Boosting the immunity and health of piglets in early life

One of the major achievements in pig production in recent decades has been an increase in the number of piglets reared per sow per year and per lifetime. Indeed, in many countries, it is not uncommon for sows to wean 30-35 piglets per year.

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However, one of the consequences of this increase in litter size has been a reduction in the quality of the piglets born or weaned. This is manifested in a reduction in the individual birth weight of the piglets, an increase in the variability of birth weight within the litter, a lower immune status, a greater susceptibility to health challenges, a higher rate of pre- and post-weaning mortality and a reduction in growth rate, resulting in a reduced weight at weaning and a longer time to market weight.

Each extra piglet born reduces average piglet birth weight by about 40g, so any method that can improve piglet quality will have significant production and economic benefits. This article discusses the strategies that may be employed to improve the performance of poorer-quality piglets in the early stages of postnatal growth.

Colostrum quality and quantity

It is of prime importance that the newborn piglet consumes an adequate quantity of good quality colostrum. This provides energy for thermogenesis, immunoglobulins to impart passive immunity against pathogens at birth and hormones for growth and development. Unfortunately, colostrum yield does not increase with litter size.

Thus, as the number of piglets born alive increases, colostrum intake decreases by about 30-40ml per piglet per day. This has a major effect on the immune status of the piglet.

The feeding of the sow in mid- and late gestation is crucial to ensuring an adequate rate of colostrum production. One of the most effective ways is to include Bio-Mos (Alltech) in the diet of the sow during gestation and lactation. Le Dividich et al. (2009) reported that the inclusion of Bio-Mos in the diet of the sow in gestation increased the growth rate of piglets in the first 24 hours of life by 48% in a study in France and by 19% in a study in Canada (Table 1).

This increased growth resulted from an increase in colostrum production (calculated as 17% and 13%, respectively) and hence a higher intake of growth hormones and immunoglobulins. These factors will positively influence subsequent growth and immunity of the piglets.

Based on the mean response of some 3,000 sows in 12 worldwide trials, Close and Taylor-Pickard (2010) reported an extra 0.32 piglets weaned per litter, equivalent to an extra 0.75 piglets weaned per sow per year, when Bio-Mos was added to the sow's diet during gestation.

In addition, when compared to control piglets, the mean weaning weight of piglets from sows fed Bio-Mos increased from 6.87 to 7.17kg; in several of the studies, the difference was statistically significant ($p<0.05$). Mean litter weaning weight was increased by 6kg, representing a 9% increase over the control.

These results show that responses to Bio-Mos in sow diets are consistent and bring considerable advantages for both sow and piglet productivity and profitability.

	Brittany		Quebec		P value
	Control	MOS	Control	MOS	
Birth weight (kg)	1.37	1.41	1.45	1.48	0.38
Growth rate (0-24h) (g/d)	83	123	138	164	0.02
Colostrum consumption (g/piglet)	304	362	364	385	0.04
Number of piglets weaned	9.96	10.09	10.64	11.69	0.09
Piglet weight at weaning (kg)	5.94	6.13	6.73	6.87	0.23
Litter weight at weaning (kg)	58.2	61.6	71.6	79.3	0.02

Table 1. Effects of MOS in sow diets on piglet performance (Le Dividich et al. 2009).

Mineral status

Trace minerals are essential for the metabolic, endocrine and physiological control of growth, reproduction and immunity and have a major influence on the piglets in terms of overcoming disease challenges.

As litter size increases, unless the mineral content of the sow's diet is increased, fewer minerals will be deposited in the developing foetuses during gestation. This results in a reduced mineral status of the piglets at birth, with consequences for their health, well-being and performance.

One way to enhance the mineral status of piglets is to include organic rather than inorganic minerals in the diet of the sow. The inclusion of organic minerals has been shown to increase the mineral content (especially selenium) of colostrum and milk as well as liver, loin, blood and overall total body mineral contents.

Several studies have shown the superiority of organic minerals over inorganic minerals. Close (2008) reported that the partial replacement of inorganic minerals by organic minerals resulted in a 0.5 (range 0.3-0.8) increase in litter size. Similarly, Mahan and Peters (2007) have shown that sows fed organic minerals produced more piglets per litter ($p<0.05$) compared with sows fed inorganic minerals: 12.2 versus 11.3 total born and 11.3 versus 10.6 born alive, respectively.

Bertechini et al. (2012) evaluated the performance of sows when fed inorganic or organic minerals at 1 or 2kg/t. When organic minerals were provided in the diet, litter size was increased by 1.1 extra piglets per litter at the 1kg inclusion level and by an extra 0.98 piglets per litter at the 2kg inclusion level. However, despite the larger litter size, the birth and weaning weights of the organic-mineral piglets were significantly higher ($p<0.05$) (Table 2).

Interestingly, the iron content of the livers of newborn piglets, their blood haemoglobin levels and the iron content of sow's milk were significantly higher ($p<0.05$) when organic minerals were provided in

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Table 2. Effects of mineral sources and levels on sow and piglet performance (Bertechini et al. 2012).

	Inorganic		Organic**		CV (%)
	1 (kg/t)	2 (kg/t)	1 (kg/t)	2 (kg/t)	
Live born piglets	10.80^{b}	11.20^{ab}	11.90^{ab}	12.18^{a}	12.5
Weight at birth (kg)	1.50^{b}	1.52^{b}	1.64^{a}	1.68^{a}	6.9
Weight at 21 days (kg)	6.18c	6.92^{b}	7.64^{a}	7.83^{a}	5.2
Liver Fe (mg/kg)	1638^{b}	1779^{ab}	1897^{a}	2171^{c}	203
Milk Fe (mg/l)	664^{b}	773^{b}	818^{a}	1014^{c}	13.7

* Means within a row with different superscripts: $p<0.05$ ** Bioplex, Alltech

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the diet. Acha and Chae (2002) and Peters and Mahan (2008) also reported higher piglet weaning weights when lower levels of organic minerals were fed, compared with higher levels of inorganic minerals. Thus, one way to improve the performance and immunity of piglets born in large litters may be through the inclusion of organic rather than inorganic minerals in the diet of the sow.

Lessons from human infant nutrition

It is common practice to provide creep or pre-starter diets to piglets while they are suckling the sow. These provide additional nutrients to the piglets at a time when the sow may be unable to produce sufficient milk to adequately nourish her offspring. This practice generally results in an improvement in overall weaning weight, with the greatest advantage for lightweight piglets and those suckling less productive teats.

So what is an ideal pre-starter/starter diet for piglets? Interestingly, since the human infant and the young, under-developed piglet have many biological similarities, the question is, 'are there lessons from infant nutrition that could be applied to piglet nutrition?' It is therefore interesting to examine the essential ingredients in infant formulations and to discuss whether any of these are relevant to piglet nutrition and diet formulations. The most commonly used infant formulas contain purified cow's milk, whey and casein as protein sources (comfort proteins), lactose as a carbohydrate source, a blend of vegetable oils as a fat source, a vitamin-mineral mix and other unique ingredients.

In addition, several unique functional and bioactive ingredients are included that may have relevance to piglet nutrition. These include:

- Oligosaccharides, to encourage the development of friendly bacteria within the gut.
- Increased levels of n-3 and n-6 fatty acids, to aid brain development as well as immunity.
- Enriched iron, lactoferrin, to enhance brain function and enhance immunity.
- Nucleotides, to ensure proper growth and development and stimulate health and immunity.

It is therefore of interest to establish whether any of these specific ingredients may be of relevance to piglet nutrition.

Oligosaccharides: As discussed earlier, the inclusion of the Bio-Mos and the second-generation product Actigen have been shown to improve the quality and quantity of colostrum, with beneficial effects on piglet growth and immunity. Their inclusion in pre-starter/creep diets will give similar effects.

Lactoferrin: This multifunctional globular glycoprotein of the transferrin family possesses antimicrobial, antifungal and antiviral properties. It regulates the absorption of iron in the intestines and is essential for good health and well-being. It acts by preventing the growth of bacteria by depriving them of essential nutrients or by killing bacteria by destroying their cell walls.

Including lactoferrin (1kg/t) in the diet of piglets after weaning has been shown to improve growth rate and feed efficiency when compared with a control diet and one containing antibiotics (Table 3).

Villus height was increased and crypt depth of the small intestine was reduced, resulting in a higher villus height to crypt depth ratio and greater nutrient absorption.

Shan et al. (2007) also reported improved growth rate and feed efficiency as well as increased serum iron, serum immunoglobulin, lymphocyte proliferation and immune function.

These results suggest that the inclusion of lactoferrin in piglet diets improves small intestine morphology, regulates immune function and improves non-specific immunity, which protects the piglet against infections and stress post-weaning and results in improved performance. Interestingly, in studies using the neonatal piglet as a model for human infant nutrition, Reznikov et al. (2014) showed that when colostrum-deprived piglets were fed sow milk replacer formula, the inclusion of lactoferrin in the diet improved intestinal development (villus area) and cell proliferation, resulting in increased absorptive capacity and greater functional maturity of the gut.

These results suggest that lactoferrin may be considered as a bioactive and functional nutrient in the diet of piglets.

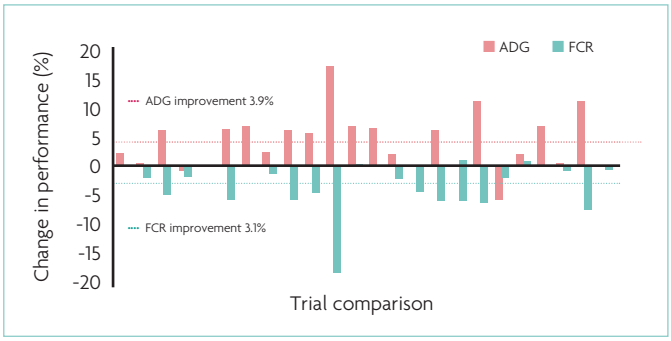

Fig. 1. Effects of NuPro on swine performance (Groenewegen 2007). Phases fed: 1 = 6-8kg, 2 = 8-12kg, 3 = 12-25kg. NuPro inclusion: 1 = 3-5%, 2 = 2-3% (approximately).

Nucleotides: These organic molecules serve as building blocks for DNA and RNA, which are both essential for life. Nucleotides play a major role in the body and are essential for health and immunity as well as intestinal function. They are abundant in milk. Nucleotide-deprived diets depress immune response and reduce intestinal structure under certain conditions such as weaning, stress and disease challenge.

In newly weaned piglets, all of these factors are present, and there is therefore a high need for nucleotides at this time. However, Mateo and Stein (2004) have shown that the nucleotide content in a typical starter diet is significantly less than that in sow's milk. Since in this case the piglet cannot meet its need for nucleotides at a critical stage of its development, it may be beneficial to add a source of nucleotides to such a diet.

Yeast-based products are rich sources of nucleotides, inositol and glutamine and are highly available sources of proteins. One yeast-based product that has been widely used is NuPro (Alltech), and Groenewegen (2007) has reviewed over 30 studies where it was included in piglet diets. He reported a 1% improvement in feed intake, a 3.9% improvement in growth rate and a 3.1% better feed conversion ratio (Fig. 1).

The improvement in growth rate resulted in piglets being 1kg heavier some four weeks after weaning. Similar results have been reported by Henman and Murphy (2009).

More recently, Hewitt and van Barneveld (2016) conducted a series of trials in which NuPro was compared with other ingredients and reported that it improved piglet performance in the first four weeks post-weaning regardless of diet complexity.

These results suggest that the response to NuPro is above the sum of its nutrient content and that NuPro is a cost-effective ingredient to include in piglet diets, with considerable economic benefits.

Fatty acids: Of specific interest is the omega-3 fatty acid DHA. It is essential for health, growth and development as well as brain and cognitive function, and it is generally added to infant formulas.

Fish-based products are sources of DHA, but the highest concentrations are found in algae, and their inclusion is recommended in piglet diets.

Table 3. Effects of lactoferrin on the performance of weaned piglets at 7-12kg (Wang et al. 2006).

	Control	Antibiotics	Lactoferrin	SEM
Feed intake (g/d)	276[a]	308[ab]	333[b]	20.5
Growth rate (g/d)	240[a]	293[ab]	340[b]	25.4
Feed-to-gain ratio (g/g)	1.15[a]	1.05[ab]	0.98[b]	0.04
Villus height (µm)	2.13[a]	2.29[ab]	2.46[b]	7.1
Crypt depth (µm)	2.35[a]	2.33[ab]	2.13[b]	6.6
Ratio of villus height to crypt depth	0.91	0.98	1.15	–

* Means within a row with different superscripts: p<0.05

Conclusions

Weaning is a critical period in the life of the pig; body weight at weaning and growth rate post-weaning have a major influence on the pig's future growth and development. Any treatment or dietary inclusion that promotes these factors will have significant production and economic benefits.

Everything must contribute toward the same objectives: maintaining gut structure and intestinal health, enhancing nutrient digestion and absorption, promoting beneficial gut bacteria, preventing anti-inflammatory responses and priming the immune system.

This will ensure that the piglet gets off to a good start, which results in a better finish and an increased net margin per pig. ■

References are available from the author on request.