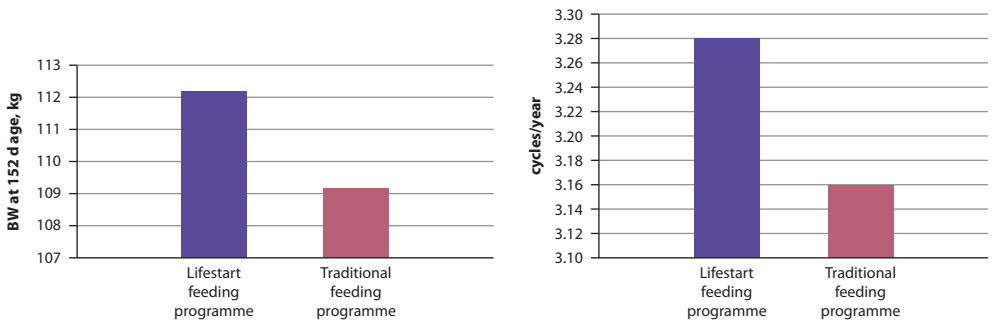
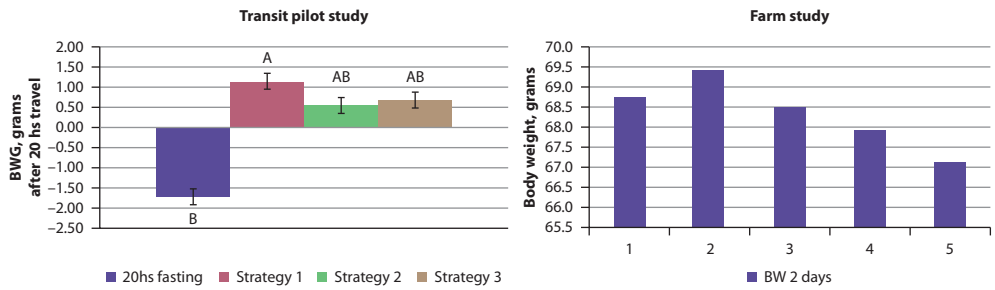


Figure 2 - The effects of high quality nutrition in early life.



Source: Practice research from Inssolpig, Belgium, 2015.

Figure 3 - Effects of different feeding strategies for recently hatched chicks.



Source: Trouw Nutrition R&D, Spain, 2015.

impacts the farrowing process and colostrum production. This, in turn, provides the neonate with optimal conditions. During the first days of a piglet's life the stomach and intestines grow rapidly. To support this process, the sow's colostrum and early nutrition are essential in promoting the desired intestinal development. Moreover, pre-weaning supplements can induce accelerated maturation of the digestive system to prepare the piglet for greater and healthier growth.

In early life, the newborn pig has very few immune relevant cells in the gut and its associated lymphoid tissues. Initially, they are protected only by maternal immune factors provided through sow milk and at the moment of weaning its immune system is not yet mature. Therefore, the impact of an abrupt removal of maternal protection, coupled with stress and infection pressure, results in an immunity gap. Through the addition of functional nutrients, the immune system of the young pig can be augmented to ease transition, while reducing the need for antibiotic interventions and allowing the pig to focus all energy and nutrients for growth.

Trials conducted by Trouw Nutrition show that nutrition in the early life of pigs affects overall performance. By offering milk replacer in addition to sow milk in the first two weeks after birth together with high quality diets up to six weeks of age, pigs accrue short, medium and long-term benefits. Pigs are heavier at the end of the nursery phase, advantage maintained up to slaughter; batches are more homogenous and there is a reduction in the number of days to reach slaughter weight, with higher quality carcasses. Light weight pigs, which are more prone to disease and mortality in early life, especially benefit from this strategy, with enhanced within-batch homogeneity. The impact on farm economics is significant as it leads to higher throughput and more meat produced per m^2.

Breakthroughs in poultry performance

In the area of poultry, the variable time between hatching and first feed means that those important nutritional windows are frequently missed, compromising the growth of chicks. While first access to feed occurs on the broiler farm, the path to that moment can be long, such that a so-called day-old chick can actually be well within their third day before feeding.

Trouw Nutrition R&D is developing different nutritional strategies in order to improve the performance of chicks starting at the earliest stages. In the hatchery, immediate access to feed in the post-hatch period has been shown to enhance tissue development (i.e., gastro-intestinal tract and immune system development). *Figure 3* shows the results of different feeding strategies for recently hatched chicks.

While metabolic programming and the epigenetic adaptations that underpin it have been part of scientific knowledge for some years, only now is it beginning to have practical and widespread application in the area of production animal performance. But metabolic programming requires another level of adaptation: on the part of livestock professionals. They must adapt their techniques, farm management practices, logistics and economics to a new guiding principle - that any compromise in early nutrition is ultimately a compromise in farm performance.

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Feeding cows to **nourish** the dam and the calf

PHOTO: ROBIN BRITSTRA

Nourishing the pregnant cow benefits the offspring's health and production later in life. Therefore, the energy balance and nutrition of the pregnant cow must be given proper attention.

By Alex Bach, Department of Ruminant Production, IRTA, Barcelona, Spain

Nutrient supply and hormonal signals at specific windows during development (both pre- and early postnatal) may exert permanent changes in the metabolism, as well as changes in performance, body composition, and metabolic function of the offspring of livestock. This is due to processes generically referred to as foetal programming and metabolic imprinting. Thus, it is likely that the cow of today, with high milk yield but also reproductive and metabolic challenges, is not only a consequence of genetic selection, but also the result of the way her dam was fed and the way she was fed early after birth. This article reviews the recommended feeding practices for pregnant cows and the potential connections between nutrition of the dam and metabolic function, milk production, reproduction, and susceptibility to disease of the offspring, as well as future milking performance of the dam.

Nourishing the pregnant cow

Since the early 1990's (and especially after the release of the NRC model in 2001, which recommends energy densities around 1.60 Mcal of NEl/kg during this period) late pregnant cows have been fed high-energy rations in the immediate pre-calving period to 1) compensate for the assumed decrease feed intake as calving approaches, 2) minimise body fat mobilisation, ketosis, and fatty liver after calving, 3) adapt the rumen microflora towards a high nutrient dense ration (that will be fed post-calving), and 4) foster the growth of rumen papillae to minimise the risk of rumen acidosis during lactation through an improved absorption (and removal) of volatile fatty acids from the rumen. The first two objectives (compensate reduction of feed intake and minimise body fat mobilisation) do not seem to be attained by feeding high-energy diets before calving. The third objective (adapting the rumen microflora to a high-starch diet) is also debatable. In ruminant nutrition it has typically been assumed that at least three weeks are needed for the rumen microflora to adapt to a dietary change. However, the vast majority of organisms in the rumen are bacteria and they can double their population in as quickly as 20 minutes. Thus, three weeks seems like an extremely long time to consolidate a change in terms of bacteria lifespan. In fact, researchers have recently evaluated changes in the rumen microbial population when shifting steers from a prairie-based diet to a high-grain ration. Within a week of each step-up (animals were gradually moved to a high-grain diet), the authors already reported drastic changes in the rumen microbial population. Lastly, the fourth objective (fostering growth of rumen papillae) could also be argued. The NRC (2001) made this recommendation based on a study from 1985 that compared the characteristics of rumen papillae between cows fed a straw-based gestation ration to a high concentrate lactation ration. However, studies substituting barley for forage in the diets of late-gestation dairy cows, in an attempt to increase rumen acid

load and alter rumen volatile fatty acid concentrations, had no effect on rumen papillae characteristics or subsequent lactation performance. Furthermore, a more recent study that compared a high fibre diet vs the same diet plus additional 800 g/d of barley pre-calving reported that total mass of rumen papillae excised from the floor of the cranial sac was not affected by transition diets, but the number tended to be greater when barley was fed, and this was associated with a marked reduction in average width, which resulted in a reduced average surface area. Thus, it would seem that there would be no need to 'adapt' rumen papillae before calving by providing high-starch diets.

Nourishing the calf

Most of gestation, especially the first two-thirds, in the lactating cow coincides with lactation, and embryonic development must compete for nutrients against the demands of maternal milk production. Nutrition is among the most influential intrauterine factors dictating placental and fetal growth. In dairy cattle, there is little information about the potential effects of the maternal metabolic status on subsequent metabolic function of the offspring, and nutrient requirements associated with early pregnancy are ignored and unknown (NRC, 2001). However, embryonic metabolic activity is high and it is a critical period for organogenesis and tissue hyperplasia and foetal development is most vulnerable to maternal nutrition around the peri-implantation period and during rapid placental development. Several studies have reported clear effects of undernutrition during pregnancy on birth weight. In addition to obvious effects on birth weight, maternal (and foetal) nutrition can have long-term metabolic consequences that might be less obvious to identify. For example, a study done in 2000 illustrated the importance of foetal metabolic environment on future metabolic function of the offspring when, in a study involving Pima Indians (a population with a great incidence of type II diabetes), they reported that siblings born to mothers that had diabetes had twice as much risk of having type II diabetes than those that were born before the mother had type II diabetes. Thus, the foetal environment clearly programmed the metabolism of the offspring and its consequences were seen later in life, not at birth. Whether this phenomenon occurs in dairy cattle is not well known. In 2007, it was reported no significant effects of maternal milk production during pregnancy on subsequent offspring milking performance in the first lactation,

It is important to nourish and proper feed the pregnant cow to make sure the fetus and newborn calf don't have to deal with deficient amounts of macro and micronutrients.

but other researchers found a negative relationship between milk production of the dam and milking performance of the offspring in the first and third, but not second, lactations and concluded that the majority of the maternal effects in progeny performance were due to factors other than maternal milk production. The lack of an association between milk production and long-term effects on the offspring is most likely due to the fact that different milk production levels can occur with distinct metabolic environments in the dam (i.e., negative, neutral, or even positive nutrient balances), and thus, it seems clear that it is the latter, not milk yield per se, that may exert modifications in the metabolic function of the offspring.

Protein deficiency has an effect

It was also shown that protein deficiency (i.e., 65% of recommendations) may compromise the reproductive performance of the offspring. For instance, in primiparous beef cows during the last 100 days of pregnancy delayed age at puberty of the progeny, whereas heifers born to dams supplemented with protein during the last third of pregnancy had increased pregnancy rates compared with heifers born to non-supplemented dams. Furthermore, protein deficiencies at the end of the gestation seem to alter the hormonal content of the colostrum and this, in turn, may compromise intestinal maturation and the immune passive transfer of the calf. Linear decreases in protein intake during the last 100 d of gestation resulted in linearly impaired serum IgG concentrations in the calf, despite the fact that IgG concentration in the colostrum and amount of colostrum consumed by calves was not affected. In 2010, researchers illustrated that a moderate (i.e., ~80% of recommendations) nutrient restriction during early to mid-pregnancy of beef cattle altered the jejunal proliferation and total intestinal vascularity of the foetus, which could alter the capacity for IgG absorption.

Sufficient amounts of micronutrients

Although macro nutrient requirements (energy, protein, etc.) for embryonic growth are low in early pregnancy, it is likely that the embryo is sensitive to deficiencies of micronutrients such as specific amino acids, vitamins, etc. as well circulating concentrations of hormones and growth factors. For example, arginine, leucine, and glucose are essential for the correct development of the histotroph. Also, vitamin A is important in regulating early lung development and alveolar formation, and thus maternal vitamin A status is an important determinant of embryonic alveolar formation and respiratory health. It was recently reported that, in humans, vitamin A supplementation of deficient pregnant mothers greatly improved the respiratory health of the offspring. Methionine has been identified as a limiting amino acid in both lactating and dry cows. Methionine has been reported to be transported into bovine embryonic cells and to participate in the regulation of translation and DNA methylation. Thus, perturbations in the methionine-homocysteine and folate cycles, associated with inadequate methionine supply during development stages, may lead to hypomethylation of DNA and dysregulation of gene expression and metabolism of the offspring. In 2007, evident changes were reported in the methylation status of lambs born to mothers with a restricted supply of methyl donors (i.e., vitamin B12, folate, and methionine) compared with those born to ewes under physiological ranges. Vitamin B12 is a water-soluble vitamin produced by rumen microbes for their use and use by the host animal. In early lactation, dairy cattle fed supplementary folic acid and rumen-protected methionine were observed to have lower-than-optimal levels of vitamin B12, confirmed by reduced serum methylmalonic acid concentrations and increased milk production of primiparous cows given weekly intramuscular vitamin B12 injections; thus, it could be hypothesised that the foetus of cows that become pregnant in early lactation may experience some shortages of vitamin B12, and thus, potentially, a shortage of methyl donors and some dysregulation in gene expression. In fact, in humans, a clear correlation between vitamin B12 status and the degree of methylation of the offspring has been recently documented. Furthermore, reduced methylation of several genes in cord blood DNA has been associated with increased folic acid intake during pregnancy and genome-wide DNA methylation in cord blood DNA correlated inversely with maternal plasma homocysteine concentration.

Conclusion

Most of gestation, especially the first two-thirds, in the lactating cow coincides with lactation, and embryonic development must compete for nutrients against the demands of maternal milk production. It is therefore important to nourish the pregnant cow and to make sure enough macro and micronutrients are available. It was also shown that protein deficiency (i.e., 65% of recommendations) may compromise the reproductive performance of the offspring. Adequate nutrient supply to the foetus in the form of micronutrients (such as vitamins and amino acids) is key. Vitamin A for example is important in regulating early lung development and alveolar formation. It can be expected that in the near future, pregnant cows will be supplemented with specific amounts of nutrients to ensure optimal foetal development.

References are available on request.

Effect of heat stress on newborn calves

Not only the nutritional environment may program or alter the metabolism of the offspring. For instance, Tao and Dhal (2013) reported that heat stress in late gestation decreases birth weight of newborn farm animals, which reflects compromised foetal development in utero. Interestingly, foetal growth retardation under heat stress is independent of the nutritional status of the dam. Furthermore, it was described that heat stress of the dam during the dry period compromises immune function of offspring from birth through weaning. Across many species under thermoneutral conditions, the foetus has a consistently higher body temperature relative to its dam, which is mainly due to poor heat exchange with the dam and about a 2-fold greater metabolic rate of the foetus relative to that of the dam. Interestingly, calves born to heat-stressed dams have greater insulin concentrations (which may suggest a state of insulin resistance) relative to calves born to cooled dams when consuming the same amounts of colostrum the first four days after birth.

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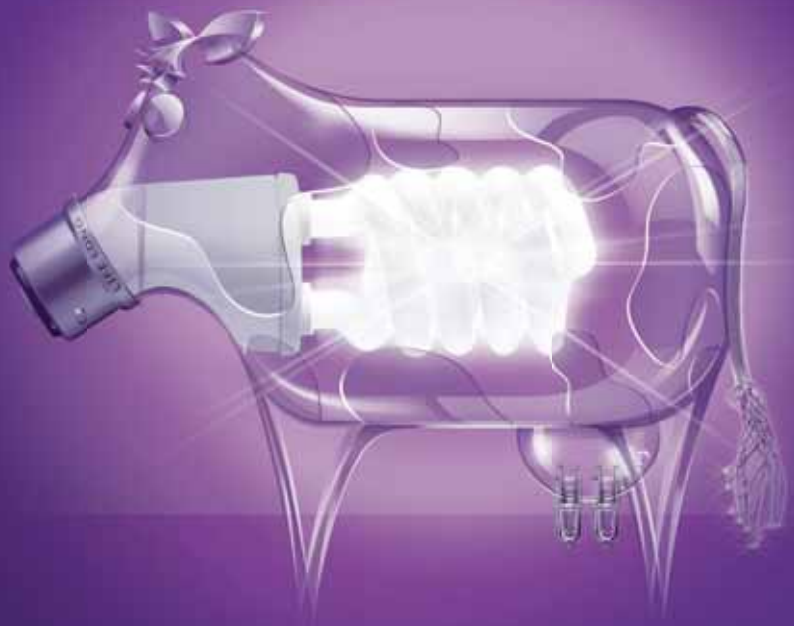

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SWITCHING ON LIFETIME PERFORMANCE IN NEONATES

Milk feeding calves in tropical conditions

PHOTOS: SHUTTERSTOCK

Rearing young stock on tropical dairy farms in Asia can be challenging. Here we discuss some of the decisions that have to be made when planning the milk feeding program for replacement heifer calves.

By John Moran, Profitable Dairy Systems, Kyabram, Victoria, Australia

The diversity of climate, milk returns and concentrate costs throughout Asia have created a wide range in calf rearing systems. The length of time, if at all, that calves remain housed, the method and level of milk feeding, the type of solid feeds offered and the age and weight at weaning therefore vary widely. The simplest rearing system involves putting young calves out to pasture, giving them access to trees or a simple shed for shelter and feeding them whole milk to appetite (ad lib) from a trough or feeding drum for up to 12 weeks of age, but with no additional concentrates. The other extreme would be to house calves for the first two months and feed them limited milk (or milk replacer), specially formulated concentrate mixes plus limited amounts of low quality roughage. This encourages early rumen development and also achieves high pre-weaning growth rates. In both cases, it is the people who rear the calves not the system. The calf rearer teaches the animals to drink and decides on when and how the milk should be fed. In this article we focus on different types of milk and the choice of feeding methods.

The choice of liquid feeds

The term colostrum is generally used to describe all milk not accepted by milk processors. However, a more correct term for milk produced after the second milking post-calving is transition milk. This milk no longer contains enough immunoglobulins to provide maximum immunity to calves, but still contains other components, which reduce its suitability for milk processing. Milk from newly calved cows should not be put into the bulk milk vat for up to eight days after calving. Regulations vary between countries and between different situations. During this period, cows will produce considerably more colostrum or transition milk than that consumed fresh by her calf. If only rearing heifer replacements, the colostrum produced by cows, that have given birth to bull and cull heifer calves, would then be available for milk feeding. Using a 25% heifer replacement rate and 45 L colostrum and transition milk per cow available for heifer rearing, this can provide up to 180 L milk available per reared calf. These calculations take into account any milk used for early feeding of bull and cull heifer calves. There should be little need for dairy farmers to buy milk replacer or use marketable whole milk to rear their heifer replacements. Dairy farmers can save considerable money through modifying their transition milk storage systems to minimise the need to feed marketable milk or milk replacer to their heifer calves. Transition milk has the greatest value when fed fresh or within a day or two from milking. It can be stored in a refrigerator for a week or so, or in a freezer for up to 12 months. In most farm situations, neither method is very practical for routine storage, except for a small supply of frozen colostrum for emergency use with newborn calves. There is little difference in the immunoglobulin levels in frozen compared to fresh colostrum. Only the first few litres of colostrum produced immediately after calving from older cows should be frozen for later use as a source of immunoglobulins. The ideal method to freeze the colostrum is in 1 litre plastic bags placed in flat trays. This will produce wafers of colostrum about 2 to 3

cm thick, which can be rapidly thawed in lukewarm water. Very hot water should not be used to thaw the frozen colostrum because it can reduce its effectiveness in providing immunoglobulins. Extremely bloody colostrum or colostrum from cows freshly treated for mastitis should not be stored, although it can be fed fresh, to calves not to be sold.

Proper storage of milk

Natural fermentation is an excellent way for storing transition milk for feeding as a source of cheap nutrients. It must be handled in clean containers to prevent contamination and should be kept in plastic or plastic-lined containers with lids. Old stainless steel milk vats are also ideal. If stored below 20°C, the natural fermentation will make the milk acid, stopping spoilage for up to 12 weeks. In warm conditions, preservatives may need to be added. These include propionic acid or formalin. The stored milk should be stirred every day to maintain uniform consistency and fresh milk should be cooled before adding to it. The preserved liquid will develop a characteristic odour but calves will continue to drink it provided they are not abruptly switched from fresh milk or milk replacer to stored milk. They may refuse to drink it if it becomes too acidic. In this case, its palatability can be improved by neutralising it with sodium bicarbonate or baking soda at the rate of 10 g/L milk. Fresh colostrum has a slightly greater feed value than whole milk so less can be fed or small quantities of warm water can be added to feed at the same rate as whole milk. When teaching calves to drink stored transition milk, it may be easier to begin feeding it warm, hence diluted with warm water (hot water will curdle it) and then gradually change to cool, stored milk when calves are drinking more confidently. Calves will continue to drink such stored milk long after the rearer can't bear to get too close to it. When the supply of stored transition milk begins to run out, fresh milk or milk replacer should gradually replace it over a week or so to give the calves time to accept their new diet. Changing from fresh milk or milk replacer back to stored transition milk can reduce intakes and lower growth rates.

Use of whole milk or milk replacer

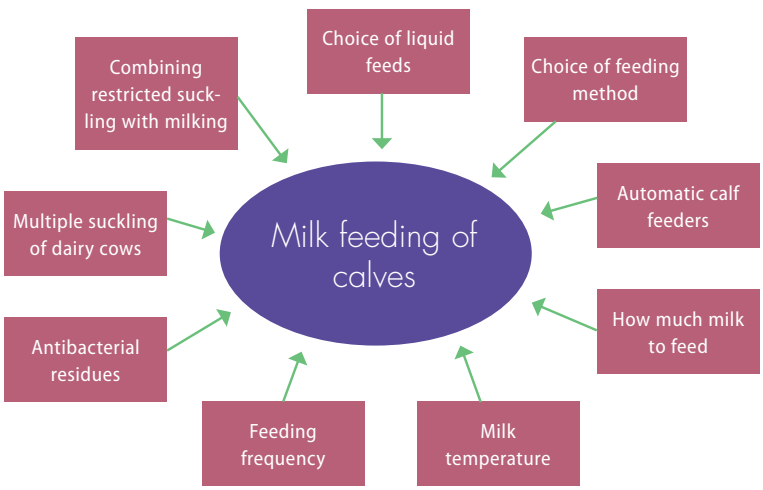
Whole milk is the ideal food for calves. It has a high energy value and the correct balance of protein, minerals and vitamins for good calf growth and development. Health problems are generally lower when feeding whole milk compared to milk replacer as there is guaranteed quality control of the sources of protein and energy and there is no need to have to follow recipes to ensure the correct strength for proper feeding. Whole milk can either be the commercial milk being sold or it can be waste milk, that is milk from treated cows or mastitic milk that cannot be sold. Calves fed whole milk are less prone to scours

It must be remembered that most dairy calves in the tropics, whether from Bos indicus or Bos taurus, are smaller at birth and grow more slowly than they would in the temperate zones. Different feeding strategies might apply for these calves.

The diversity of climate, milk returns and concentrate costs throughout Asia have created a wide range in calf rearing systems. The length of time, if at all, that calves remain housed, the method and level of milk feeding, the type of solid feeds offered and the age and weight at weaning therefore vary widely.

than those fed milk replacer. Although it is common practice to feed mastitic whole milk to heifer replacement calves, recent evidence suggests that this could lead to an increased incidence in herd levels of mastitis in later years. Whole milk and milk replacer can both be preserved by acidification for easier feeding management. Formalin can be added at the rate of 1-5 ml/L milk or hydrogen peroxide at the rate of 5 ml/L milk. Acidification can be achieved through adding 1.5 g citric acid/L milk or including a buttermilk culture (or non-pasteurised yoghurt) to ferment the milk. If the milk is made too acid, calves' daily intake will be reduced. To many producers, the decision on whether to feed whole milk or calf milk replacer (CMR) during rearing depends largely on cost. Sourcing a consistent quality of the milk replacer and its convenience for feeding are other factors influencing its use. Some farmers are concerned with the marked variation in milk replacer quality from batch to batch. Even though whole milk may be cheaper, it may not always be readily available for feeding to calves. For example, the calf feeding area may be some distance from the milking parlour.

Figure 1 - Decisions to make when considering milk feeding



The choice of feeding methods

Calves should be started on buckets then confined to a small yard to feed for a few days until they get used to trough feeding. Groups of calves will have more uniform growth rates when matched for drinking speed and age or size. Each animal should be allocated a feeding space of 35 cm or if using rubber teats, one teat per calf. Rubber teats give no additional nutritional benefit over bucket feeding as the speed of drinking milk has little effect on its utilisation. However, the production of saliva is greater in teat-fed calves and it may help maintain fluid intake in scouring calves. Teat feeding has also been shown to reduce the incidence of pizzle sucking in calves housed in groups. More capital is required in setting up the system and more labour is required for feeding and cleaning. One way of group feeding calves using teats is with a suckle bar. This can be made from 50 mm PVC piping fitted with milk line entries and self-closing teats. Milk is poured into one end and sucked out by the calves. It saves carting milk and is easy to wash. Calfeterias and feeding drums are used with rubber teats and can feed large numbers of calves quickly. Because the milk can always remain covered they can be fed away from shelter. The calf controls the amount of milk taken per feed so scouring is usually reduced provided the total milk provided is consistent. They can then be used for ad lib feeding. With calfeterias, the teats are either positioned in a metal frame which is attached to the top of the milk reservoir with plastic tubes to draw milk from inside the reservoir, or the milk reservoir allows the milk to run into the teats' by gravity. Modern calfeterias are made from moulded plastic to provide a reservoir of 2 or 4 L per teat.

Automatic calf feeders

In recent years, automatic calf feeding (ACF) machines have become popular on many large scale calf rearing operations. Calves can enter and leave the milk or concentrate feeding station at will but its feeding regime is controlled by computer technology. Each ACF machine can handle four teats and/or concentrate dispensers, thus allowing up to 100 calves to be reared in a single group. They are promoted as labour saving devices which can provide for a more carefully controlled milk feeding program. Each calf is individually identified to allow its milk feeding regime to be controlled by pre-determined programs of daily milk allocations. Some machines also allow for controlled concentrate feeding as well. ACF technology is not cheap, since as well as the initial capital investment of the machine and associated computer software, each calf will require an electronic ear tag and the calf rearing shed has to be modified to hold larger groups of calves. Because calves can be reared in large groups, extra surveillance is also required to minimise issues with animal health and behaviour. Their potential for integrating into calf rearing systems in tropical Asia will be limited by the relatively low cost of farm labour and the need for extra management skills.

Calves should be started on buckets then confined to a small yard to feed for a few days until they get used to trough feeding. Groups of calves will have more uniform growth rates when matched for drinking speed and age or size.

How much milk to feed?

When fed ad lib, six week old Friesian calves can drink up to 12 L/day and Jerseys up to 9 L/day of whole milk. By the time the calves reach six months of age, any live weight advantage in calves previously fed ad lib milk, compared to restricted milk, is lost. With access to concentrates and good quality pasture together with once or twice daily feeding of 4-5 L whole milk/day, Friesians should reach a suitable weaning weight (70 kg) in nine weeks and Jerseys (60 kg) in ten to twelve weeks. Many farmers still use live weight as their major criterion for weaning, often feeding more milk than is really necessary. Although ad lib milk feeding is more expensive than other rearing systems, this system is often justified through faster growth rates and lower labour requirements, if using drum feeding. Earlier weaning compensates for the greater milk intake of ad lib fed calves and advocates of this system argue that it uses only slightly more milk over the whole period compared to restricted milk feeding. Provided that there are no setbacks to growth, weaning can occur as early as six weeks of age. Some farmers claim to be able to wean such young calves directly onto pasture but it is unlikely that rumen development would be sufficient and a severe growth check would be likely. If considering such a rearing system, calves would have to be fed 0.5-1 kg/day of concentrates at least until they are ten weeks old. Many experienced calf rearers in Australia initially feed milk twice daily at 10% the calves' live weight for the first few weeks and provide fresh concentrates and drinking water each day within the first week of age. This ensures each calf has a 'good start to life' with high immunity to diseases and a positive energy balance. Only then will they restrict the milk or feed it once each day, which will stimulate concentrate intake and allow for a successful early weaning program. After weaning, consumption of concentrates should increase to 2 kg/day until the animals are three to four months of age. Concentrates can then be gradually withdrawn, provided good pasture or forages are plentiful. This early weaning system is low cost and has minimal labour requirements once milk feeding ceases.

This article is based on the book: Rearing Young Stock on Tropical Dairy Farms in Asia, written by John Moran.

Specific decisions for the tropics

Decisions on the most suitable milk rearing systems for calves often depend on local circumstances. For example, in regions where ghee or butter is produced, skim milk and milk substitutes are becoming increasingly available in the tropics as livestock feed industries develop. What must be remembered is that the environment in most tropical countries is more hostile for the dairy calf than in temperate regions and that it is more economic to spend additional money on calf rearing in order to reduce calf mortality and increase live weight gains. It must also be remembered that most dairy calves in the tropics, whether from Bos indicus or Bos taurus, are smaller at birth and grow more slowly than they would in the temperate zones. Thus temperate feeding standards are not completely applicable in the tropics and, if adhered to, may lead to some overfeeding of calves. In the tropics it is probably more economic to feed calves on additional milk than to attempt to early wean them as say five to six weeks of age. There are obviously many compromises with managing dairy calves in the tropics and ten or even twelve weeks of milk feeding is more the norm.

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Good lifetime performance with a **nutritional** software upgrade

Neonates (baby animals) present a window of opportunity within which farmers can influence the lifetime performance of an animal. By working with the neonatal animal, every producer has the means to influence their whole herd's profitability.

By Paul Toplis, AB Neo, United Kingdom

Farmers can have a huge effect on lifetime performance by what they do on farm in a key period of an animal's life pre- and postpartum, compared to investing in progressive genetics which cannot be influenced or changed after purchase. In addition, farm management of neonates can have other genetic effects.

The neonate opportunity

Neonate nutrition is about making a small but well-timed investment to achieve greater than normal returns later. There are many variables that control the growth and performance of an animal through its life, but if the neonate phase is underutilised then the opportunity for switching on improved lifetime performance has been lost forever – and thereafter the animal will be developing on a lower plane of growth or less efficiently. It's all about increased incomes from pigs reaching slaughter sooner or heavier or more milk production from cows.

It's already known that a better start in life through improved nutrition will improve lifetime performance. However, more recently, epigenetic effects were discovered, caused by nutritional factors that deliver an additional step-change in making the animal perform more efficiently for the rest of its life.

The first few days and weeks of an animal's life are formative for the rest of its life.

Realising true potential

Farmers invest in advanced genetics that deliver progressive productivity benefits such as greater litter sizes in pigs or milk yields in cows. The neonate presents a real opportunity to optimise the existing genetic 'hardware' (and to even cause epigenetic changes) by using novel neonatal nutritional technologies (comparable to software upgrades) that work in partnership to deliver real performance and commercial gains.

As such, farmers might think that once they have chosen their genetics, their potential growth performance has been fixed. What they buy is like computer hardware, say a new laptop but to make it work better they also need good software. What we are learning is that how farmers feed their newborn pigs and calves upgrades the software in a way that may result in reducing neonate mortality in hyperprolific sows, switching on lifetime performance in pigs or optimising lifetime milk yield in dairy

cows. So having invested in the genetic capabilities, it makes sense to realise and extend the true genetic potential. Another commercial bonus is that the period of investment in the neonate is when animals are eating relatively small quantities of food, making the actual investment relative to the costs through the rest of the animal's life very small, particularly when compared to the lifetime of returns.

When to act?

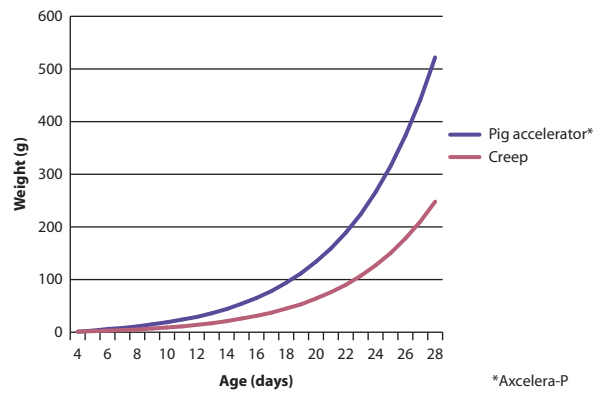
Because the neonate develops from conception, the first few days and weeks of an animal's life are formative for the rest of its life, just as much as the time prior to the animal being born, and even in the run up to conception. AB Neo's postpartum work with both swine and ruminants has shown that the earlier the neonate is offered particular diets, the more significant the outcome. Broader pig work clearly shows nutritional influences on the neonate around conception, at points during the pregnancy as well as shortly pre- and postpartum. In ruminants, influence can also be achieved relatively easily in the calf from birth to weaning.

For farmers to be interested and willing to influence the neonate, it needs to be easy to do and present clear commercial benefits. One approach is to encourage the animal to eat 'more of the same' where feed intake is the key measure. Additionally, a new technology ('accelerators') - its development was spurred by diminishing returns from the more of the same technology - is delivering greater lifetime benefits. This new technology is no longer concerned with just feed intake and weaning weight – but rather what effect a particular formulation can have on the neonate over and above the nutritional value of the feed or ingredients – a type of software change to enable the animal to perform better.

A combination of academic and commercial trials have proven the concept of accelerators in both swine and ruminants. In pigs there are three fundamental benefits:

- An improvement in lifetime performance – reaching slaughter heavier or earlier;
- Reduced pre-weaning mortality – proving to be very effective with hyperprolific sows;
- Improved uniformity of pigs at weaning, reducing the number of 'smalls' and making stock management easier.

Figure 1- Piglet intake; creep vs accelerator.



How does it work?

It's best not to think of accelerators in terms of offering a better feed or a new diet. Accelerators have 'non-nutrition' features in how they perform and are produced. They use a proprietary formulation and a new production technology to activate specific ingredients that create a novel effect whose performance impact is greater than can be accounted for by the ingredients alone by changing the way ingredients are digested in the gut.

With accelerators in ruminants (where only 10 kg of an accelerator offered from birth to weaning can accelerate a calf) calf growth accelerating prior to and beyond weaning is observed, which will then go on to deliver higher yielding herds with improved longevity and fertility. Uniformity of the herd also improves, bringing up the bottom end of the herd.

Accelerators in cows stimulate earlier intake which means high quality solid food is reaching the rumen and stimulating its development very early. Ongoing provision of the accelerator fuels faster growth up to and beyond weaning, setting the foundations for accelerated lifetime performance.

In pigs, conventionally, farmers have looked for an increase in feed intake and an increase in weaning weight as an indicator of progress in the area of neonate nutrition. After many years of trying to research ways of exploiting compensatory or catch up growth farmers have increasingly realised that it just cannot be done predictably in a commercial situation and carries too much financial risk. This means the most effective way of producing profitable farm animals is through fast growth throughout their life. Because of their novel mode of action, when an accelerator is offered to a neonate, it is proven to take animal performance to a higher trajectory than could be achieved using conventional pre-weaning diets. As a result, they accelerate the performance of animals above their peers reared on the maximum nutrient intake system when offered at the neonate phase. AB Neo's first accelerator for pigs is called Axcelera-P where each piglet typically only consumes up to 200 g from day 4 and through to weaning resulting in finishing pigs heavier or earlier. This often compares to 300-500 g of a conventional pre-weaning diet.

Mode of action

With accelerators, pre-weaning feed intake is no longer the only measure – it's about switching on and preparing the gut where little growth effect is seen until after the weaning phase, after which the performance is accelerated throughout the animal's whole life.

The animal's gut is the delivery organ for feed efficiency and for a lean, fast growing animal – and accelerators thought to act by turning on the gut as the delivery system. This may involve epigenetic effects (turning genes on or off) which may act in one or more distinct ways, by helping the immune system to react more appropriately to challenges common on commercial farms and utilise less nutrients to run the immune system and leave more for growth. Another effect may be to directly improve transporter systems by or through the changed microbiota, to open up high performing metabolic pathways.

In short, it's as though the switch has been turned on in the neonate to boost pre-weaning survival and post-weaning lifetime performance.

Hydrolysed wheat proteins

Including hydrolysed wheat proteins in the starter feed and milk replacer of piglets and veal calves can lead to high growth performance. And as these wheat proteins are highly digestible, they allow gut health to be maintained.

PHOTO: JAN WILLEM SCHOUTEN

Several studies performed in veal calves demonstrated that the replacement of 5 to 15% animal or milk proteins in diets by hydrolysed wheat proteins does not impair growth performance

By Dr Emmanuelle Apper and Dr Frédérique Respondek, Tereos, Innovation department, France

Animal scientists are constantly looking for alternative protein sources to include in starter feed and milk replacer. However, young animals have immature digestive and immune systems and are very sensitive to the quality of the proteins used. Some protein sources may reduce digestibility or harm gut health. Hydrolysed wheat proteins (HWP) are a soluble protein source produced from vital wheat gluten by a specific process based on hydrolysis, purification, and drying.

HWP are a highly concentrated protein source with around 80% crude protein, 6% fat, 3% starch and 1% fibre on a product basis. No signs of anti-nutritional factors have been seen when using the product in different animal species. These characteristics make HWP interesting as candidates to be included in starter feed diets and in milk replacers.

Highly digestible proteins

Dietary proteins may play an important role in the development of intestinal disorders leading to high diarrhoea incidence associated with increased microbial fermentation of undigested proteins and with greater proliferation of proteolytic and potentially pathogenic bacteria[1]. Thus, it is important to choose highly digestible protein sources in order to minimise the part of undigested proteins that will be fermented. Substituting 10% of high quality LT herring meal with 9.5% HWP in diets of weaned piglets (28 days of age) significantly increases apparent digestibility of dry matter, organic matter, and crude protein calculated from 0 to 2 weeks after weaning and significantly increases apparent digestibility of crude protein calculated from 3 to 5 weeks after weaning[2] (*Figure 1*). Additionally, no significant differences on apparent digestibility of dry matter, organic matter, and crude protein are observed when 8% spray-dried porcine plasma are replaced by 8% HWP in diets of 21-day old piglets for a 28-day period[3]. In 12-week old veal calves, ileal crude protein digestibility of HWP is similar to that of whey proteins. It is about 95% as digestible as proteins in milk where HWP provided 36 and 76% of crude protein completed by skim milk powder[4]. Furthermore, apparent ileal digestibility of most essential amino acids is comparable to that obtained with whey powder, which is considered as a high-quality protein source for calves[5].

No damage to the gut

In piglets, weaning is often associated to gut damage. This is because there is a period of transient villous atrophy and crypt hyperplasia after weaning, probably due to anorexia. A correlation between anorexia, crypt hypertrophy, and local inflammatory responses is observed when piglets are fed with a diet based on soybean meal compared with those fed a milk replacer[6]. As previously seen, proteins are known to influence gut health of piglets so that their effects on gut morphology and function have been extensively studied. It is shown that diets based on legumes may reduce activities of most duodenal enzymes and total tract digestibility of energy and N compared with a diet based on casein[7]. Feeding animal protein sources, whey protein concentrate or fishmeal to piglets results in higher villous height and lower counts of caecal C. perfringens compared with plant proteins such as soybean meal, fermented soy protein and rice protein concentrate[8]. HWP do not reduce villous height and even slightly increases it when compared to animal proteins, and notably fishmeal[9]

for piglets and calves

(*Figure 2*). Similar results are reported when 8% spray dried porcine plasma are replaced with 8% HWP[10]. Significant increases of villous height and digestive enzyme activities are observed in broilers and fish when HWP partly replaces soy proteins in the diet[11,12]. Beside effects on gut structure and activity, a modulation of immune or antioxidative system is observed in rats and fish[13,14]. Feeding rats with HWP increases secreted IgAs in intestinal contents and the phagocytic activity of peritoneal macrophages while it improves antioxidative system in juvenile hybrid sturgeon.

Effect on growth performance

Several studies performed in post-weaned piglets and in veal calves demonstrated that the replacement of 5 to 15% animal or milk proteins in diets by HWP does not impair growth performance. Replacing the protein from skimmed milk powder with a mixture of whey products and HWP (HWP providing 49% of crude protein from day 29 to day 83 and 61% from day 84 to day 146) does not significantly change carcass colour, carcass conformation, and body score condition in veal calves after slaughtering. Similarly, it does not alter dressing and haematocrit percentages[15]. In weaning piglets, replacing 4 to 10% of fishmeal or spray-dried porcine plasma with HWP during the first 5 weeks after weaning does not modify growth performance of weaned piglets[16,17]. Furthermore, using HWP does not increase incidence of diarrhoea in weaned piglets. Indeed, experimental results[18] indicate no difference in growth performance but a lower diarrhoea index for pigs fed 4% spray-dried porcine plasma plus 4% HWP or 8% HWP. Using HWP improves N utilisation in the small intestine. Indeed, digestive contents contain the lowest ammonia-N concentration when piglets are fed with HWP[19]. Such measure may be considered as an indication of microbial deamidation and therefore a high ammonia-N concentration is related to reducing amino-acid availability in the small intestine. A recent trial performed in US demonstrates that using a blend of fishmeal and HWP in order to replace blood porcine plasma 10 days after weaning allows achieving same growth performance at 42 days after weaning while the cost by lb of body gain drops from US$1.19 to 1.15[20] (*Figure 3*).

Conclusion

An inclusion of 3 to 15% hydrolysed wheat proteins in the diet of piglets and veal calves ensures high growth performance by maintaining gut health. HWP are high-protein sources, devoid of anti-nutritional activities, and highly digestible for young animals. Furthermore, including HWP in diets allows gut health to be maintained. As a result, partial replacement of animal proteins by these wheat proteins allows same level of performance while it is economically more competitive.

References 1-20 are available on request.

Figure 1- Effect of substituting animal proteins by hydrolysed wheat proteins on apparent digestibility. *: P<0.05

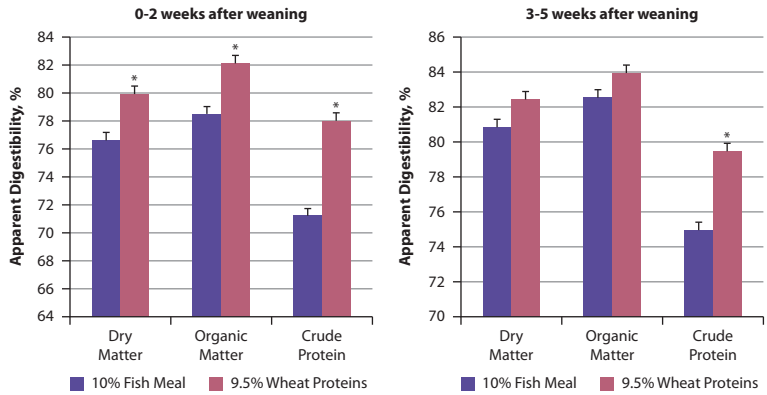


Figure 2- Effect of substituting animal proteins by hydrolysed wheat proteins on villous height.

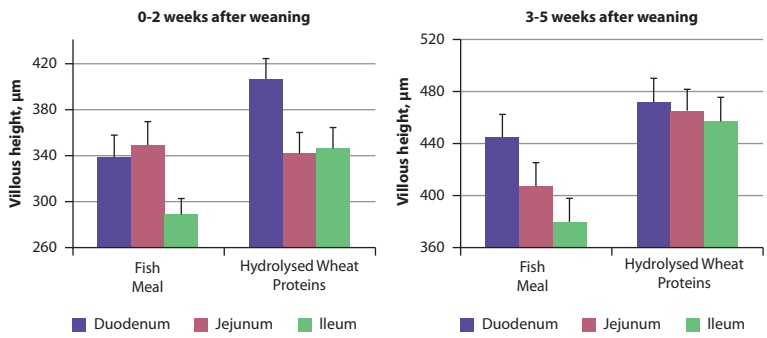
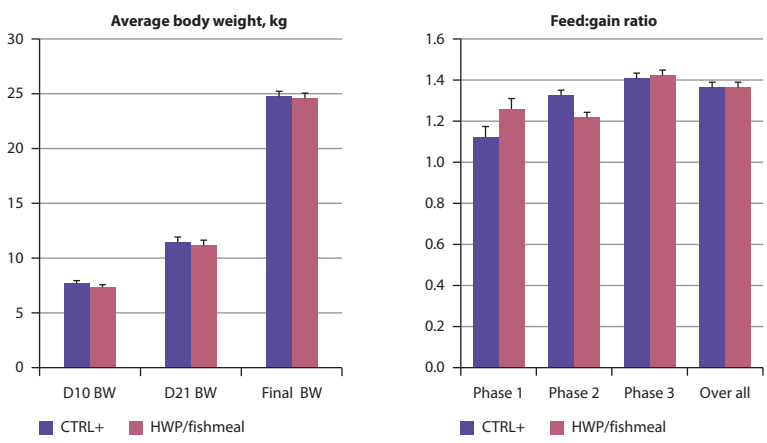


Figure 3- Average body weight and feed efficiency obtained with piglets fed a blood plasma diet or a HWP diet in phase 1. Phase 1: 0-10 days after weaning; phase 2: 11-21-days after weaning; phase 3: 22-42 days after weaning. Tereos data trial performed in 2015.



"It's best for animals to get the right nutrition as soon as possible."

"Whatever **animals eat** is important for their growth"

Professor John Pluske, associated with the Murdoch University in Perth, Western Australia, is one of the world's leading authorities in the field of the nutrition of young animals. Applying correct feeding cannot start early enough – get to it way before farrowing.

By Roger Abbott

Raised in a city, with school holidays out in the country on farms sounds like an ideal carefree childhood for many and while it was undoubtedly thoroughly enjoyed by the young Prof Dr John Pluske it also helped lay the foundations for a distinguished career as a pig nutritional digestive physiologist in his native Australia, as well as in other pig-producing nations around the world where his knowledge and advice is much sought after today.

Small piggery

By good fortune, one of the last farms he worked on as an undergraduate student during the summer university break had a small piggery on it, which grabbed his interest, especially the piglets.

"I got really involved with these piglets and when I had to find a small mini-research project to do in my final undergraduate year, I decided to look at split weaning for piglets. Then, after a year of broad acre farming, I went back to the University of Western Australia and did a PhD (with Dr Ian Williams as supervisor) in the physiology, morphology and enzymeology of the small intestine in response to nutritional and social stress imposed on piglets at weaning. His interests have remained in this area, with subsequent post-doctoral studies in Canada (1993-1994). Dr Pluske has also worked with cats and chickens (Massey University, New Zealand) and with dogs at Murdoch University, with the studies in these species also related to nutrition and digestive physiology.

Nutrition is important

His work has helped in developing the concept that nutrition is important right from the very start of life for piglets, well before they are even born. "Whatever animals eat is important for their growth and development and it's best for them to get the right nutrition as soon as possible," he says.

"Once you get down to the cellular levels there is good evidence to show biology at work and the way different nutrients impact upon the physiological function of the animal, whether that be in the liver, the heart, the brain, or the gastro-intestinal tract. What we eat is pretty much reflected in the phenotype. There is obviously a genetic component to physiological function, but there is also a strong nutritional component.

"It's an area that is being increasingly focused upon in pigs, with gene sequencing techniques and with the way we are mapping the microbes in the animal, as well as our understanding of that physiology-nutrition link and metabolism, of course. You can really start to drill down now into the effect of specific nutrients on functions."

Alternative ingredients

As far as the search for 'alternative ingredients' goes to reduce the reliance on antimicrobials in the post-weaning period, Pluske does not see anything new immediately on the horizon.

"I wish there was, so that we could definitely say that ingredient 'x' reduced diarrhoea for example, however in saying that we really need to look at the whole package because there are some ingredients, existing and in the future, that will play a role in this area. And of course there are also feed additives

John Pluske

Biography

Prof John Pluske is a nutritional digestive physiologist with expertise in the nutrition and growth and development of the young pig. A graduate of The University of Western Australia, where he gained both a Bachelor of Science (Agriculture) and Doctor of Philosophy, he is currently a professor at the School of Veterinary and Life Sciences at Murdoch University in Perth, Western Australia.

PHOTOS: VINCENT TER BEEK

Prof Pluske during a presentation at Trouw Nutrition's LifeStart Event, in May 2015, in Eindhoven, the Netherlands.

that play an important role. I think it's more about a suite of interventions encompassing diet, disease control, management and the environment, to assist that post-weaning transition."
He points out that increasingly it is becoming recognised that the formation of the foetuses can be influenced *in utero* by what is fed to the sow, as well as the behaviour and environment of the sow, and producers need to be aware of this. Whatever the animals eat is important from the growth and development point of view, with different nutrients having a far-reaching effect on all the organs, as well as the young pig's metabolism and health – and especially during the weaning and post-weaning periods.

"If animals are sick, you have to treat them."

Effect of the environment

"We are just starting to appreciate how much effect the environment has on piglets, with noticeable differences, for example, between those raised outdoors, compared with ones that are reared indoors, where producers have more control over the environment, even if they are fed the same diets and are of the same genotype," he adds, though he hedged around the question of whether he thought it was better for piglets to be indoors, or outdoors. "That depends on so many different circumstances that it would be in appropriate to say one is better than the other, without considering the particular issues facing specific producers."
When talking to producers about the right weaning age, Pluske says that in his view a later weaning age is better for the young pig, pointing out that he and others have done work weaning out to at least five weeks of age and while they still suffered a setback, the magnitude of that setback seemed to be less than if they were weaned younger, and especially if pigs were lighter at an earlier weaning age. However, he admits it largely depends on the economics of the particular pig operation in question, suggesting that a detailed whole-of-operation financial analysis needed to be done before deciding on weaning ages.
Asked what he would use to feed his own imaginary herd of piglets on, Pluske laughed and said: "I think I would choose something based on milk, because it's an ideal substrate for a young animal – but obviously you cannot always provide that and the question really boils down to margin over feed cost. However, it also depends on any local or national restrictions."

Antibiotics

Regarding the use of antibiotics, a subject that has led a lot of debate in international circles, he believes that "in general, producers would rather not use them, even in countries where they are still legal, because of cost, antimicrobial resistance and ever-increasing concerns and restrictions related to their use. But in some situations they feel they need to use them to medicate, or feed medicate just because they have to and then it becomes a welfare issue for the animals.
"Again, it depends on the circumstances that particular producers are facing. I don't think there is any doubt that if you are getting good performance and healthy pigs in the absence of them then why would you include them – and certainly producers here (in Australia) as in Europe and many other parts of the world have developed diets in conjunction with appropriate management strategies, disease mitigation strategies and environmental strategies to be able to exclude some antibiotics, certainly on the growth promotion side; so you can do it, it is possible. There is some pain involved initially of course but it can be done.
Confessing he was 'a bit ambivalent' about the idea of banning antibiotics completely, Pluske says: "I think there needs to be a recognition that they will always have a place or role in production to treat disease and prevent animals suffering. If animals are sick, you have to treat them."

Improving pig production and pig health

Currently back in Perth, where he is a professor at the School of Veterinary and Life Sciences at Murdoch University, Pluske says he now spends most of his time doing research aimed at improving pig production and pig health, especially in the post-weaning period.
While still optimistic about the future for the global pig industry, Pluske is more circumspect about the move towards highly fecund sows giving birth to ever increasing litter sizes with co-related mortality, health and production issues. "The breeding companies still seem to be on an upward trajectory in this respect and I think we need to look more closely at how producers can manage and feed these sows and their piglets properly on both the nutrition and welfare fronts. This is an area that certainly needs more attention."
He also believes there is also "still plenty of room for new research into developing ways to feed and manage sows in gestation and into lactation with respect to nutrition and how you can influence the phenotype of the piglet with sow nutrition and feeding – there is some remarkable research coming out that nobody would of thought about before. We are right at the very start of this work," affirms Pluske.

This interview has been made possible with the kind assistance of Trouw Nutrition.

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Ingredients

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Copper is key for piglet performance

Copper is essential to a functional immune system and optimal health. Supplementing nursery pig rations with copper can improve daily gain and feed conversion ratios. Choosing the right type of copper defines its availability in the digestive tract, minimises excretion into the environment and maximises return.

By Cassio Villela, Sr marketing specialist, global swine, Novus International

The weaning process is a stressful one for piglets. A new environment, pen mates and feed source can all impact the feed intake and growth potential of young animals. Meeting their essential nutritional needs during this transition is critical to minimise stress and maximise feed efficiency, overall health and performance.

Ensuring proper early nutrition requires careful attention to ration details. Certain elements, although needed only in small amounts, are critical for maintaining young animal health. Copper is one of those elements and is essential for a functional immune system and necessary for a variety of processes in the growing animal.

Recent studies have helped researchers better understand the role of copper in the diet of young pigs. "We're starting to understand how copper can stimulate a certain gene expression that increases feed intake, which leads to improved gain," says Dr Yulin Ma, technical services manager for Novus International. "We've found that the improvement of dietary fat digestibility in weanling pigs is related to improved intestinal activity of the enzyme lipase when dietary copper is added."

Table 1 - Dietary treatments.

	Day 0-21 Supplemental Cu	Day 21-42 Supplemental Cu
Control (Ctrl)	Ingredient + VTM	Ingredient + VTM
CuSo4 ($CuSo_4$)	Ctrl + 150 ppm	Ctrl + 150 ppm
Tri-Basic Cu Chloride (TBCC)	Ctrl + 150 ppm	Ctrl + 150 ppm
Chelated copper* (MT 150/50)	Ctrl + 150 ppm	Ctrl + 50 ppm
Chelated copper* (MT 150/80)	Ctrl + 150 ppm	Ctrl + 80 ppm
MAAC (MAAC 150/50)	Ctrl + 150 ppm	Ctrl + 50 ppm

Improved ADG and FCR

Ma and colleagues conducted a meta-analysis of published literature on copper supplementation in nursery and growing-finishing pig diets in the US, including six studies with varying levels of copper inclusion. Their analysis revealed that supplementing nursery pigs with an organic, chelated copper source (metal methionine hydroxy analogue copper chelate, or MMHAC Cu) significantly improved ADG by 3% and FCR by 2.6% when compared to an inorganic copper sulfate. The incidence of diarrhoea was reduced by 23% in weaners fed MMHAC Cu, and grower-finisher pigs fed the MMHAC supplement experienced an improved immune response and improved nutrient digestibility of a basic corn-soybean diet.

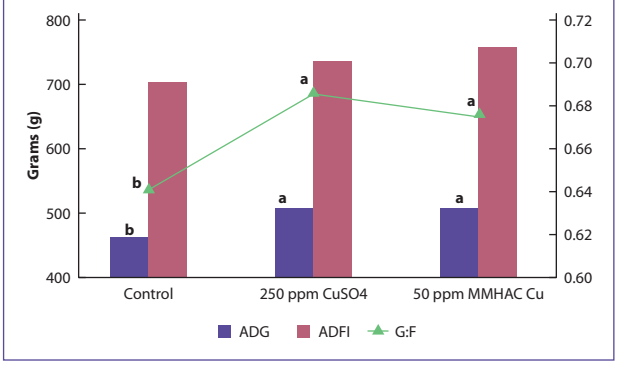
In addition to the antibacterial effects of copper in the gut, the studies also showed that MMHAC Cu improved villus height-to-crypt depth ratio and promotes better nutrient digestion and absorption. Specifically, MMHAC Cu improves the digestibility levels of copper by 42%, dry matter by 8%, crude protein by 9%, phosphorus by 14%, energy by 8% and fat by 10% compared with a basal diet. The biggest advantage of feeding MMHAC Cu was observed in pigs in later nursery phases, including pigs 28 days or older and 7 kg or heavier.

The advantage of chelated organic trace minerals

Trace mineral supplements can perform differently in the animal's digestive tract. For example, when inorganic salts are used as a copper source, much of the mineral is often excreted and lost in the faeces due to chemical antagonisms and interactions with other diet components in the digestive tract. That loss results in continued metabolic deficiencies, which limits the performance of the animals. Chelated minerals help overcome these digestive challenges.

In scientific terms, chelation means the trace mineral is bound to a ligand forming at least two coordinated covalent bonds which can be further verified by chemistry techniques such as X-ray crystallography and fourier transform infrared spectroscopy (FTIR). Differently from other organic mineral sources, "this chelate creates a stable complex in the acidic pH of the upper gastrointestinal tract, reduces mineral-ligand breakup, helps reduce losses caused by antagonisms and protects the mineral for efficient delivery to the absorption site and uptake in the small intestine," explains Dr Ma.

Figure 1 - Copper supplementation improved ADG and G:F.



Because of this significant difference, a new feed ingredient category was proposed by Novus International. This category is Metal Methionine Hydroxy Analogue Chelate (MMHAC). "The Association of American Feed Control Officials recognised this new definition, which literally makes Mintrex Cu chelated copper one of a new class of trace minerals," says Gavin Bowman, executive manager, minerals, for Novus International.

More bioavailability

Over the years, the majority of trials with weaned pigs have demonstrated performance enhancement when dietary copper exceeded 125-150 ppm, particularly during the first eight weeks after the start of copper supplementation. The challenge has been to increase performance and avoid excess copper excretion, which poses a significant environmental hazard and is typically caused by the relatively poor availability of copper from inorganic sources.

The key to reducing mineral excretion is to optimise mineral uptake by improving its availability. "That can be accomplished by decreasing the interaction of minerals with various dietary and digestive components such as phytate and fibre, and by decreasing the opportunity for mineral interactions in the gastrointestinal tract," explains Bowman.

Bowman states that *in vitro* tests with the copper MMHAC feed supplement "clearly show enhanced stability when compared with other mineral sources". He adds that trials show that 50 ppm of copper from the copper MMHAC supplement "yields similar growth and feed efficiency improvements to 250 ppm of copper from $CuSO_4$". *Figure 1* illustrates this.

Supplementation strategy

Because MMHAC chelated copper is better absorbed by animals than inorganic trace mineral supplements, a producer can feed less mineral while still maintaining feed efficiency. "By substituting inorganic copper sources with organic MMHAC in post-weaning diets, a grower can maintain performance levels, while decreasing the level of copper excretion and lowering the cost of copper supplementation," says Bowman.

A recent feeding trial provides further evidence. The performance of 924 newly weaned pigs was compared; they received copper supplementation from inorganic sources, being copper sulfate ($CuSO_4$) and tribasic copper chloride (TBCC); or from an organic source (MMHAC), at two rates. The animals were fed at equal copper levels the first 21 days post-weaning. The copper in the control group was solely derived from the ingredients and the basal level of copper supplied in the trace mineral mix (*Table 1*).

In general, growth rates for the first seven days post-weaning were improved with all forms of Cu supplementation, although feed intake appeared to be numerically improved with the higher rate of organic copper (*Table 2*). During the first 21 days post-weaning, pigs receiving the copper supplement gained 0.6-0.9 kg (1.3-1.9 lbs) more weight than those on the basal diet.

Feed conversion improvements with copper supplementation ranged from 2.9% for pigs fed TBCC to 6.6% for pigs receiving copper sulfate to 13.5% for pigs fed the MMHAC copper supplement (*Table 3*). Study results also demonstrated improved accumulation of copper in the livers of pigs supplemented with the MMHAC organic copper form vs. copper sulfate.

"More efficient absorption of organic chelated trace minerals means less mineral is excreted by the animal," says Bowman. "That's not just better for the environment, it's better for the producer's bottom line."

PHOTO: NOVUS

Meeting a piglet's essential nutritional needs is necessary during weaning.

Table 2 - Day 0-7, effects of copper source.

Weights	Basal	$CuSO_4$ 150	TBCC 150	MMHAC Cu* (150/50)	MMHAC Cu* (150/80)	MAAC 150/50	SE	P<
Day 0								
Day 7 (kg)	5.92^{b}	6.08^{ab}	6.15^{a}	6.11^{ab}	6.05^{ab}	6.08^{ab}	0,09	0,02
Day 0-7								
Gain (g/d)	131.5^{b}	154.2^{ab}	163.3^{a}	158.8^{ab}	145.2^{ab}	158.8^{ab}	0,01	0,05
Intake (g/d)	158,8	167,8	163,3	186	181,4	181,4	0,01	0,06
Feed/gain	1.22^{a}	1.10^{ab}	1.01^{a}	1.17^{ab}	1.26^{a}	1.16^{ab}	0,02	0,001

** Mintrex Cu, Novus International*

Table 3 - Day 0-21, effects of copper source.

	Basal	$CuSO_4$ 150	TBCC 150	MMHAC Cu* (150/50)	MMHAC Cu* (150/80)	MAAC 150/50	SE	P<
Weights								
Day 21 (kg)	10.01^{b}	10.68^{a}	10.62^{ab}	10.90^{a}	10.69^{a}	10.65^{ab}	0,34	0,01
Day 0-21								
Gain (g/d)	190.3^{b}	326.6^{ab}	317.5^{ab}	340.2^{a}	331.1^{a}	322.1^{ab}	0,02	0,05
Intake (g/d)	390,1	417,3	417,3	417,3	403,7	417,3	0,03	0,63
Feed/gain	1.35^{a}	1.26^{abc}	1.31^{ab}	1.22^{c}	1.21^{c}	1.28^{abc}	0,02	0,001

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Combining strategies to reduce antibiotic usage

In order to achieve antibiotic usage reduction, it is important to embrace various strategies simultaneously. Which ones are these exactly? And how do they help piglets get through their first weeks?

By Wouter Naeyaert, product manager pigs, Nuscience

There are different strategies in reducing the antibiotic use in piglets, from reducing crude protein levels to the use of organic and medium chain fatty acids to stimulate animal health. However, every sustainable strategy should not only take into account the antibiotic use as such, but also the farmer's profitability. For this reason an ideal strategy to reduce antibiotic use focuses on different topics. The most valuable strategies to reduce the antibiotic use in weaned piglets are:

1. Assure a high feed intake. A high feed intake after weaning is of utmost importance to maintain intestinal health.
2. Improve diet digestibility. A well digestible diet leaves no substrate for the outgrowth of pathogens in the intestines.
3. Improve gut health and general animal health.

Table 1 – Acid binding capacity (ABC-4) of different raw materials.

Raw material	ABC-4 (mEq/kg)
Wheat	108
Corn	111
Barley	113
Soybean meal	642
Beet pulp	191
Whey powders	434
Limestone	12,932
Calcium formate	3,983
Lactic acid	-5,079
Fumaric acid	-10,862
Zinc oxide	16,321

Source: Lawlor and others, 2005.

Feed intake

As generally known, a high feed intake the first days after weaning is of utmost importance to maintain intestinal health. A low feed intake results in villus shortening and a loss of gut barrier function with a long lasting impact on the health and performances of piglets. The feed intake during the first week after weaning determines for a large part the lifetime growth of the piglet. This is why adapting the piglets to solid feed with a good creep feed is essential to assure a high feed intake.
The improvement of feed intake after weaning depends on a variety of factors like: animal health, creep feeding, weaning age and weight, environment, water supply, form of diet presentation, diet raw materials, and nutrient composition of the diet. A good selection of raw materials and taste enhancers is of utmost importance to achieve a well palatable diet. Not only the diet composition is important to improve feed intake, also the form of diet presentation can play an important role. Field trials have shown that the supplementation of piglets with a porridge next to the solid weaning diet can improve the feed intake the first week after weaning with up to 22%.

Digestibility

The main constituents in a piglet feed are protein sources, lactose sources and cereals. It is important to control and stimulate the cereal and protein digestibility to improve the digestibility of the diet. A well digestible diet is important to ensure a high nutrient supply to the piglets, and to reduce the amount of substrate left for pathogen outgrowth in the large intestine.
The digestibility of the feed can be improved in multiple ways, but the control of the acid binding capacity is essential to assure the digestibility of protein as the capacity to secrete acid in the stomach of weaned piglets is very low. It is only at the age of seven to ten weeks that the acid secretion capacity in the

Table 2 – Villus length and gut barrier function in the jejenum of weaned piglets.

	Days post-weaning			
	0	3	7	14
Villus height	765^{a}	452^{b}	468^{b}	731^{a}
TER[1], Ω cm2	65.8^{a}	51.4^{b}	48.7^{b}	53.3^{b}
FD4 flux[2], µg cm-2h-1	1.2^{c}	1.7^{b}	2.3^{a}	2.0^{ab}

[1] Transepithelial electrical resistance, measurement of gut barrier functioning.
[2] Fluorescien isothiocyanate dextran (4 kDa), a macromolecular marker.
Source: Hu and others, 2013.

stomach of piglets is fully developed. A careful selection of raw materials is in this essential to minimise the acid binding capacity of the feed (*Table 1*).

Health promotion

In the farrowing house piglets are well protected by antibodies in the milk. Around weaning this protection disappears. The combination of this immunity gap with the large number of stressors around weaning, the low feed intake, and the immature intestinal tract makes piglets very susceptible to disease. There are different options to stimulate the health of piglets, like organic and medium chain fatty acids. However, it's not only important to look at additives with an antimicrobial effect, also supporting the immune system and gut barrier function is essential in piglets. Especially the impact of stressors on the gut barrier function of the piglet shouldn't be underestimated.

The oxidative stress in intestinal cells results in a reduced gut barrier function. This leads to an increased passage of pathogens, antigens and toxins over the gut barrier, and an increased susceptibility to disease. Compared to villus length, which returns to preweaning values 14 days after weaning, the gut barrier function takes much longer to recover with long lasting effects on piglet health and performance, see *Table 2*. The lower the electrical resistance, and the higher the passage of macromolecules over the intestinal epithelium, the worse the gut barrier functions.

Strategies reflected

All these strategies are reflected in Nuscience's Porcito range, with prestarters and starter concentrates for piglets. The focus on these three strategies switches as the piglet grows: in the farrowing house feed intake and digestibility are important, health stimulation becomes more important after weaning as piglets lose the immunity derived from sow milk.

Feed intake

Babito, the Nuscience creep feed, is known for leading to high feed intake. In addition, in multiple trials the positive effects of feeding Porcito prestarters before and for some days after weaning (to smoothen the weaning transition) on post-weaning performances have been shown, *Figure 1*.

PHOTO: NUSCIENCE

Digestibility

A careful selection of raw materials with a high digestibility and low acid binding capacity is combined with the use of the Nuscience enzyme concept Vitazym. This results in very well digestible feeds, improving health and performances.

Good quality creep feed for the youngest piglets can ensure feed intake improvements after weaning.

Health promotion

The Nuscience health concept protects the piglets, ensuring a high health status and high performances around weaning. The concept focuses on gut health protection as well as on general health status, by a combination of antimicrobial, gut-barrier enforcing and immunity improving products. This results in a broad protection of the piglets and less susceptibility to infections like *E. coli* and *S. suis*. This way, not only the amount of intestinal disorders, but also the vulnerability for Streptococcus infections and even pulmonary disorders can be reduced. A 2014 publication by Wageningen University mentioned that Aromabiotic, a patented product with free and active medium chain fatty acids, was the only additive ever tested that could significantly reduce the amount of veterinary treatments needed to reduce respiratory disorders. Concluding, this improved health results consistently in improved performances of piglets after weaning (*Figure 2*).

By improving technical results with the Porcito feed concepts, profit increases and antibiotic usage goes down.

Figure 1- Impact of a different prestarter (fed from day 10 of age till 3 days after weaning) on piglet performances in piglets fed with the same weaning and starter diet.

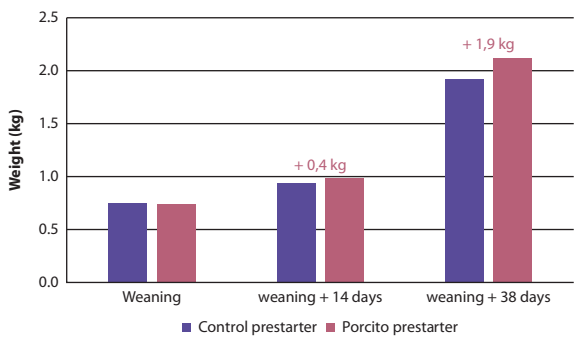
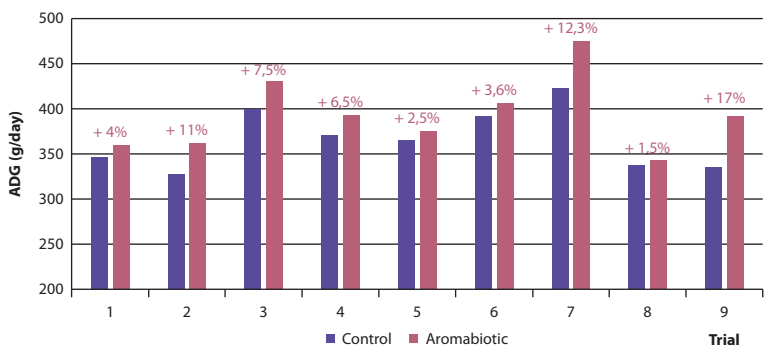


Figure 2 - Impact of aromabiotic-MCFA on growth performances of piglets after weaning in different trials.



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Reducing ZnO by changing gut microbiota


In piglets higher levels of ZnO in feed are needed to meet their requirements.

Zinc (Zn) plays an important role in the metabolism of swine and as such is an essential trace element for growing pigs. The element is also known to have negative side effects. Which alternatives exist?

By Maja Marien and Tim Goossens, business development managers digestive performance, Nutriad International

In the late 1980's, it was discovered that pharmacological concentrations (1,500-3,000 ppm) of zinc oxide (ZnO) resulted in reduced diarrhoea and increased growth in weanling pigs. To minimise the risk of environmental pollution, in the EU, the legal norm for Zn is 150 mg/kg (ppm) of Zn in complete animal feed (EU Regulation 1334/2003). Since 2005, ZnO at pharmacological levels has been reallowed in some European countries as a means to reduce the use of antibacterial compounds shortly after weaning.

The mechanisms behind the beneficial effects of ZnO to prevent diarrhoea and promote growth in weaned piglets are not completely understood. Recent advances in research suggest it is achieved through multiple regulatory pathways.

In piglets higher levels of ZnO in feed are needed to meet the requirements due to the fact that Zn absorption after weaning is about 30% reduced and bio-availability may be less than 20%. Moreover, it has been shown that ZnO regulates secretion of brain-gut peptides that stimulate feed intake. This results in the growth promoting effect of ZnO.

ZnO results in an improved intestinal barrier function by increasing the expression of intestinal insulin-like growth factor-1 (IGF 1, regulates cell growth and development) and its receptors and through reducing paracellular permeability by upregulation of tight junction proteins in the intestine. ZnO reduces the release of pro-inflammatory histamine, by inhibiting proliferation and activation of intestinal mast cells and in this way has an immunomodulating effect. ZnO also reduces secretion of ions to the intestinal lumen, enhancing water resorption and preventing diarrhoea. Supplementation of weaning diets of piglets with ZnO during a short period of time at relatively high doses (2,500 ppm) enhances stability and diversity of the intestinal microbiota after the change of diet in weaned piglets and it reduces attachment of pathogenic bacteria such as enterotoxigenic *E. coli* (ETEC) to the intestinal villi. In addition, it is demonstrated that ZnO prevents the translocation of (pathogenic) bacteria such as *E. coli* and Enterococcus species in the mesenteric lymph nodes of the small intestine.

Table 1 – Dietary treatment groups evaluated.

		Pre-starter day 28-42	Starter day 42-76
HiZ [1]	ZnO:	3 kg/T	3 kg/T
LoZ + S [2]	ZnO:	3 kg/T	-
	S:	3 kg/T	2 kg/T

[1] standard ZnO inclusion; [2] Low ZnO inclusion + multifunctional additive S (SANACORE®En)

Downsides of zinc usage

It is clear that the use of high levels of ZnO (1,500-3,000 ppm) has many positive effects on piglet health and performance. However, such use of pharmacological ZnO dosages has potentially some negative consequences as well.

Zinc toxicity

Pharmacological usage of ZnO for short periods of time (maximum of 14 days) does not cause severe negative consequences for the health of the animal but if used for longer periods, may negatively affect piglet health and performance.

Nutritional interactions

High levels of Zn cause a risk for sub-deficiencies of some minerals such as copper, iron, zinc, and selenium. Also, at pharmacological dosages Zn can form a complex P-phytate

PHOTO: SHUTTERSTOCK | THEMORNINGGLORY

and as a consequence the phosphorus cannot be released by the phytase, possibly resulting in a reduced efficacy of phytase and phosphorus deficiency.

Contamination by heavy metals

Impurities such as cadmium in commercial ZnO can be a considerable problem when Zn quality is not strictly controlled.

Zinc and microbial resistance

Although bacterial sensitivity to Zn is not always defined, acquired Zn resistance does seem to occur. Much more alarming, however, is that intensive usage of Zn in animal diets may favour the development of bacterial resistance against other antimicrobials. This can be caused either by an increased production of efflux pumps or by the fact that selection of bacteria resistant to Zn leads to the co-selection of bacteria resistant to some antibiotics, a genetical aspect.

Search for alternatives

Because of these negative aspects of ZnO usage, producers are looking for suitable replacements. When developing an antimicrobial support product, Nutriad has focused on products with a similar mode of action as ZnO. This research has resulted in the development of the product Sanacore EN, a multifunctional product with a broad-spectrum antibacterial approach. The aim of using the product is to reduce the use of ZnO and/or antimicrobials while supporting health and welfare of the animals, as well as to improve production results.

Multifunctional approach

The different components in this strategy cover the same range of positive effects as described above for ZnO. Butyrate, for example, is a strong stimulator of for example glucagon-like peptide-2 (GLP-2). There is a great number of GLP-2-induced effects in the intestine that promote growth and performance: decrease in gastric motility, enhancement of intestinal nutrient transport, stimulation of intestinal blood flow and increase in intestinal cell proliferation. Also it speeds up intestinal mucosa maturation during the development or repair after and up-regulates tight junction proteins in the intestine and in this way decreases intestinal permeability (improved intestinal barrier function). Furthermore, butyrate has been shown to reduce inflammation through its effects on several types of immune cells (immunomodulating effect) and modulates ion absorption and alleviates the severity of the diarrhoea.

The strategy contains several components with a distinct antibacterial spectrum selected ensuring that their combination resulted in a broad antibacterial effect (Gram-negative and Gram-positive). Furthermore, butyrate also stimulates antimicrobial host defense peptides secretion in the GIT. Research done at the University of Bologna in Italy showed that butyrate was able to protect piglets from mortality and from the reduced growth rate due to the *E. coli* K88 (ETEC) infection.

Field trials

In a first trial, 68 crossbred piglets, weaned at 28 days of age, were allocated to one of two dietary treatments based on live weight (see *Tables 1 and 2*). The inclusion of the multifunctional product in pre-starter feed (on top of ZnO), resulted in a significant increase in feed intake and ADG (48 g/day and 10 g/day respectively). Inclusion in starter feed (no ZnO) lead to higher performance in comparison with the control group (standard ZnO inclusion): a significant increase in feed intake (56 g/day), in ADG (94 g/day) and a reduced feed conversion rate (FCR), being 0.29 lower.

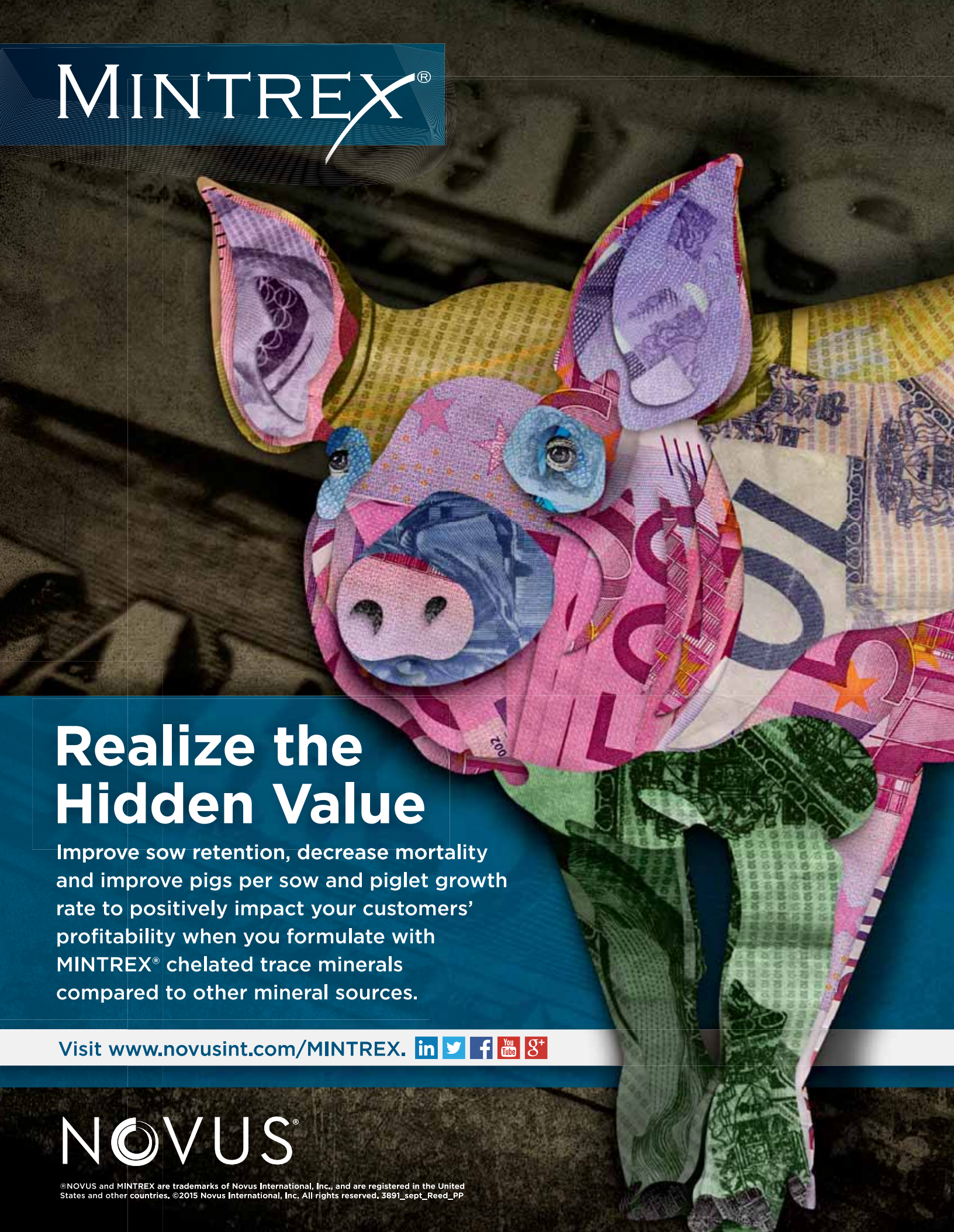
When looking at the performance results throughout the complete trial period the strategy's application in pre-starter feed (on top of ZnO) and starter feed (no ZnO), resulted in a significant increase in feed intake (56 g/day), a significant higher ADG (71 g/day), and lower FCR (-0.2) in comparison with a standard ZnO programme (3 kg/tonne throughout pre-starter and starter). At the end of the trial at 76 days of age, piglets receiving the new diet weighed on average 3.6 kg heavier than the piglets from the straight ZnO programme. Faecal consistency was monitored throughout the trial period and no severe diarrhoea was observed in the piglets of both trial groups.

The study demonstrated the potential of a multifunctional strategy to be used in programmes with reduced ZnO levels in weaning piglet diets. Applying that can make a difference for producers aiming to limit the use of ZnO.

Table 2 – Performance parameters measured during the trial.

	Pre-starter day 28-42		Starter day 42-76	
	HiZ	LoZ + S	HiZ	LoZ + S
End weight (kg)	9.1	9.2	21.6	25.2 *
Feed intake (g/d)	266	314 *	605	661 *
ADG (g/d)	240	250	374	468 *
FCR	1.2	1.3	1.7	1.5 *

** indicates $p < 0.05$*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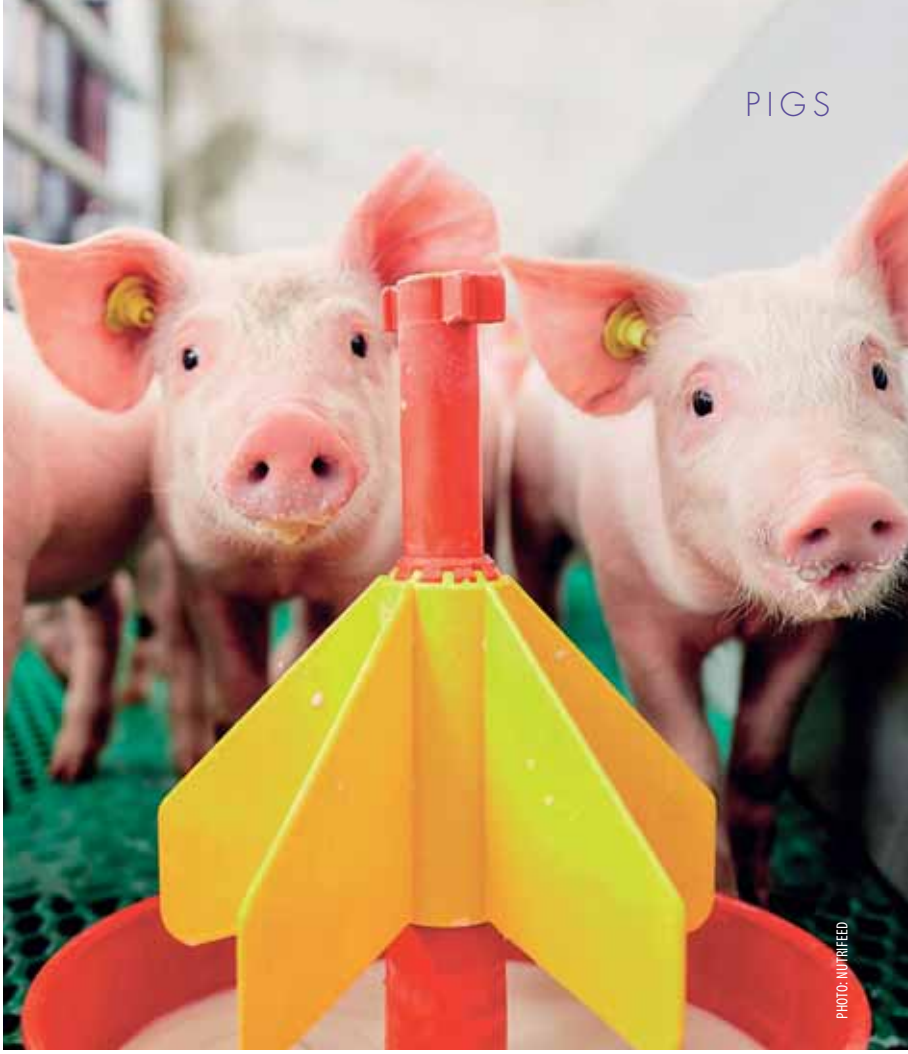
Dairy makes all piglets grow

For raising pigs successfully one might want to take a look at the world of dairy cows. Milk ingredients can help piglets as well as their mothers better overcome the often challenging moments of farrowing and weaning. Proof comes from around the world.



Feeding a premium milk pre-weaning will help young piglets get through the first weeks post-weaning.

By Bart van Ovost, product manager and Anniek Lammers, nutritionist, FrieslandCampina Nutrifeed, the Netherlands

By 2050 the world's population is expected to have grown to between 9 and 10 billion people. Feeding this growing population will be an enormous challenge and has implications for people, animals and the environment. For raising pigs tackling this challenge starts with dairy, and therefore FrieslandCampina Nutrifeed developed the Piglet & Sow Performance Programme. The programme is a tested and proven concept of three complementary dairy products that fit the specific needs of the sow and her piglets in different stages of their lives; two spray-dried, fat-filled dairy concentrates (Lactolat for sows, and Serolat fat-filled, for piglets around weaning) and a premium milk for young piglets (Porcolac Extra).

The programme brings extra support to sows and directly and indirectly improves piglets' condition. As a result, sows lose less backfat, the fat content of sow milk increases significantly, mortality decreases or is prevented and growth rates and feed conversion ratios are improved. All in all, this will help to farm more efficiently to feed the growing world population with regard to the scarce raw materials, and, finally, to become more appealing to younger people as a pig farming sector.

Giving piglets a head start

To give piglets a head start, the starting point is the sow's general condition. When a sow is in a good condition, farrowing will be smoother and this will also impact the level and quality of the sow milk produced. Eventually, this will affect the number of piglets born alive as well as the mortality rate among piglets in the first days after birth.

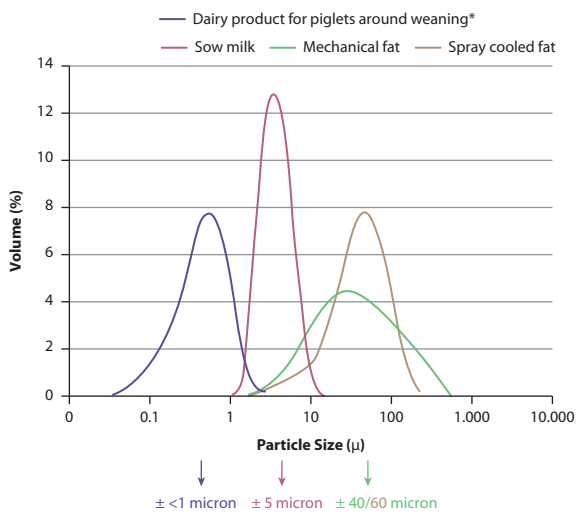
Especially this last effect is important, because the production of more and higher energetic sow milk creates more vital and stronger piglets. This is becoming increasingly important, due to continuously increasing litter sizes. Providing sows with an easily digestible energy source will improve the condition, farrowing and the level and quality of their milk.

Another challenge is to feed all piglets with the right level of nutrients. Additional feed intake, providing a milk to young piglets during the lactation period, is a desirable way to increase nutrient intake of piglets. This will improve the piglets' general condition and result in less mortality and increased growth rates. Furthermore, the intake of additional feed during lactation will facilitate the change from liquid milk to solid feed after weaning. Piglets will have higher energy reserves to overcome weaning problems and reach a higher post-weaning feed intake.

Especially right after weaning, piglets need highly digestible dietary components. Since piglets' digestive tracts are suited to digest dairy nutrients like lactose and milk proteins, it is advisable to supplement them with creep, weaning and starter diets containing high quality, easily digestible, dairy components.

Dairy proteins can also be easily spray-dried using vegetable

Figure 1 – Particle sizes of different fat sources.



*Serolat, FrieslandCampina Nutrifeed

Figure 2 – Backfat loss (%) of sows during lactation.

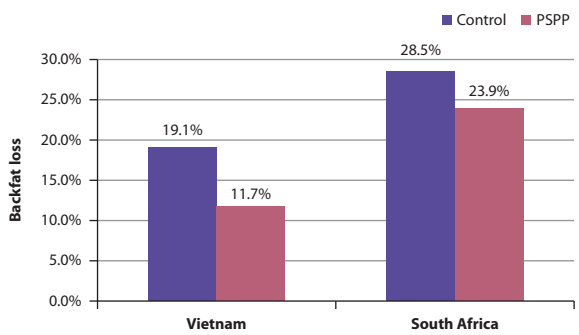


Figure 3 – Body weight from birth until day 70.

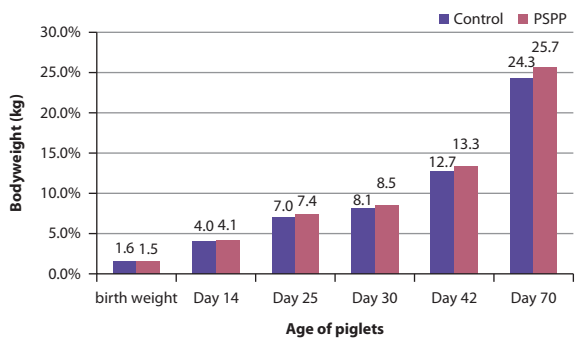


Table 1 – Milk composition of sows in week 2 of lactation.

	Control	Dairy product for sows*
Dry matter	19,30%	20,9%**
Fat	7,80%	9,1%**
Protein	5,30%	6,00%
Lactose	5,60%	5,20%

*Lactolat, FrieslandCampina Nutrifeed, **P<0,1

oils, resulting in small fat particles which can easily be digested by piglets, see *Figure 1*. Especially the piglets' capacity of digesting fat is compromised when enduring weaning stress, so it would make sense to replace part of liquid vegetable oils by spray-dried, fat-filled dairy components. Eventually, this will result in more efficient piglet growth and a reduction of feeding costs.

Different trials have been performed to test the effect of the Piglet and Sow Performance Programme. Studies were performed at scientific institutes in Thailand and the Netherlands. In addition, trials were done on commercial farms in Vietnam and South Africa to investigate whether the programme improved sow condition and piglet performance as a whole. The approach on both studies was comparable. The trial in South Africa included 50 sows and their piglets; the trial in Vietnam included 40 sows and their piglets.

The study comprised of two treatments, the control group received commercial regional lactation (sow), weaning and starter (piglets) diet. The trial group received the same commercial diets, but with inclusion of the three complementary dairy products of the programme.

Trial in Thailand

A first trial was performed to test the effect of the dairy concentrate for sows (Lactolat) on the general condition of sows and on the composition of sow milk. This trial was executed by the Chulalongkorn University in Bangkok, Thailand, in cooperation with FrieslandCampina Nutrifeed. In total 90 sows entered the trial at five days before the expected farrowing date. As a result, *Figure 2* shows the general condition of the sow in terms of backfat loss. Sows receiving the dairy concentrate lost less backfat during lactation. Furthermore, the dairy concentrate had a positive effect on milk composition; fat levels were significantly increased and the metabolic energy level increased as well, see *Table 1*.

Trial in South Africa and Vietnam

Subsequently, the results of the trials performed with the total programme showed positive effects as well. Trial piglets had on average 100 g lower birth weights, but already after two weeks trial piglets were 100 g heavier compared to the control piglets. This is likely the result of feeding the dairy concentrate to the sows and feeding the premium milk (Porcolac Extra) to young piglets *ad lib* next to dry pre-starter. At weaning, the growth advantage increased to 400 g. At the end of the trial, day 70, the piglets fed with all three complementary products of the programme reached a bodyweight that was 1.4 kg higher compared to the control group, see *Figure 3*.

Trial in the Netherlands

The trial at Schothorst Feed Research, the Netherlands, was performed to look at the effect of the premium milk given to piglets five days pre-weaning. This resulted in significantly increased growth rates and higher feed intake pre-and post-weaning. The institute suggested that "a more gradual transition of the piglets from liquid (milk) to solid feed could have reduced intestinal damages and improved intestinal integrity. Additionally, effects on immunity or microflora may contribute to the improved performance of these piglets after weaning."

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Amino acids: Balance is essential

PHOTO: HENK RISWICK

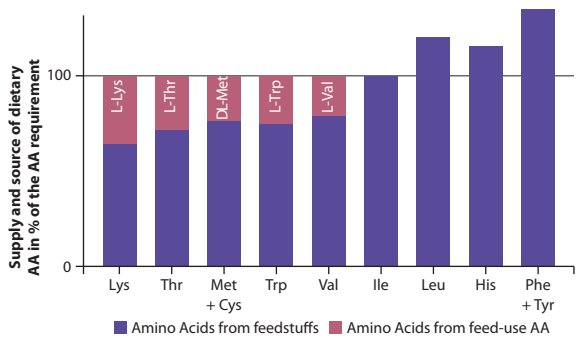
Behind the addition of amino acids in low crude protein diets for piglets, there is a world of calculations and mathematics. The keyword here is balance – if one ingredient is too strongly present, or is missing, feed intake might suddenly just fade away.

By Etienne Corrent, head of Innovation and Customer Solutions, Ajinomoto Eurolysine, Paris, France

A major concern to deal with in piglet nutrition is to feed a high nutrient demanding animal while its feed intake capacity is limited, even more so at the time of the stressful period of weaning. Highly concentrated feeds are therefore used to answer the animal's needs. However, if a high dietary crude protein feed is given to the piglet, it results in an increased gut pathogenic bacteria proliferation due to the excess of undigested protein and causes severe diarrhoea.

A lower supply of dietary crude protein reduces the global amount of undigested protein in the distal intestine of piglets and results in a better acidification (and digestion) of the bolus. The dietary crude protein reduction solution contributes to a safe start of the pig's life and should not be done at the expense of the technical and economic performance. The increasing availability of feed grade amino acids has made the further decrease of dietary crude protein possible and changed the way of addressing risk management in piglet feeds.

Figure 1 - Example of the 7 co-limiting AA in a piglet formula in which dietary crude protein is reduced, taking into account requirement of indispensable AA, and using feed grade AA.



Feed grade amino acids

With the feed grade amino acids available in the European market it is possible to formulate diets, without minimum constraint on the crude protein level, in which at least seven amino acids are co-limiting: lysine (Lys), threonine (Thr), tryptophan (Trp), methionine and cystine (Met+Cys), valine (Val) and the next limiting amino acid (see also *Figure 1*).

This next limiting amino determines the resulting dietary crude protein level and can be different in each particular situation as it depends on the feedstuffs locally used and the choice made on dietary amino acid levels.

Indispensable amino acid requirements

From a pool of 20 amino acids, piglets can synthesise all proteins needed to fulfill their maintenance and growth requirements. The 20 amino acids can be considered as essential for the protein synthesis during growth, but nine of them are either not synthesised at all or only in small quantities by pigs. Considered as indispensable in piglets are the six ones summed up earlier, as well as isoleucine (Ile), leucine (Leu), histidine (His), phenylalanine (Phe), and tyrosine (Tyr). This is why they all must be supplied in the diet.

In practice, it is of great importance to ensure that the minimum requirement of each indispensable amino acid is met.

Ideal amino acid profile for practical piglet diets

Ideal amino acid profiles, expressed in ratio to Lysine (*Table*), are commonly used in practice and based on dose-response trials. In a recent work from 2015, a team around the researchers Elham Assadi Soumeh and Jan Værum Nørgard (Aarhus University), conducted dose-responses to valine, isoleucine and leucine in young piglets. Requirements values found for

Piglets are capable of detecting an unbalanced amino acid supply and as such will lower their feed intake.

average daily gain (ADG) were 71% standard ileal digestibility (SID) Val:Lys, 52% SID Ile:Lys and 94% SID Leu:Lys.
Comparing the response to these amino acids (*Figure 2*), it can be easily understood that in these experiments valine or leucine deficiency is more detrimental to performance than isoleucine deficiency in blood free diets.

Recognising when diets are imbalanced

Amino acids have different impacts on feed intake and it must be considered when low crude protein diets are implemented to avoid amino acid deficiencies or imbalances. Here are a couple of examples.
It has already been demonstrated that **tryptophan** can stimulate feed intake. Its effect on feed intake is directly linked to tryptophan metabolism and it is advised to maximise levels in young piglet diets to 22% SID Trp:Lys.
The other side of the coin is also possible. Piglets are capable of detecting an unbalanced amino acid supply and as such will lower their feed intake. In a meta-analysis work, a team around Jaap van Milgen, associated with the French National Institute of Agricultural Research (INRA), concluded in 2013 that **valine** deficiency decreases feed intake to a great extent and consequently gain.
The same observation can be made for **isoleucine**, but contrary to valine, the response is quadratic and an excess of isoleucine can deteriorate also the feed intake of the piglet. Again the team of Elham Assadi Soumeh very recently also demonstrated a feed intake reduction when leucine is provided below its requirement. Excess **leucine** was shown not to be detrimental to piglets in her work but dietary valine and isoleucine were strictly controlled which avoided the imbalance and known interaction with leucine.
In 2010, a team led by researcher Mathieu Gloaguen (INRA, Ajinomoto Eurolysine) reported indeed an interaction between **valine** and **leucine**: the negative impact of leucine excess on feed intake was much greater in case of a valine deficiency than when valine was supplied at its requirement.

Interpreting a feed intake response

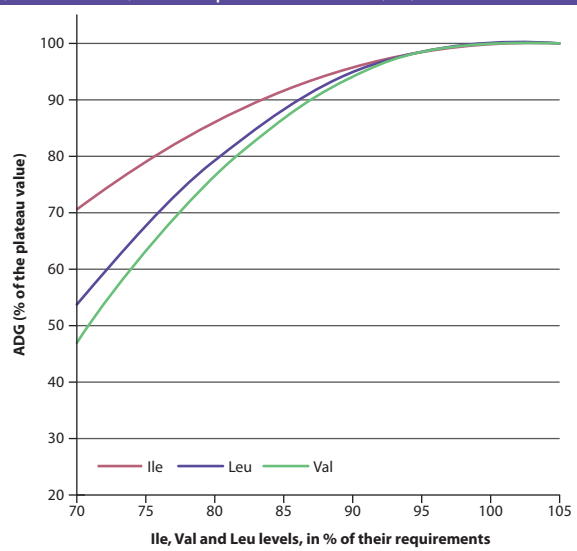
Interpreting a feed intake response is difficult. It cannot easily be determined if the response is due to a nutritional deficiency, a nutritional excess, or an imbalance between amino acids. More research is needed in this field of amino acid interactions, signaling effects and impact on feed intake. From a practical view, providing a low crude protein diet with a balanced amino acid profile is a solution to allow the highest nutrient intake of young piglets.

References available on request.

Ideal amino acid profile for piglets (up to 25 kg live weight) expressed in standardised ileal digestible (SID) values in % of Lys (blood free diets).

SID Values in % of Lys	Ajinomoto Eurolysine (2015)
Threonine	65
Methionine	30
Methionine + Cysteine	60
Tryptophan	22
Valine	70
Isoleucine	53
Leucine	100
Histidine	32
Phenylalanine	55
Phenylalanine + Tyrosine	95

Figure 2 - Effect of Val, Ile and Leu on piglet average daily gain (ADG) based on curvilinear-plateau models (Val and Leu) and a quadratic model (Ile).



Source: Soumeh et al. (2015).

Indigestion: An overlooked factor in animal nutrition?

MARK PASVEER

Many articles on young animal feed composition focus on digestibility of ingredients. It is interesting, however, to take the opposite view. What happens when trying to measure indigestibility and thus quantify what is in the feed that young animals don't need?

By Lars Sangill Andersen MSc and Dr Carsten Pedersen, nutritionists, Hamlet Protein, Denmark

When evaluating feed ingredients, digestibility of nutrients as a measure of quality and potential in feed formulation is typically used. These values are published in various nutrition guides and are often the target of research projects to verify published data or shed light on new hypotheses.

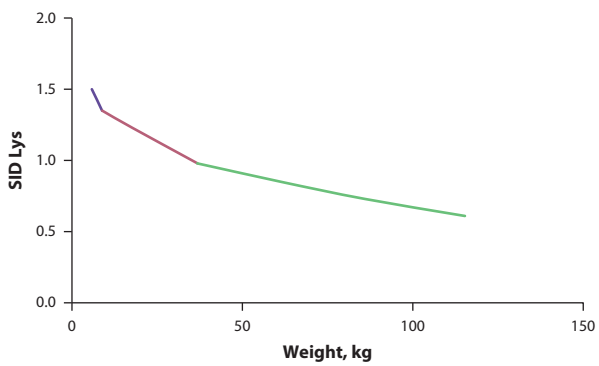
It is important information when formulating feed to provide the nutrient requirements for a given animal.

However, in this article, a different view is taken of the nutrient perspective: indigestibility. In this text, indigestibility is used to describe the undigested protein in the raw materials or the reciprocal of digestibility. This is related to what happens further along in the digestive tract, after easily digested nutrients have been absorbed, to the fraction that is not digested.

A discussion of all the nutrients and animal species or ages would require many pages. Instead this article zooms in on protein and piglets as an example, not only because there is interesting data with regard to this perspective, but also because protein is the most costly of the major nutrients and is always susceptible to scrutiny. Indigestible protein may cause potential gut health problems which makes it interesting from a health perspective as well as from a growth perspective. Finally, there is an energy cost involved in excreting nitrogen from de-aminated amino acids.

Piglets are of interest as below data shows that the indigestible protein fraction is larger in young piglets (<20 kg) during the first few weeks post-weaning. Subsequently, the indigestible fraction drops over the next few weeks to a level which resembles what we know from pigs over 25 kg (*Tables 1-3*).

Figure 1 – Recommendations for Standardised Ileal Digestibility (SID) lysine for pigs.



Source: National Research Council (NRC), 2012.

Digestibility develops with animal age

The data in *Table 1* shows there is a significant difference in

the standardised ileal digestibility (SID) of protein among soy-based ingredients. The data comes from all published values for the individual feedstuffs. However, comparing the SID crude protein values for each individual ingredient for pigs weighing less than 20 kg, there is a difference for soybean meal 48% of 4.5% units, but for enzyme-treated soybean meal, no difference is found (*Table 2*). The reason is that only results with pigs lighter than 20 kg have been published.

In *Table 3*, SID of crude protein values for soybean meal 48%, grouped according to weight are reported. The data in *Table 3* is in line with the difference found between results in *Table 1* and *Table 2* for soybean meal 48%. Going from piglets (5.6-12.2 kg) to growing pigs (23.2-50.0 kg), an increase in SID of 8.8% units is observed.

Digestibility of amino acids

These values listed in *Tables 1-3* are in agreement with a report set up by Ron Ball and Soenke Moehn, University of Alberta, Canada, 2015. They found that the SID of amino acids was significantly lower in weaned piglets (end weight 8.1 kg) in comparison to grow-finishing pigs for barley, wheat, maize, peas and soybean meal. According to them, the mean SID of amino acids for canola meal was highest for weaned piglets compared to the other ingredients they reported. The researchers' explanation for the differences in SID of amino acids for these ingredients in weaned piglets in comparison to grow-finishing pigs were due to the higher relative endogenous losses in the younger pigs. Similar findings have been reported for broilers; older birds show higher SID of amino acids compared to younger birds.

Figure 1 shows the National Research Council's (2012) recommendation for SID of lysine for pigs. The lines are divided into three different straight lines, with two break points. The slope of the line for piglets less than 11 kg is clearly different from the slope for piglets up to 37.5 kg (median of the interval 25-50 kg). The slope of the line from 37.5 kg to slaughter is again different from the first two lines. The steep slope from 5-11 kg can be explained largely by a lower SID of amino acids in soybean meal, since most of the studies conducted to estimate the amino acid requirements in piglets used soybean meal as the main protein source.

Sensitivity to anti-nutritional factors

In addition to the differences in endogenous losses between young animals and older animals, there is also the sensitivity to anti-nutritional factors. Crude protein (N x 6.25) can be calculated into nitrogen from amino acids and from non-protein nitrogen (NPN), see *Figure 2*.

As the figure shows, the digestibility of the amino acid fraction varies resulting in various amounts of undigested amino acid entering the large intestine. But apart from the indigestibility of these raw materials, they also contribute a non-protein nitrogen (NPN) fraction to the large intestine. Those two fractions of the original crude protein from the feed can be utilised in the gut by proteolytic bacteria causing growth and potential risk of an imbalance in the microflora with subsequent diarrhoea. The NH^3 formed in the gut is absorbed and contributes to the nitrogen load which has to be removed by the liver and excreted from the kidneys via urine; all of which costs energy and takes up capacity in the liver from other metabolic outputs which could have supported growth and health.

In conclusion, the indigestibility and NPN content of raw materials do not contribute to support the growth and health of young animals. They do, however, add to the health risks and maintenance costs of those same animals.

References available on request.

Figure 2 – Breakdown of crude protein in amino acids, digestible and non-protein nitrogen.

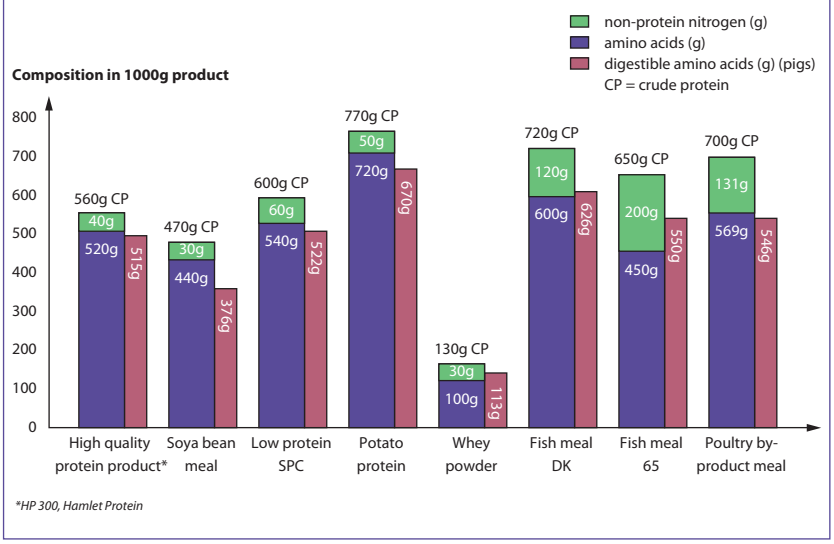


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Table 1 – Standardised ileal digestibility of CP in soy-based ingredients, %.

Item	SBM 48%	SBM 44%	ETSBM	FSBM	SPC	SPI	SEM	P-value
CP	85.5^{yz}	85.8^{xyz}	89.5^{yz}	83.0^{x}	89.0^{z}	88.2^{xyz}	2,4	0,05

Note: SBM= soybean meal; ETSBM=enzyme treated soybean meal; FSBM=fermented soybean meal; SPC=soy protein concentrate and SPI=soy protein isolate. Source: Pedersen and others, 2015.

Table 2 – Standardised ileal digestibility of CP in different ingredients, tested in piglets under 20 kg.

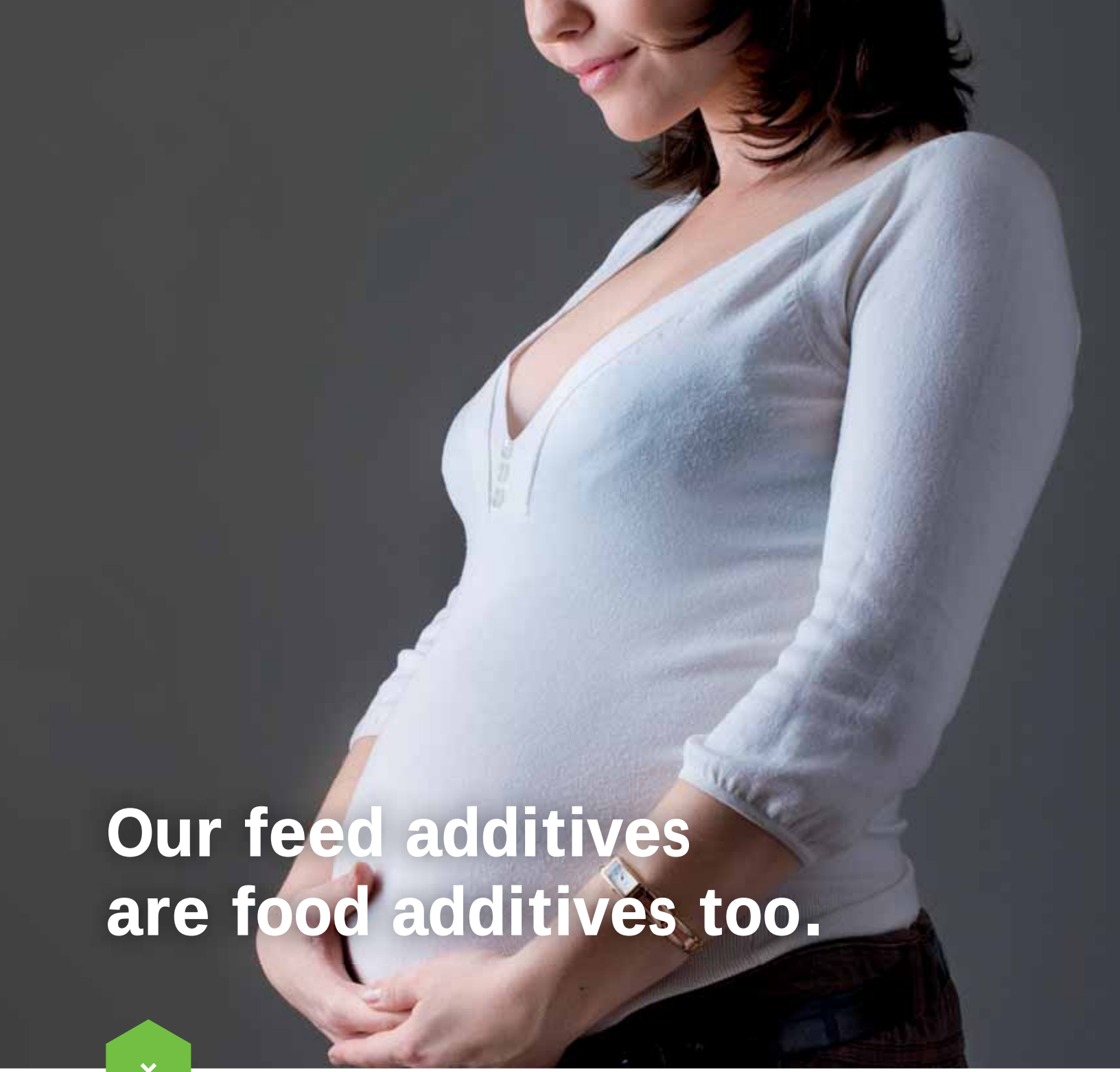
	Feedstuff						P-value		
Item	SBM 48%	ETSBM	FSBM	SPC	SPI	SEM	Weight	Feedstuff	Interaction
CP	81.0^{x}	89.5^{y}	81.1^{x}	89.1^{y}	87.4^{y}	3	<0.01	<0.01	<0.01

Note: SBM= soybean meal; ETSBM=enzyme treated soybean meal; FSBM=fermented soybean meal; SPC=soy protein concentrate and SPI=soy protein isolate. Source: Pedersen and others, 2015.

Table 3 – Effect of initial body weight (kg) on standardised ileal (SID) CP of SBM 48%.

Item	Body weight range (kg)									SEM	P-value
	5.6-12.2			23.2-50.0			55.0-110.0				
	N	Average	SD	N	Average	SD	N	Average	SD		
CP	25	80.2^{x}	5	34	89.0^{y}	2,5	10	88.7^{y}	2	1,1	<0.01

Source: Pedersen and others, 2015.



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Controlling piglet diarrhoea with a holistic approach

Piglet diarrhoea can be viewed as caused by one particular reason – and hence the cure can be found by removing this cause. It might also make sense to view the problem of piglet diarrhoea from above: why not make sure that everything around the pig is in top condition? In this article, views from the feed/nutrition side is discussed.

PHOTO: KOOS GROENEWOLD

By Pierre-Stéphane Revy, research manager, Calcialiment-Vilofoss & Jacob Dall, head nutritionist swine, Vitfoss-Vilofoss

Worldwide, there is a growing acceptance that a reduction of the consumption of antibiotics for animal production is needed. At the same time, there are also increasing concerns about the use of therapeutic levels of zinc oxide, which is allowed in some EU countries. This calls for a new approach to piglet nutrition with increased focus on both nutritive and non-nutritive sides of feeding young animals, including focus on strengthening the immunological status of pigs. This is why research by the Danish agricultural cooperative society (DLG Group) aims at a discontinuation of preventative use of antibiotics, as well as limiting the need for curative medication.

Limiting diarrhoea at weaning

Antibiotics can be used to solve digestive disorders at weaning. Application sometimes is done not only on a curative basis, but also preventatively, mixed in water or feed. There is a trend and a will, however, to even further reduce or even to completely remove the use of preventatively used antibiotics. This is not something just for the European Union, but in fact a tendency that can be observed throughout the whole of Europe. Zinc oxide (ZnO) in some cases is very helpful in controlling piglet intestinal health, but it also has negative side-effects. There could be interactions with other nutrients, such as phytase, other minerals or a change of palatability of other substances.

Traditionally, different strategies have been applied to avoid or limit diarrhoea at weaning. These include the use of low crude protein levels (and high inclusion of crystalline amino acids), organic acids, pre- and/or probiotics and essential oils. Because not all essential amino acids are available in crystalline form, there is a limit to how low it is possible to go on a protein level, without impairing piglet performance, and an optimisation between protein level and performance has to be performed on herd level.

Where organic and inorganic acids* can be said to be included in generally all feed for piglets for solving health issues and improving performance, there are some differences between continents when it comes to the remaining product types. In an industry survey, the needs of the industry from Asia, Europe and the American continents was unanimously described as 'controlling piglet diarrhoea' and 'being able to create antibiotic-free diets'.

Understanding mechanisms

Besides focusing on the technological effect of additives, it is also vital to understand the mechanisms that determine feeding behaviour and non-nutritive effects created by feed and feed additives. These non-nutritive effects are referred to by different terms. The word 'eubiotics' is used for any compound or product that works through modification of the microflora; the term 'epigenetics' address the fact, that certain substances have been shown to be able to up- or down-regulate specific gene expressions, supporting the digestive and

immunological abilities of the piglets.
Recent work, carried out at the Swine Innovation Centre in Sterksel, the Netherlands, shows that even though palatable creep feed is offered pre-weaning, a large proportion of piglets have not started to take in feed when the time of weaning comes. Time from weaning to first feed intake was significantly higher for these 'non-eaters', which influenced post-weaning performance. What follows is that if the right high quality feed is used in creep/prestarter and starter feed, experience shows that piglets are more robust, and can be fed in a more cost-beneficial way, using high levels of soybean meal in diets for piglets from 15-20 kg.

Gut development stage is important

Administering feed that is not adapted to the gut development stage of the pig, often will lead to a non-infectious inflammation and diarrhoea. Research indicates that this kind of physiological stress might not only reduce performance at the time of the inflammation, but also could lead to an increased susceptibility to stressors for the remaining lifetime of the pig, lowering the threshold of diarrhoea and impairing lifetime productivity potential. To better understand the link between feed quality and performance, a meta-analysis of validated performance data from more than 200 Danish herds concluded that using premium feeds leads to better performance. It seems that the markets are changing; it is recognised that it pays off to invest in high quality feed for young animals, to achieve and optimise overall lifetime performance. This probably is due to the fact that avoiding intestinal diseases in the early stages of life can be linked to a better lifetime performance.

PHOTO: RONALD HISSINK

Optimising protein supply

As the intestine of the small and newly weaned piglet is designed for digesting and absorbing proteins from milk, protein sources can be classified as 'iso-milk' proteins, depending on the digestibility and impact of the gastro-intestinal tract (GIT). Soy-protein concentrates from fermentation of extraction processes, potato protein concentrates, blood plasma and pea protein concentrate are components that can be considered iso-milk proteins.
Amino acids have other properties other than solely being a building block for protein synthesis. Specific amino acids have very important functions in immune function (methionine), gut epithelium and mucosa function and renewal (threonine), and neurotransmitters (tryptophane). When feeds are developed, aimed at challenged pigs, these should be formulated with an amino acid profile that takes these properties into consideration.

Properties of minerals

For several years, the Vilofoss group has been gaining experience and documentation on the benefits of including specific trace mineral chelates into piglet feeds. Including trace mineral chelates at levels corresponding to the maximum legal level within the EU, can be part of the strategy of controlling intestinal health in the post-weaning period. Field trials have shown, that to a certain extent, the inclusion of the concept PigOmic, performance can be increased, and the impact for *E. coli* infections can be reduced. In countries where therapeutic use of zinc oxide is legal, PigOmic can be used in the most cost-beneficial way, succeeding the ZnO administration. Only adding PigOmic to the diets, not using prophylactic treatment or antibiotic growth promoter (AGP) levels, or ZnO have been shown to reduce the impact of both general *E. coli* and also type O149, which leads to oedema disease.

Zinc – an essential trace mineral

In the late 1980's, several researchers (e.g. Anders Holm, 1988; Hanne Damgaard Poulsen, 1989) proposed to supplement piglet feed with high level of zinc from oxide to reduce the severity and frequency of diarrhoea occurrence just after weaning. Since then, many studies have confirmed the positive effect on diarrhoea and growth performance. The addition of ZnO must be realised immediately after weaning and for two weeks to optimise its effectiveness considering clinical and ecological parameters. A synthesis of scientific studies has shown an improvement of growth performance between 10 and 30% when piglet feed was supplemented with 1,500 to 3,000 mg/kg of zinc from ZnO. To limit the emission of zinc to the environment, a limited use by prescription has been adopted in a number of European countries. This, however, can be a temporary permission in some cases, which at some point probably is likely to be discontinued. Above 1,000 mg/kg, zinc can induce an iron and a copper deficiency and lead to anaemia if the feed is not well balanced on these two trace elements. On top of this, there is some evidence,

that once the treatment with ZnO ends, the balance of the microflora changes dramatically in the following weeks. Using amino acid chelates of zinc has been shown to improve gut integrity and improve performance with only 10% of the therapeutic levels of ZnO.
With the decreasing possibilities of using traditional antimicrobials, improved knowledge on the health management, not only around, but also inside piglet intestines is essential to keep productivity at its best.

New promising research results

For some time, it has been considered, that piglet diets had to be quite nutrient-dense to fulfill the animal's daily nutrient requirements, as it was assumed that piglets, due to a small volume of the GIT, have a low feed intake capacity. Recent studies have shown interesting results in using specific fibre fractions as an alternative to antibiotics in the feed. The exact correlation between fibre, health and growth is still not fully understood, but some authors have demonstrated a reduction of the severity of diarrhoea after weaning with high fibre diets, whereas for others fibre could increase pig susceptibility to diarrhoea.
This could be explained by the fact that there is a large variety of fibre with very different characteristics (digestible or not) and that there is no real recommendation regarding use of fibres in piglet diets. Fermentable fibre improves gut health in piglets: increase short-chain fatty acids (SCFA), decrease pathogens despite effects on growth performance. Nevertheless, from a practical point of view, the inclusion of fermentable fibre could be an additional risk factor after weaning especially in poor sanitary conditions. On the other hand, inert fibre could help limit digestive disorders and improve growth performance at weaning, but further research has to be done to better describe the type of fibre for a better use in piglet feed.

Plasma

From a technical point of view, blood plasma is one of the best alternatives to antibiotics. The use of blood plasma in piglet feed increases feed intake that is fundamental just after weaning. Blood plasma is also the best source of protein because it is not only a protein for growth but also a functional protein (immunoglobulins), that improves immunity and hence piglet health status. Studies have shown an improvement of growth performance by 25% on average when compared to other highly digestible protein sources as milk and soy protein sources. According to some veterinary experts, blood plasma has an important potential for reducing the use of antibiotics in digestive disorders of the piglet, by decreasing diarrhoea and mortality. They recognise that blood plasma improves palatability of the feed, growth rate and piglet health.
The use of plasma does not present any risk from a sanitary point of view if good practices (good manufacturing practice) are respected. Experts advise minimal requirements for plasma manufacturing. The heat treatment must be controlled in terms of temperature and duration, treated product storage of at least seven days must be applied and hygiene measures must be respected to avoid recontamination. Additionally, the origin of pig blood is regulated in Europe.
Even though protein sources of animal origin traditionally have been used for feeding young animals, the feed business can be forced in some cases to find non-animal alternatives, as the fear for contamination-related health issues is rising.

Piglet feed programme

The Vilofoss piglet programme Primefeed utilises the latest knowledge in pre-and post-weaning nutrition, offering feed solutions for piglets from birth to when they transition to more soybean meal (SBM) based diets. The earliest diet that can be offered in a hygienic way is a milk product, that includes the benefits of supplemental milk, teaches the piglets to eat dry feed, thereby easing the adaptation to more vegetable-based feeds in the creep/prestarter/starter range.
The programme offers solutions for the high-health, high-performing piglet, that benefits from highly digestible nutrient dense diets, through diets designed for optimal growth in more challenged piglets, to diets for more robust piglets, where a more competitive pricing is required. This means that the programme offers a feeding solution for all piglet producers, at any required level, and it will be possible to find the most cost-beneficial solution for each herd.

** Blends used at weaning should be an optimised mix of organic and inorganic acids, and minimum at 1% inclusion level.*

Offering feed solutions after weaning is still a matter of great precision and quality.

The importance of early nutrition

Growth rate and feed conversion are needed to bring pigs and poultry to the optimal weight for the best economic results. To achieve this, a well-developed gastro-intestinal tract with a balanced microbial ecology and strong immune system is required.

By Francois Nell, poultry specialist EMEA, DSM
and Rene Bonekamp, swine specialist EMEA, DSM

In many ways, the lives of pigs and broilers are different – eggs versus liveborn, feathers versus skin, wings versus legs – six weeks versus six months. In one way, however, they are remarkably similar, and this is when it comes down to nutrition.

Both animal species benefit from targeted nutrition at the right moment and in both cases, feeding the young animal aptly is pivotal. And one simply cannot start young enough. A newly hatched broiler chick increases its body weight by 25% overnight and in the first week almost 20% of the total growth takes place at a feed conversion ratio of 1:1.

A piglet's potential for growth right after birth is significantly substantial compared to later phases of its life. This article touches on five stages in the young animals' lives where correct feeding and application of feed additives can make a difference.

Correct nutrition for young chicks starts long before they hatch – maternal nutrition matters too, as well as the embryo phase.

Maternal nutrition – broiler breeders

The life of the broiler chick starts nine days before the egg is laid. Breeder hen nutrition can influence the size of the egg and the yolk itself. This is important as the embryo develops from the egg yolk and the size of the yolk determines the size of the chick. Vitamins not only have an effect on embryo viability but also chick quality. Hens fed higher levels of fat soluble vitamins, ß-carotene and vitamin E have been shown to produce chicks with increased lymphocyte proliferation and a stronger immune system.

Trials show that broiler breeders fed with a commercial form of vitamin D3, 25-OH-D3 produce chicks with significantly increased innate immune functions as measured through white blood cell phagocytes on day 1 and day 4 after hatch. Several recent research trials suggest that 25-OH-D3 can stimulate cell mediated muscle fibre hypertrophy in certain muscle types, thus improving meat yield.

Maternal nutrition – sows

During the last few weeks of gestation, piglets grow quickly, putting strain on the energy and nutrient levels the sow gets nutritionally. For the sow, this translates into many challenges throughout the birth process which can cause oxidative stress. Increasing or balancing the sow's diet with vitamins, especially E, C and selenium with their anti-oxidant properties can help detoxify the animal.

Vitamin D is a key nutrient piglets lack in their blood from birth, right up to two weeks after. With piglets preferring to drink sow milk at this early period in their life, it is essential the sow's milk is rich in vitamin D3, in the form of 25-OH-D3. With the increase in stress challenging the sow's immune system, the risk of pathogens taking over the surface of the gut is increased. Prevention through the anti-bacterial organic acid Vevovitall is proven to be effective in the stomach and latter parts of the small intestine, while also reducing the pH in the sow's urine, cleansing the birth canal area.

Embryo stage – broilers

Before hatching, the embryo consumes the amnion orally and begins a series of metabolic and physiological changes. Rapid development of the intestine is needed as the bird's energy supply comes from exogenous carbohydrate-rich feed in contrast



Feeding piglets correctly should start with a balanced diet for sows.

to the endogenous supply through the yolk. Often in the hatchery, the earliest hatched birds are withheld feed and water and are at risk from dehydration, as well as reduced growth rate, myogenesis and the ability to utilise energy.
Immediate post-hatch nutrition stimulates intestinal morphological development. Feed intake will increase the weight of the intestine by 600% during the first seven days as well as the development of enzymatic secretions and the gastro-intestinal tract microflora. An effective way of decreasing the negative effect of delayed feeding is to supply the birds with early feeding supplements.

Birth – piglets

The intake of colostrum is vital at birth to protect the piglets from unknown bacteria. A few hours after birth, the piglet's innate immune system steps into action, requiring a balance of good and bad bacteria in the intestines. To combat an imbalance in bacterial presence and stabilise the gut flora, Cylactin (DSM) can be used in the lactation diet of sows with piglets.
In addition, a well-developed gastro-intestinal tract is needed to get piglets ready for the important weaning process. Many feed solutions can be used to stimulate the weaning process, but it should be known that the development of the intestines also works as a feed intake stimulator.

Early feed – broiler chicks

Optimal nutrition at this time affects the ability of the developing intestine and microbiota to utilise exogenous feed and ensures a rapid increase in feed intake. Early feed intake results have positive effects on the rate of yolk absorption and the development of a strong immune system.
Pre-starter chick diets should be formulated with high levels of digestible protein and energy to fulfil the demanding requirements of the bird. The combination of the birds' developing intestine and the use of less digestible ingredients can lead to the presence of undigested nutrients in the small intestine then caeca and colon. The undigested nutrients act as an abundant source for microbial growth that could disturb the balance of the microbiota in the developing intestine.
Many non-nutritive feed additives can be considered to alleviate this problem.

- *Exogenous enzymes* complement the limited endogenous enzyme excretions in the chicks' developing intestine. Protease enzymes hydrolyse the protein bonds, breaking up the complex protein structure into smaller peptides for further absorption or hydrolysation by endogenous proteases.
- *Probiotics* containing live bacteria, stabilise the gut flora and improve overall performance by enhancing the in situ production of lactic acid and short chain fatty acids in the chicks' developing intestine.
- *Pre-biotics* are non-digestible feed ingredients with selective effects on the intestinal microbiota. Their benefit lies in the selective stimulation of the metabolic activity of a limited number of commensal bacteria species.
- *Organic acids* have strong antimicrobial properties that successfully reduce gastro-intestinal pathogenic bacterial growth. The efficacy of different organic acids differs depending on their chemical properties and interactions with the acidic stomach and alkaline small intestine environments.
- *Essential oil compounds* are also additives with well-known antimicrobial properties. Research has shown that a blend of essential oil compounds, along with organic acids works better than any single ingredient alone.

Fibrous diets – piglets

Piglets have a limited capacity to digest and ferment fibres yet are under pressure to develop quickly and adapt to consuming these new raw materials. Barley is used a lot in piglet diets due to its fibrous character, fibre being an important property to support gut development and prevent outbreaks of bacteria.
The combination of a xylanase and ß-glucanase, for example the commercially available Ronozyme MultiGrain can be used to improve digestibility and support the piglet through this crucial phase.

Investing in their future

More and more trials are being done to uncover the importance of early nutrition, from gestation to post birth. Controlling pathogenic bacteria in the intestine and promoting the development of balanced microbiota in the gut is a worthy investment to grow healthy animals and sustainable food.

References available on request.

High quality proteins for young animals

Dairy, potato protein and fishmeal are expensive and the quest is on to find suitable and cheaper alternatives for these commonly used proteins. A Danish company processes soy in such a way that young animals show similar performance compared to conventional protein concentrates.

By Aloys Laue, nutritionist, AgroKorn, Denmark

With a global human population quickly rising above eight billion people scarce high value proteins from dairy, potato and fish – traditionally used for infant animal nutrition – will now enter the food chain for human consumption. For fishmeal we have seen a steady decline in volume for the aqua and livestock industry of around 2 - 3 million tonnes over the last 15 years down to around 5 million tonnes today. Therefore, the development of more suitable digestible proteins is a must to be able to substitute these highly nutritious animal based or scarce plant protein sources for optimal animal performance, health and profitability - allowing payable healthy animal proteins to feed the quickly growing world population. A Danish company is using a new technology where the protein is extracted from vegetable raw materials – in this case soy – by gentle water extraction. This results in a protein level similar to fishmeal and very low in anti-nutritional factors. The new technology allows the conversion of abundantly available plant raw materials with global outputs of soy (320 million tonnes) and canola (65 million tonnes) into highly digestible proteins for infant livestock nutrition. Due to raw material availability Agrokorn chose to start with soy. The technology used splits up the soy in the

Table 1 - An overview of the most recent test results for the soy protein products in comparison to Danish fishmeal.

Protein concentrate	Ileal protein digestibility coefficient (%)	Country
Soy protein concentrate*	96.6	Germany, 2015
Soy protein concentrate*	96.5	Denmark, 2015
Soy protein concentrate*	94.0	Denmark, 2014
Soy protein concentrate*	97.2	Denmark, 2013
Soy protein concentrate* average	95.3	
Fishmeal, super prime	96.0	Danish feed table 2014/15
Skim milk powder	96.0	Danish feed table 2014/15
Potato protein low solanin	90.0	Danish feed table 2014/15

*AlphaSoy Premium

Gentle water extraction can turn soy beans into a nutritious protein concentrate, which is able to subsitute other (more scarce or expensive) animal or vegetable protein sources in the animal diet.

protein concentrate product*, which is around 70% protein comparable to fishmeal and a byproduct carrying the not wanted group of anti-nutritional factors. In addition to performance trials, research has been carried out to confirm fishmeal and dairy equivalent protein digestibilities of around 95% needed for nutrition of young animals in the lactation and nursery period as well as fry in aquaculture (*Table 1*).

Comparison with high quality fishmeal

Most of the trials have been with young animals in the lactation and nursery period. In the aquaculture sector studies have been carried out in fry. An overview of the trials with this new soy protein concentrate* in different animal species, substituted ingredients, substitution rates and overall conclusions is given in *Table 2*. In these trials, the use of high quality fishmeal has been the dominant benchmark for testing the soy concentrate. The researchers looked at 5 - 15% replacement of the fishmeal protein with that of soy protein concentrate. It was shown that the animals showed similar growth results across all tested species. This is owed to the very 'clean' protein this processing method gives leading to the very high standard ileo digestibilities of amino acids as well as good feed intake data due to nice palatability. Overall, the presented data illustrate that the soy protein concentrate is able to substitute both quality animal and vegetable high protein concentrates while keeping or improving animal performance.

Effect on feed intake and growth

The soy protein concentrate was also tested as a substitution for low solanin potato protein and pea protein concentrate. Opposite to soy, the latter is very limited in availability, often increasing rearing cost. Therefore, other protein sources can be a good alternative to these concentrated plant-based proteins. In the trial, carried out in France, pea and potato protein were in part or completely substituted with the soy protein concentrate in piglet diets during the first two and a half weeks after weaning (day 28). The soy protein concentrate led to an improved feed intake and weight gain. This difference is statistically significant when combining this product with low solanin potato protein. The higher nutrient intake is more efficiently converted into a higher growth at the same feed cost. This confirms that all or a part of the conventional protein sources in the diet can be replaced by a soy protein concentrate, while keeping or improving animal performance.

Conclusion

The new soy protein concentrate allows for de-bottlenecking the tight supply chain of fishmeal for neonate livestock feeding along with extensive improvement in production cost while maintaining animal performance and well-being. One area of application is baby piglet nutrition. Current breeding progress leads to more piglets per litter and along with that more light weight and vulnerable baby pigs which need very high quality proteins for a good start. Among the many ongoing livestock initiatives to optimise animal well-being and performance to allow a decent farmer income, the industry across all species is focusing on reducing the use of antibiotics in the interest of public health. Also here high quality ingredients like the soy protein concentrate discussed here can widen the range of options in our toolbox to support successful neonate livestock nutrition.

*AlphaSoy Premium

Table 2 - Overview of trials with different animal species.

Species	Year	Type of ingredient substituted in diet	Ingredient substitution with soy product*	Results
Trials substituting animal protein concentrates				
Mink (Mustola vision)	2011-14	Danish fishmeal	3-15%	· 94% SID protein · 90% AID protein
Salmon/ Trout/ Sea Bream	2012-14	Danish/ Super prime fishmeal	8-10%	· Similar nice SGR · Same good FCR
Piglets	2014	Danish/ Super prime fishmeal	5-8%	· High good ADG · Identical good FCR
Calfs	2012	Dairy protein	10%	· High identical milk intake · Equal strong ADG · 0% mortality
Trials substituting vegetable protein concentrates				
Piglets	2014	Pea, Potato Protein and combinations	3-6%	· Improved ADG · Identical good FCR

AID: Apparent ileo digestibility; SID: standard ileo digestibility; ADG: average daily gain; SGR: standard growth rate; FCR: feed conversion rate.

Butyrate: An effective molecule for young birds

When chicks are hatched, they have an extremely challenging start. From this moment, the microflora should be in balance, to make sure a healthy and productive chicken can be raised. Butyrate has confirmed its value in achieving this.

By Stephan Bauwens, Innovad, Belgium

Today's livestock industry is known for its animals with high genetic potential. However, the potential is often not achieved due to different and complex challenges during the animal's lifecycle. One of the critical points is found at the border of the intestinal tube. This area is pivotal in selecting what can be absorbed and what should remain outside the animal's body. At the same time, the surface of the intestinal tract (300 times the size of the surface of the skin) is there to absorb nutrients. Keeping the intestinal tract healthy is therefore very important. Its relation with animal nutrition might be one of the most complex ones. But once you know how to positively influence the gut health, especially in young animals, the pay-off can be significant.

Understanding how the gut works

In order to obtain a high intestinal health status, possibly in combination with a reduced use of antibiotics, it is first of all important to understand how the intestinal system works. The intestinal barrier consists of different types of cells, of which the enterocytes are the most abundant ones. These enterocytes are linked to each other by means of complex protein structures called 'tight junctions'. These structures have the major task of closing the cell lines and avoiding paracellular passage of bacteria, toxins and other undesired substances from the lumen to the inside of the body. The intestinal lumen is folded into villi and microvilli in order to increase the absorption area for digested nutrients. The length and the structure of these villi are key to assure optimal feed usage and obtain excellent feed conversion ratio (FCR). The intestinal microbiota consists of more than 500 different species, which live in direct symbiosis with the host. They provide energy to the intestinal wall, prevent colonisation by pathogenic bacteria and help to maintain the intestinal immune system. It has often been demonstrated that the status of the immune system is (partly) defined by the presence and the type of microbiota in the intestine.

Table 1 - The effect of product 1 and product 2, Tylosin and sodium butyrate on the growth performance of the chickens.

Items	Treatments:					SEM	P-value
	Control	Tylosin	Product 1	Product 2	Sodium butyrate		
BW, g							
0 d	41.68	41.79	42.10	41.89	41.86	1.30	0.965
7 d	154.28b	150.32bc	151.23bc	166.39a	140.61c	10.90	<0.001
14 d	334.24c	412.90ab	423.33ab	436.10a	372.46bc	53.15	<0.001
21 d	697.53c	875.88ab	905.23a	875.33ab	764.22bc	117.02	<0.001
FCR, g/g							
0-7 d	2.20ab	2.66a	1.99b	1.92b	2.60a	0.46	0.001
7-14 d	3.64a	2.25b	2.03b	1.75b	1.78b	0.93	<0.001
14-21 d	1.65a	1.31b	1.34b	1.36b	1.39b	0.24	0.020
0-21 d	1.97a	1.61b	1.47b	1.40b	1.53b	0.49	<0.0001

Challenging start for young birds

Young birds, at the moment of birth, have an extremely challenging start. The digestive tract, including the gastro-intestinal immunity, and the whole digestive process are immature. The microbial flora, and by consequence the production of volatile fatty acids, are inexistent and the environment is extremely challenging due to the immediate need for high performance and the presence of pathogenic bacteria. Straight after hatching, everything should be done in order to start the digestive engine and build in safety precautions as the birds will have only one chance to make a good start. A failure, such as retarded performance or development of imbalanced microflora is unacceptable as this will show off at the end of the production cycle.

Using coated butyrate in the diet

So what can be done to make sure the young birds get a good start? One solution is adding butyrate to the feed. Butyrate is an amazing molecule which has been used intensively for more than a decade in animal nutrition. Benefits of butyric acid include the anti-inflammatory effects, the support of long slender villi, the enforcement of tight junctions and much more. More confusion exists about the form in which butyric acid is added to the diet, referring to the place where butyric acid is

released in the intestinal tract. We can all agree that the supplementation of pure sodium butyrate, which has a persistent and unpleasant smell, does not really have a major impact on the intestinal environment, as it is a water soluble component. A coated version is needed in order to reach the lower part of the digestive tract. Coating quality is an extremely important feature of the product and nutritionists should distinguish an 'odour control'- coating from a real functional protection. The first group of products is mostly characterised by a high concentration of salts of butyrate (>50%), where the only function of the coating is the elimination of the butyric acid smell. Within the products at lower concentrations, it is more difficult to distinguish the real functional coatings and more sophisticated tests are needed to evaluate the target release properties. An optimal coating is found when not more than 20% of the present butyrate is released in the first step of a validated simulation test. At the end of the test, it is important that all butyrate is released from its coating in order to avoid excretion of the active ingredient in the faeces (*Figure 1*).

Esterified forms of butyric acid

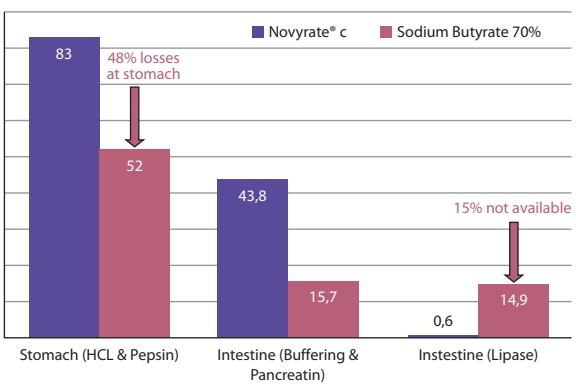
More recently, attention goes to esterified forms of butyric acid. Mono-, di- and tri-esters of butyric acid are chemically produced and are composed of a glycerol molecule and respectively 1, 2 or 3 butyrate molecules. Due to their similarity with triglycerides, they will automatically bypass the stomach during the digestive process, while the butyric acid molecules will be enzymatically released by lipase into the small intestine. Extremely important to guarantee the efficiency of the product are the type of esters provided, their stability and the know-how and the control of the esterification process. Free fatty acids, moisture and the typical smell of butyric acid can give a clear indication of whether the esterification process is complete and irreversible. One can easily understand the complexity of the intestinal system. Many scientists and veterinarians agree that one single non-antibiotic molecule will have its limits in order to control the overall situation.

Trials in poultry

Innovad has developed a concept and a synergistic approach to ensure a high intestinal health status. The product (Lumance®, hereafter called product 1) is a combination of esterified butyrins with medium chain fatty acids and plant extracts. A trial (May 2015) carried out at the Department of Animal Science of the Oklahoma State University looked at the value of this product in the early stage of broiler (Cobb) production. The birds received 1) an antibiotic free control diet, 2) Tylosin as an alternative growth promoter, 3) product 1, 4) a coated butyrate product (Novyrate®C, hereafter called product 2), or 5) an unprotected sodium butyrate product. As shown in *Table 1*, products 1 and 2 show significantly higher body weights compared to other treatments at the age of 7 days. Knowing that natural production of butyric acid in the GIT is only significant after 10 days of life, it clearly demonstrates the benefit of butyrate supplementation during this period. At the age of 21 days, product 1 and 2 showed the best performance results in terms of body weight and FCR. Regarding body weight, product 1 performed best numerically, which confirms the effective combination with the other active components in the formulation. The uncoated sodium butyrate performed inferior to products 1 and 2, which confirms the need for proven target released properties for butyrate based additives.

To make sure young birds get a good start, butyrate can be added to the feed.

Figure 1- The % of active ingredient loss at different stages is less when a coated product is used.



Multifunctional molecule with real benefits

The high genetic potential of today's production animals, combined with a clear and inevitable tendency to reduce the use of antibiotics, may result in an increased risk of enteric problems. This is a complex situation to manage. Butyrate, as a single component or in a synergistic blend, is a multifunctional molecule which can bring real benefits. The critical factor is the form in which the butyrate is supplied, as this will determine the indispensable intestinal release properties. It is clear that young animals benefit from such supplementation from the start and carry the effect till the end of the rearing period.

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Animal plasma's memory effect on young broilers

The effect of using animal plasma in pig production is well documented. There is, however, also a lot to say for inclusion of plasma in feed for young broiler chicks. Recent research in Australia demonstrated a 'memory effect' of feeding animal plasma.

By Louis Van Deun, Sonac (Darling Ingredients)

With increased attention towards antibiotic-free rearing of livestock and a stronger focus on growth performance of starting broilers, spray-dried plasma (SDP) can offer a key feed ingredient in successfully achieving both goals. In the last decade, trials with broilers and turkeys show superior technical performance at better economics and increased resilience of young animals when SDP is introduced at low inclusion levels in starter diets.

SDP is a blend of highly functional proteins

Animal plasma is derived from porcine (or bovine, outside of EU) blood. After collection at the slaughterhouse from approved and inspected healthy animals, the blood is fractionated by centrifugation into red cells and the liquid plasma phase. After a concentration step the plasma is spray-dried and marketed as a creamy-white powder with a protein content of up to 80%. The protein fraction in SDP is known to be a highly versatile blend of functional molecules, with over 1,400 types of different proteins identified. Most important protein fractions are immunoglobulins, albumin and fibrinogen, next to smaller fractions of growth factors, enzymes and peptides. SDP protein is highly digestible and has a high biological value as about 45% is composed of essential amino acids. It has been established, however, that apart from the nutritional value of SDP its main value is in its functional component.

PHOTO: MARCO VELLINGA

Feed conversion ratios in broilers can be reduced by using up to 1% porcine or bovine plasma in their feed during the first ten days.

Well documented beneficial effects

For over 20 years the beneficial effects of plasma in young piglets have been well documented: enhanced feed intake, improved weight gain and more efficient feed conversion observed especially in the first week post-weaning. The highly functional ingredient has a positive effect on gut barrier integrity, can bind to pathogens thanks to its immunoglobulin (IgG) component and can modulate a strong pro-inflammatory immune response after infection or artificially imposed antigen challenge. Effects are maximised in sub-optimal hygienic conditions. Research on plasma performance in poultry is limited but similar effects can be expected based on the suspected modes of action.

Some historical broiler trials with SDP

At the start of the millennium, several trials in the United States have been performed with SDP on broilers at different state universities, see *Table 1*. All of these trials have in common SDP is administered to the young animals during the complete growth period (21 to 42 days) at inclusion levels between 0.5 and 2%.

Some trials keep inclusion level constant over the complete period, others start with higher concentrations during starter phase and decrease the inclusion levels during grower and finisher phases. Both bovine and porcine SDP are used in different trials. Often animals are microbiologically challenged by using the same litter of a previous batch of animals.

Results of these trials all conclude more or less the same: inclusion of SDP increases daily feed intake (DFI) and average daily gain (ADG) and often improves feed conversion ratio (FCR). Animals fed with SDP show better survival and performance figures, especially in challenging conditions with sub-standard hygiene and higher microbial loads. Both bovine and porcine SDP show effects, indicating the SDP functionality seems to be species-independent. These results are very much in line with the richly documented inclusion of SDP in piglet (pre-)starter diets.

SDP inclusion in starter feed

Piglets fed with pre-starters containing SDP suffer less effects from the infamous weaning dip. This seems to give the animals a boost from which they profit their complete life cycle, even when their starter and grower diets no longer contain SDP. For economic reasons it would be preferable if a similar 'memory' effect of SDP inclusion exclusively in the starter phase could also be demonstrated in broilers.

Recently, the University of New England, Australia, published a trial performed on broilers in which the addition of 0.5% or 1% of bovine or porcine plasma was tested. Only during the first ten days pullets were fed diets containing 0 to 1% of plasma powder. Next, all groups switched to a commercial diet without SDP and were monitored for a total of 35 days. Feed conversion rate of groups fed with plasma improved several points during the first ten days. More importantly, the positive effects on FCR were maintained during the complete trial period of 35 days, see *Figure 1*, even when all trial groups shared the same commercial diet for the remaining 25 days. From this trial it can be understood that an inclusion of 0.5% of either porcine or bovine plasma to a broiler starter diet can reduce the FCR by 10 to 14 points as obtained over the total growth period of 35 days. A series of follow-up trials at the same research institute confirmed the above findings.

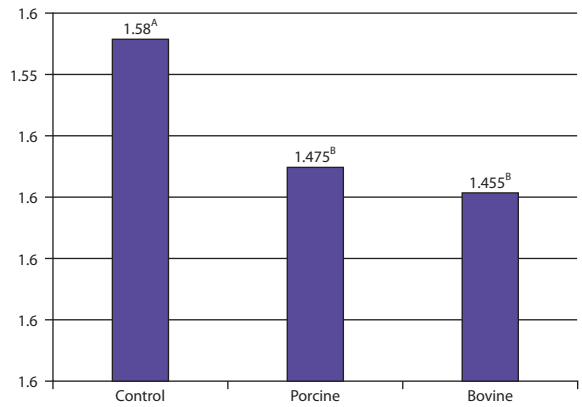
Detailed financial calculations comparing the different groups in these trials show the initial investment in a starter containing 1% of SDP is quickly recuperated because of higher weight gain and improved FCR. Actually, costs of feed per kg of meat were found to be lower in the feeds with SDP. This is excluding the reduction of indirect costs because of reduced medication use, higher resilience of the pullets and reduced mortality in the population.

A bright future for SDP in broiler starter feeds

Animal trials and performance economics seem to indicate SDP is a valid ingredient in broiler starter diets. Yet, more studies are required to uncover the full potential of SDP in broiler populations. Next to the increased resilience in SDP-fed pullets there are indications the overall health in the complete flock is increased, resulting in more homogeneous groups of animals with less variation in bodyweight. A better understanding of the working mechanisms of SDP in broiler health could further improve its enhancing effects on the performance of the animals, offering feeding specialists a natural alternative to antibiotics.

References are available from the author: louisvandeun@sonac.biz

Weight corrected FCR over complete growth period (42 days).



$^{AB}P<0.10$. Weight Corrected FCR was averaged for the 2 plasma inclusion levels

Source: University of New England, Australia, 2014.

Overview of SDP trials on broilers.

Trial	Duration	SDP details	Effects
Iowa State University (2005)	42 days	0-2%, bovine	FCR↓, ADG↑, hygiene effects
Mississipi State University (2003)	21 days	0-1.35%, bovine	FC↓, ADG↑, DFI↑, hygiene effects
Kansas State University (2006)	42 days	0-1%, porcine	ADG↑, DFI↑

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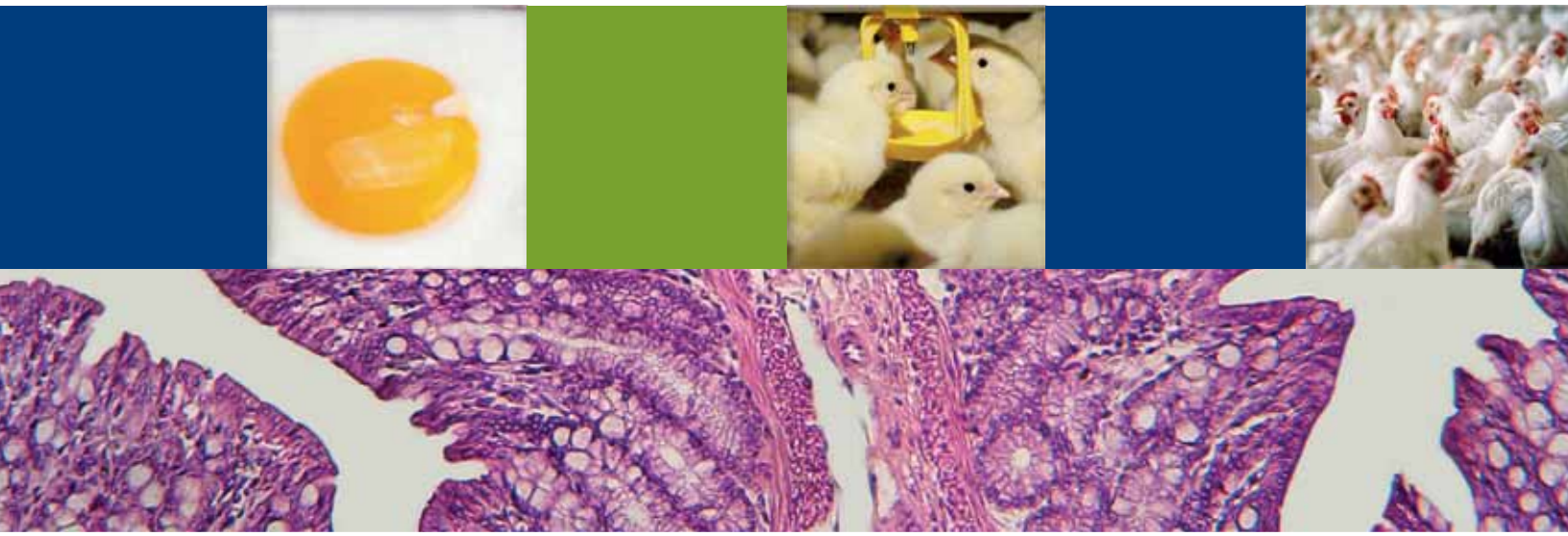

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