White paper

Optimizing swine productivity with enhanced vitamin D nutrition

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Optimizing swine productivity with enhanced vitamin D nutrition

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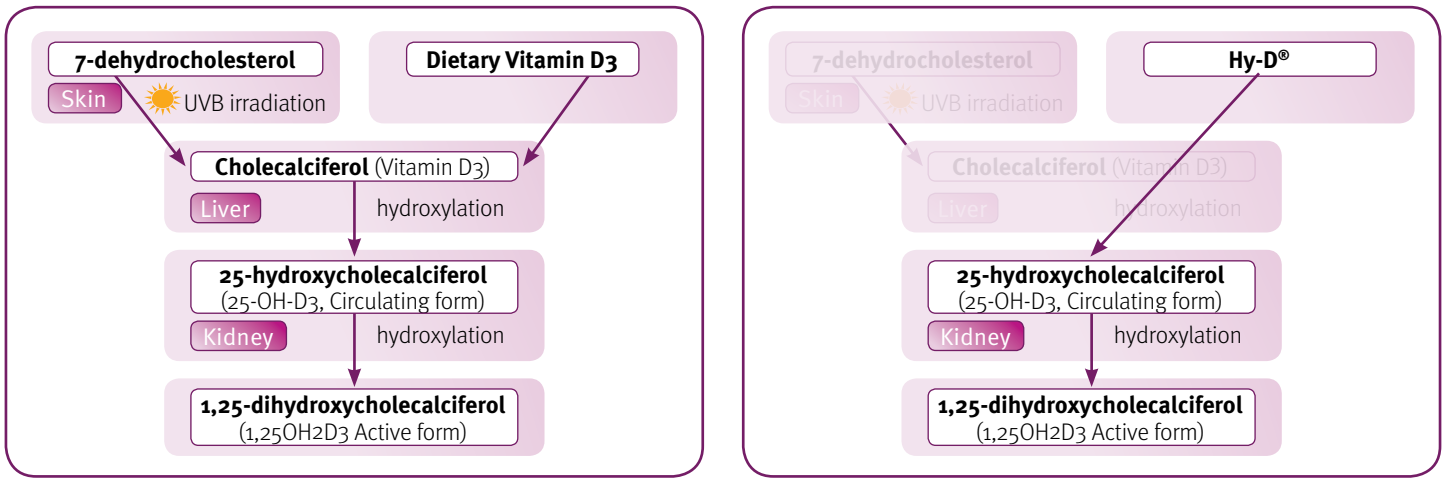
With today's pig industry facing increasing economic pressure and meat demand, producers are constantly looking for nutritional additives aimed at fully exploiting their animals' genetic potential and increasing the overall profitability of their business. Optimum vitamin D nutrition in particular can provide such benefits when added to pig feed. Indeed, not only does this vitamin play a vital role in bone development, but research findings show that it can directly contribute to a number of other essential functions, including reproduction, muscle development and immune response modulation.

Vitamin D3 and its metabolites

There are two types of naturally occurring vitamin D. In plants, the predominant form is ergocalciferol (D2), while in animals, the predominant form is cholecalciferol (D3). Vitamin D is a fat-soluble vitamin and is therefore absorbed alongside other dietary lipids via the lymphatic system, a process that is already well defined. Following absorption, vitamin D is transported to the liver, where it is converted (hydroxylated) to 25-OH-D3 – the main circulating form of the vitamin – otherwise known as calcifediol. This hydroxylation step allows vitamin D to circulate in the water-dominated environment of the blood system. Subsequently, a second hydroxyl group is added to 25-OH-D3 (primarily in the kidneys) to produce the active vitamin, 1,25-(OH)2-D3 (calcitriol), which is even more water-friendly. This compound, made from the highly-regulated step of vitamin metabolism, is actually a hormone that acts on intestinal cells to enhance calcium and phosphorus absorption for bone formation and other bodily functions. Without vitamin D, dietary calcium and phosphorus are poorly utilized.

Supplementing 25-OH-D3 directly to the diet is highly beneficial to animal health and productivity. Today, there is a commercially available form of 25-OH-D3 by DSM Nutritional Products called Rovimix Hy-D®. This calcifediol additive is less hydrophobic than the conventional vitamin D3 used in premixes and is therefore absorbed more easily than pure vitamin D3. In addition, because it is already one step ahead in the natural metabolism of vitamin D, it bypasses the first step of hydroxylation in the liver, reaching the blood stream quickly and efficiently (Fig. 1). Bypassing this first metabolic step is important, because normal liver metabolism acts as a barrier to hydroxylation of superfluous quantities of supplemental standard vitamin D3. The importance of the bypass is further highlighted by the fact that today most experts agree that feeding Hy-D® is the only way to increase blood levels of 25-OH-D3.

Fig. 1. Hy-D® – a unique mode of action



Optimizing vitamin D status

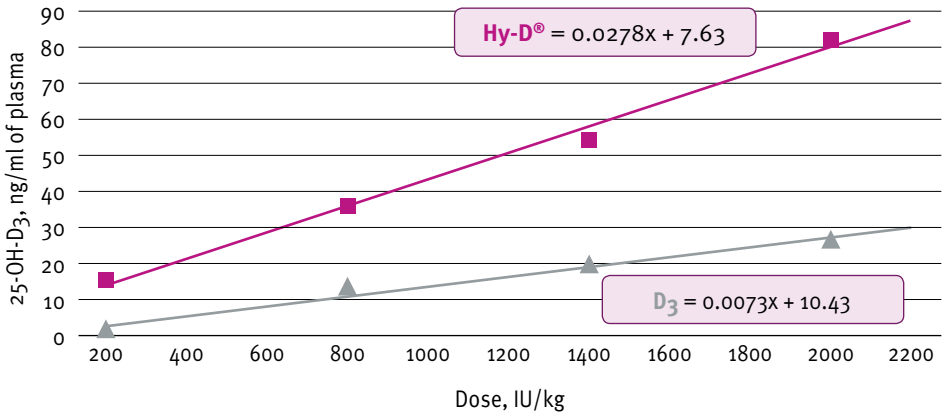
Did you know?

One gram of Hy-D® can replace 500 International Units (IU) of vitamin D_3 in feed applications, allowing for enhanced vitamin D status. For example, circulating levels of 25-OH-D_3 are significantly higher in sows receiving Hy-D®, when compared to sows fed equivalent levels of vitamin D_3, throughout the reproductive cycle (Lauridsen et al.2010; Weber et al., 2013).

An optimum vitamin D status can allow sows to reach their productivity targets, in line with their genetic potential (Fig. 2).

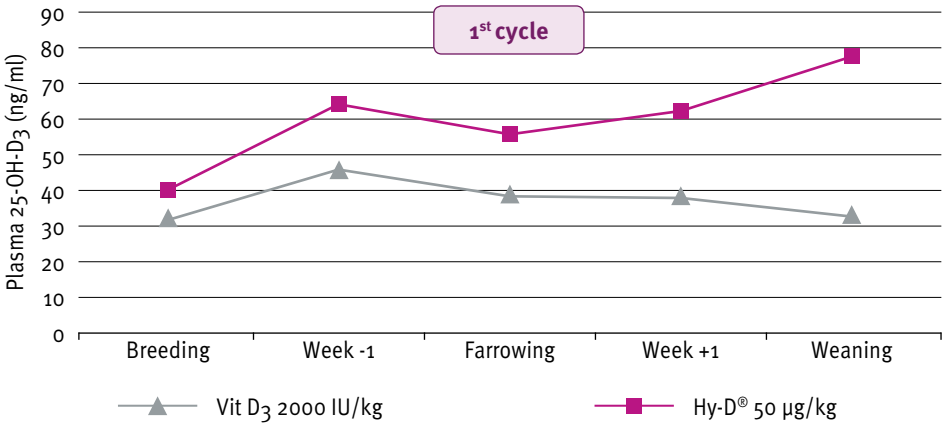
Fig. 2. Optimal plasma levels of 25-OH-D_3 in sows

Lactating sows



Source: modified from Lauridsen et al. 2010. J. Anim. Sci., 88:202-213

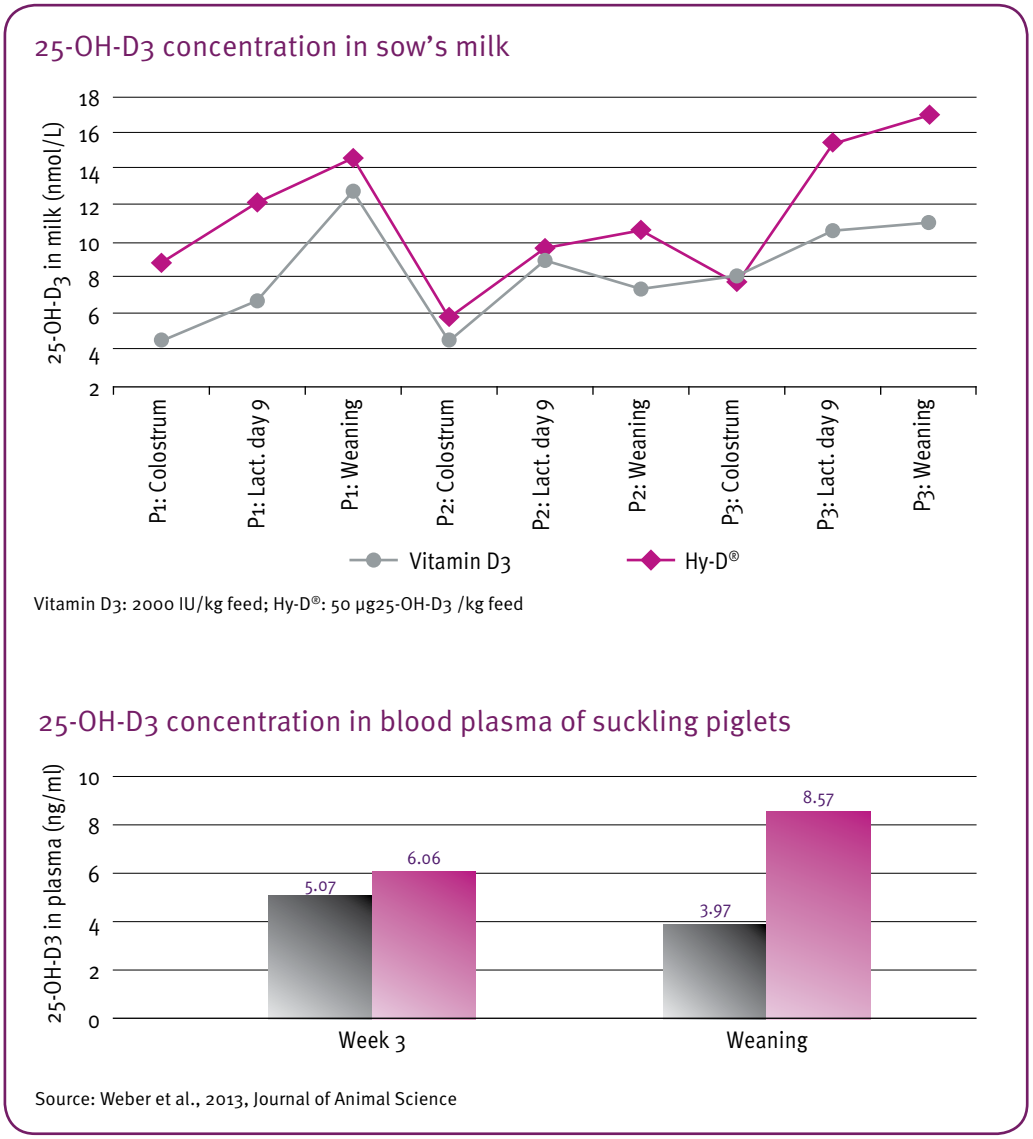
Sow's reproductive cycle



Trial ETH, Zurich: 36 primiparous and multiparous sows followed during4 parity cycles; 9 sows each per treatment, 5 blood samplings for each cycle
Source: Weber et al., 2013 J. Anim. Sci., 92:899-909

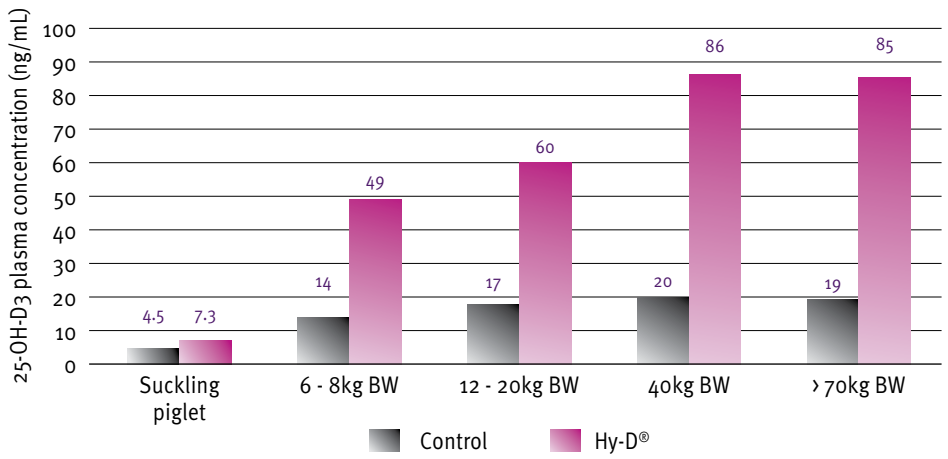
It is widely known that of all the species tested, piglets are born with the lowest circulating levels of 25(OH)D3. This is because perinatal maternal transfer (via placenta and milk) of vitamin D to the piglet is very limited. Maternal supplementation with Hy-D® in both gestation and lactation increases 25-OH-D3 concentrations in both sow milk and placenta (Weber et al., 2013), leading to higher vitamin D status in the plasma of suckling piglets (Fig. 3).

Fig. 3. Milk level in sows and plasma level in piglets



In general, 25(OH)D3 plasma concentration of weanling piglets fed a diet containing 2000 IU vitamin D3 hardly reaches 15 ng/ml around 30 days of age and does not exceed 20 ng/ml at the end of the post-weaning phase. However, any compromise to the piglet at this critical stage of production has repeatedly been shown to impact negatively on animal performance throughout life to slaughter. A study shows that piglets supplemented with Hy-D® and on fattener diets gained optimized animal vitamin D status leading to stronger performance, immunity and leg health (Fig. 4).

Fig. 4. Vitamin D status in piglets/growing pigs



Control feed: 2000 I.U. vitamin D3/kg feed
Hy-D® feed: 50 mcg 25OHD3/Kg feed (equivalent to 2000 IU D3)

Supporting bone health in swine

Calcium, phosphorus and vitamin D play a key role in skeletal development and bone health.

Pre-breeding Gilts and Sows

Profitability in swine production depends on optimizing the lifetime output per breeding place. Considerable genetic selection improvements have already been made in reproductive performance, litter size and feed conversion efficiency. However, significant improvements can still be made in lifetime productivity per sow. Herd replacements are the second largest cost of swine production after feed, and culling sows before three parities has a negative impact on profitability.

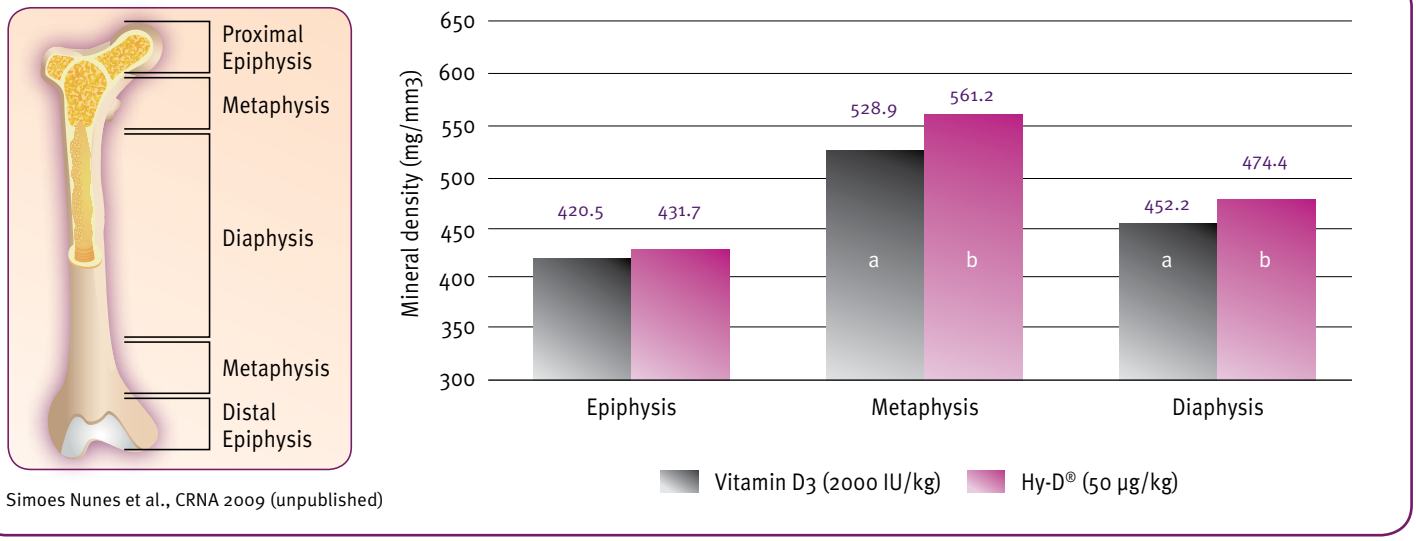
A very strong skeletal frame is required to fully exploit the genetic potential of a breeding female. Good leg and feet health is an important criterion when selecting replacement breeding stock. Up to 30% of gilts selected as herd replacements may be rejected for structural failure before they produce even a single litter. Among the top three reasons for sows leaving breeding herds are leg and frame weaknesses. Leg weakness in pigs and sows aged between four and eighteen months is often due to osteochondrosis.

Did you know?

Herd replacements are the second largest cost of swine production after feed, and culling sows before three or four parities has a negative impact on profitability.

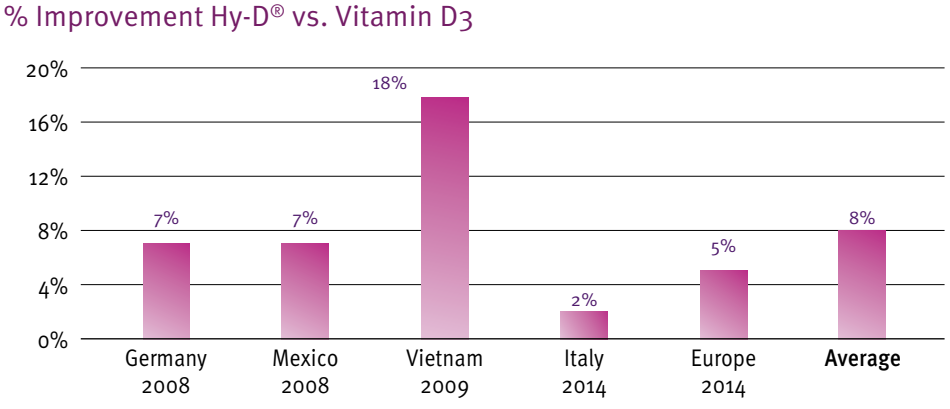
Supplementation of 25-OH-D3 during the gilt rearing phase prevents skeletal problems and increases the selection rate, due to improved bone mineral density (Fig. 5 and Fig. 6). Furthermore, guaranteeing high plasma levels of 25-OH-D3 during the critical lactation period ensures the synthesis of sufficient 1,25-dihydroxycholecalciferol. This active form of vitamin D is involved in maintaining calcium and phosphorus homeostasis by encouraging intestinal absorption of the calcium and phosphorus; mobilization of bone calcium; and reabsorption of phosphorus by the kidneys. Therefore, supplementing feed with Hy-D® very early on in the life of the gilt (development phase) and continuing to provide this supplement during the production phase (gestation-lactation) seems to result in improved bone health and increased longevity. Last but not least, a sow which is not lame will eat normally and optimum productivity will therefore be ensured!

Fig. 5. Improved bone mineral density of different portions of long bones



Simoes Nunes et al., CRNA 2009 (unpublished)

Fig. 6. Improved gilts' selection rate



Source: Summary of field trials

Piglets and fatteners

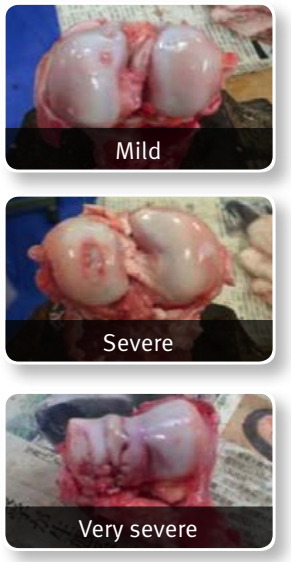
Piglets and growing pigs can also suffer from vitamin D deficiency and its associated health issues.

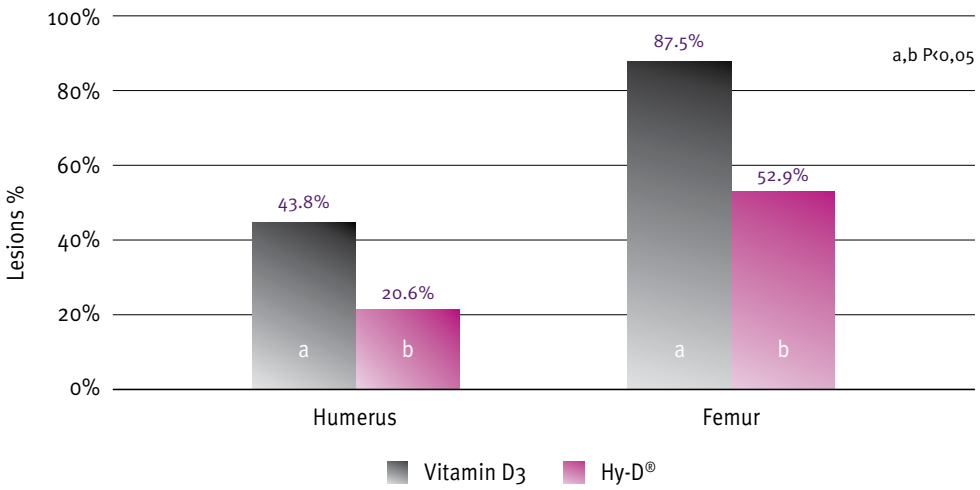
Did you know?

Piglets deficient in vitamin D can result in bone micro fractures and/or rickets by the time they are weaned, while growing pigs' vitamin D deficiency can cause poor bone strength and lead to lameness, rickets, osteochondrosis and bone fractures.

In a study conducted in Japan, Pr Sugiyama from Niigata University looked at the potential effect of 25-OH-D3 in terms of preventing osteochondrosis in pigs from 6 kg to 110 kg live weight, through a feeding period. (Fig. 7).

Fig. 7. Reduced incidence of osteochondrosis





Source: Sugiyama et al., 2013 Animal Science Journal, 84, 341-349

The piglets supplemented with Hy-D® had plasma levels of 25-OH-D3 that were considerably higher than the control group supplemented with standard vitamin D3 and showed a lower incidence of osteochondrosis. The percentage of cartilage lesions was in fact significantly lower for both the humerus and the femur. Based on these macroscopic and histopathological observations, it was therefore clearly demonstrated that supplementing with 25-OH-D3 can inhibit the development of osteochondrosis and help to maintain normal endochondral ossification in pigs. Besides its positive effect on bone strength and mineralization, 25-OH-D3 acts directly on the chondrocytes, which are cells involved in the synthesis and maintenance of cartilaginous tissues, and on the vitamin D receptors expressed in the joint cartilage.

Improving sow productivity and litter performance

Did you know?

Calcium plays a critical role in embryo implantation, farrowing time and milk yield in sows.

Calcium requirements for sows are higher during lactation and deficiency can cause Periparturient Hypogalactial Syndrome (PHS), leading to negative consequences: difficult or slow farrowing, increased stillbirth incidence, poor sow milk yield and poor sow feed intake.

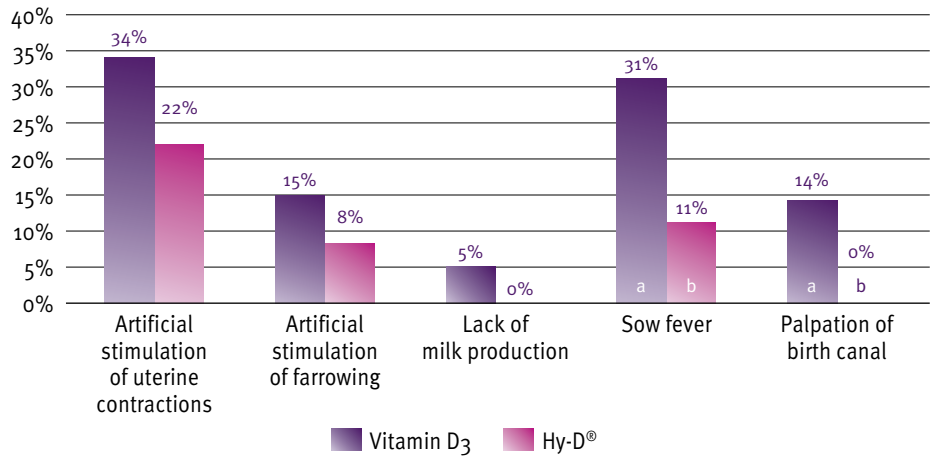
Low calcium levels in piglets can also have negative effects, such as: weak vitality, slow speed of first suckling, decreased livability (less weaned piglets) and low weight gain.

On the other hand, optimized calcium homeostasis and logistics in hyper prolific sows has a tremendous impact on sows' reproductive performance, productivity and piglet health.

Hy-D® supplementation in sows' diets increases calcium availability and therefore leads to:

- Improved conception rate (Hines et al., 2013)
- Facilitated farrowing process and less farrowing complications (Meuter et al.,) (Fig. 8)
- Lower risk of still born piglets (Fig. 9) as Hy-D® contributes to good muscle function
- Quicker start to milk production, having a positive effect on growth (Sorensen et al., 2016) (Fig. 10)
- Increased livability of litter (Sorensen et al. ,2016) (Fig. 11)

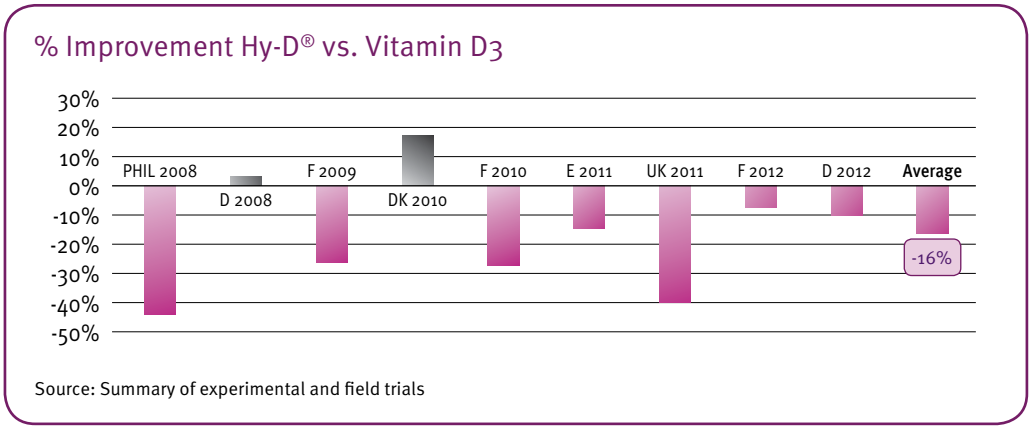
Fig. 8. Maternal supplementation for facilitation of farrowing process



Source: Trial France, 2012; Meuter et al., JRP 2016 (in press)

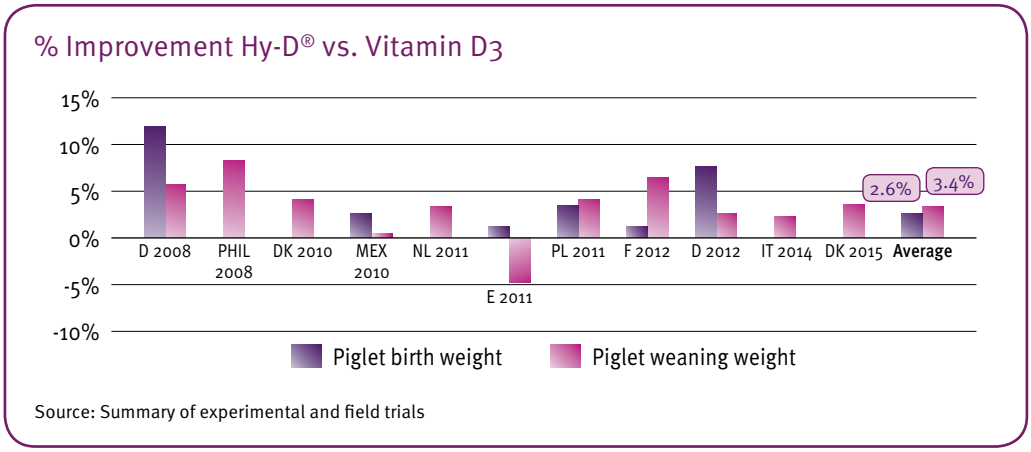
a, b P< 0.05

Fig. 9. Maternal supplementation for improved sow productivity



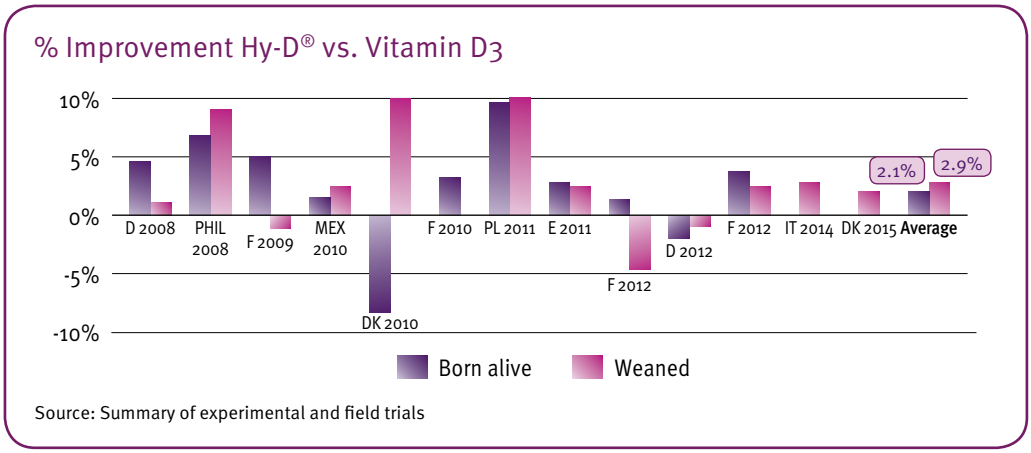
Source: Summary of experimental and field trials

Fig. 10. Maternal supplementation for improved litter performance



Source: Summary of experimental and field trials

Fig. 11. Maternal supplementation for improved litter livability



Source: Summary of experimental and field trials

Hy-D® boosts piglet immune response

More recent research has focused on the effects of feeding Hy-D® on piglet immunity. Results indicated that newly weaned pigs fed diets containing Hy-D® had significantly higher numbers of immune cells, as well as increased viability and phagocytic activity of those cells (Konowalchuk et al., 2013). These results indicate that an optimum level of vitamin D can improve performance of newly weaned piglets by enhancing the efficiency of their cellular immune response, as well as their humoral immune response. Indeed Hy-D® is also able to positively modulate the Immunoglobulins G blood levels without compromising piglet performance (Meuter et al., 2016).

This finding is clearly of tremendous value in the management of the young pig, and in particular, of the young pig at weaning. The transition from suckled to weaned state simultaneously exposes the piglet to high levels of disease challenge, while depriving it of access to the immune protection provided by factors in the sow milk. Moreover, commercial practice means that pigs are weaned from the sow at between three and five weeks of age, a stage in the young pig's life when its own ability to mount (and regulate) an immune response is far from fully developed. Any compromise to the piglet at this critical stage of production has repeatedly been shown to impact negatively on animal performance through to slaughter.

Muscle development stimulation for higher red meat yield

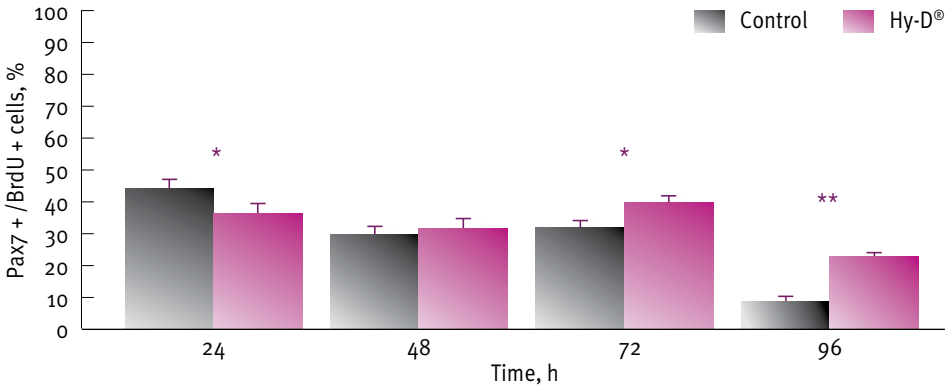
Studies suggest that enhancing vitamin D status beyond simply preventing deficiency can allow animals to reach their genetic potential for skeletal muscle development and hypertrophy, as well as overall growth performance, thus providing maximum benefit to all sectors of the pork meat industries.

Did you know?

Pigs born with fewer muscle fibers normally grow less than piglets born with more fibers, suggesting that high numbers of muscle fibers are a requirement for good growth.

Piglets born from sows receiving Hy-D® have a higher number of muscle fibers and a higher myoblast activity (Starkey, 2014) (Fig. 12). This should ultimately increase animal potential for red meat yield. Furthermore, the positive effect of a continuous 25-OH-D3 supplementation on pig performance has been confirmed in a full cycle study where the progeny of sows fed with Hy-D® were also supplemented with Hy-D® in their piglet and fattener diet. The findings therefore suggest that both maternal and postnatal vitamin D supplementation are necessary for optimal skeletal muscle development and growth.

Fig. 12. Muscle development stimulation



	Vitamin D_3	Hy-D®	P =
Total fiber muscle number	839.7	917.6	0.04
Total myogenic precursor cells*	87.2	95.1	0.12

40 first parity gilts; 43 d prior to breeding and throughout d 90 of gestation
* Treatment p<0.10
** Treatment p<0.0001

Source: Hines E.A. et al., J. Anim. Sci., 2013, 91: 4116-4122

Conclusion

In conclusion, vitamin D can play a significant role in swine performance and health. Recent studies provide strong support for the significant impact that a specific vitamin D metabolite, Hy-D® can have for optimizing animal vitamin D status, improving bone health and acting on the immune system and muscle growth. Tremendous economic value is therefore achieved by producers, thanks to enhanced sow lifetime performance and overall pig productivity.

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