Maximising Today's Hyperprolific Sow Requirements Requires Precision Mineral Nutrition

PEER REVIEWED

Minerals constitute a small proportion of the diet, but they are essential for the health, wellbeing and performance of the breeding female. They are involved in many metabolic and endocrine processes within the body and are especially important for reproduction, not only in terms of number of piglets weaned per litter or per year, but also in terms of lifetime performance.

However, it is questionable whether current trace mineral recommendations meet the needs of the modern hyperprolific sow. In this respect, it may be calculated that the daily trace mineral intake of a 240kg sow in its fourth parity is some 15-23 % less than that of a first parity sow of 160kg body weight when expressed relative to its body weight and metabolic body size (Table 1).

Mineral	Recommended[1] per kg diet	Parity 1 (160kg) Intake[2]			Parity 3+ (240kg) Intake[3]			Difference[4]	
		mg/day	mg/kg BW (2)	$mg/kg^{0.75}$	mg/d	mg/kg BW	$mg/kg^{0.75}$	(1)	
Fe (mg)	100	272	1.70	6.04	312	1.30	5.11	23	15
Zn (mg)	100	272	1.70	6.04	312	1.30	5.11	23	15
Cu (mg)	15	41	0.25	0.91	47	0.19	0.77	23	15
Mn (mg)	40	108	0.68	2.40	125	0.52	2.05	23	15
Se (mg)	0.25	0.68	0.0043	0.015	0.78	0.0033	0.0125	23	16

1 *Close (2006); BPEX (2004)*

2 *Feed 2.3 kg/day in gestation and 5.0 kg/day over a 21-day lactation*

3 *Feed 2.6 kg/day in gestation and 6.0 kg/day over a 21-day lactation*

4 *(1) per kg BW; (2) per kg$^{0.75}$*

Table 1: Trace mineral intake in sow in relation to body weight and parity.

Although mineral requirements in sows are poorly characterised, it is known that both macro and micro minerals become depleted with advancing parity, and high productivity exacerbates this depletion. This is demonstrated in results from a study of Mahan and Newton (1995) who showed that the body mineral content of sows after weaning their three litters of piglets was considerably reduced relative to that of control non-bred sows of similar age (Figure 1).

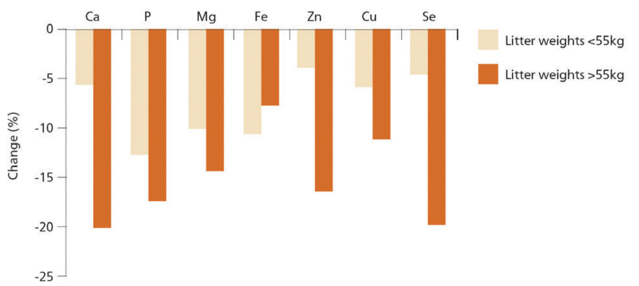

Figure 1: Change in the body mineral content of sows after three parities. (0 represents the mineral content of the non-pregnant animal) Mahan and Newton (1995)

Today's hyperprolic females, some 20 years on since this study, have further genetically advanced. In Mahan's study, litter size was on average 10 piglets weaned, with average maximum weaning weight of 5.5kg per pig; today, it is not uncommon to have litters weaned of 13-14 piglets at a range of weaning weights from 7.0 to 8.5kg. Therefore one has to ask 'is this not a significant reason as to why today's females have poor longevity with considerably increasing herd replacement rates?'

In addition, the higher the level of performance, that is total litter weight at weaning, the lower the body mineral content of the sow. Despite the animals being fed to national recommendations, there is significant loss of minerals from the body, probably from skeletal structures. This has major implications for subsequent health, welfare, productivity and culling rate, and underlines the need to provide minerals in the diet of the sow at the correct level and in the most available form.

Although the importance of macro elements, such as calcium and phosphorus, is well recognised, it is only recently that the role of trace minerals in influencing sow reproduction has been established. Specific trace minerals are involved at different periods of the reproductive cycle, as outlined in Figure 2.

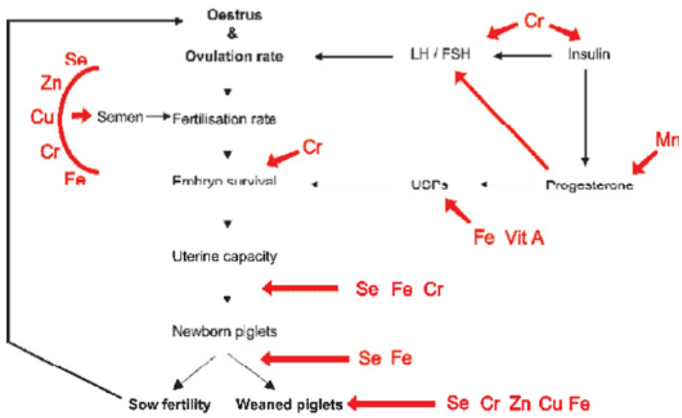

Figure 2: Role of minerals in sow reproduction. Close (1999)

There is also concern about the form of minerals provided in the diet and their availability to the animal. Inorganic minerals may form complexes that are difficult to absorb. In addition, minerals in inorganic form may interfere with each other and, when provided in excess, can result in the reduced absorption of others. For this reason, there is interest in organic minerals, that are proteinated or chelated minerals (iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn)), as well as minerals in yeast form (selenium (Se), chromium (Cr)). These are more bio-available and provide a metabolic advantage to the animal, which often results in improved productivity.

Previous research has shown that increasing the level of dietary inorganic minerals currently used by many feed companies may in fact result in a decline in the number of total and live born, whereas increased litter size has been shown to result when organic trace minerals (BIOPLEX®, Alltech Inc.) were fed (Figure 3). Reduced reproductive performance appears to be exacerbated when the gestation diet contained higher dietary levels of calcium (Ca) and phosphorus (P) than recommended by National Research Council (NRC) (1998). Feeding high Ca diets to gestating sows is relatively common in the industry in order to reduce leg problems, as the depletion of minerals is well recognised in adult reproductive sows. However, problems arise because Ca has the ability to bind other macro and micro minerals (e.g., P, Sulfur(S), Fe, Cu, Zn) within the intestinal tract, thus potentially reducing their adsorption and bio-availability for reproduction. One approach to consider is the reduction of Ca and P allowances during early gestation, when demands for Ca are not as great for foetal development or during lactation.

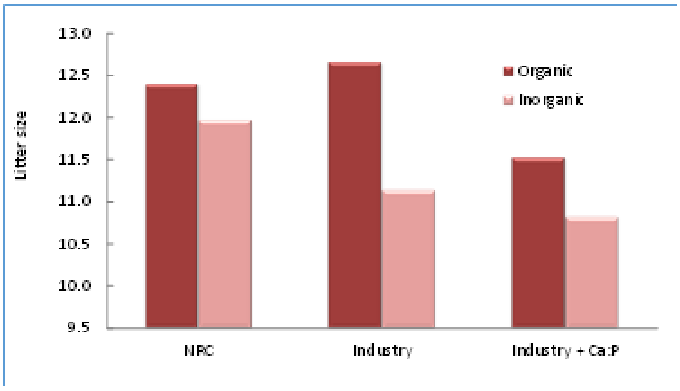

Figure 3: Effect of trace mineral source and level on litter size over six parities (n = 375 litters). Mahan and Peters (2006)

It is widely recognised that Fe has the most direct response on piglet viability and improvements in piglet weaning weight, decreasing the proportion of small live weight piglets and increasing the proportion of heavy weight piglets. The increased iron status and the higher liver iron content of the piglet means a less anaemic, more viable and stronger piglet at birth, full of vitality, with a healthy suckling stimulus. Consequently, its subsequent performance is improved. In today's large litters, with a significant number of low viability piglets born with a birth weight below 1kg live weight, increased pre-weaning mortality is observed, and for the piglets that survive to weaning, increased susceptibility to disease, and increased days to slaughter occur.

The major route of iron transfer across the placenta is via uteroferrin, an iron-binding protein. It has been shown that increased dietary inorganic iron fed to the pregnant sow has minimal effect on foetal iron uptake via the uteroferrin pathway. Alternatively, proteinated iron has been shown to increase the iron transfer across the placenta into the developing embryo. This may further explain the higher iron status of the newborn piglet (Table 2).

Uteroferrin is also secreted in the uterus in early gestation and has been implicated in embryo survival. This is consistent with the higher litter size reported in several trials.
Thus, the addition of organic Fe in the diet of the gestating and lactating sow influences both sow and piglet productivity:

- Higher placental transfer of Fe to the developing foetus
- Stronger, more viable piglets at birth
- Higher mammary transfer of Fe to colostrum and milk
- Better / higher Fe status of piglet
- Lower pre-weaning mortality
- Fewer small and heavier weight piglets
- Higher piglet performance and weaning weight

	Inorganic	Organic*	Increase (%)	Source
Newborn piglet:				
Liver Fe (mg/kg)	219	278	27	Egeli *et al.*, 1998
Liver Fe (mg/kg)	1779	2171	22	Bertechini *et al.*, 2012
Blood Hb (g/dl)	9.16	11.16	22	Bertechini *et al.*, 2012
Blood Fe (mcg/dl)	174	228	31	Bertechini *et al.*, 2012
Milk:				
Milk Fe (mg/L)	773	1014	31	Bertechini *et al.*, 2012
Weaned Piglet:				
Total body Fe (mg/kg)	26.7	28.7	7	Peters *et al.*, 2011

* Bioplex Iron (Alltech Inc.)

Table 2: Comparison of inorganic and organic iron in sows on piglet and milk Fe status

The mode of action by which organic iron influences piglet performance is outlined in Figure 4.

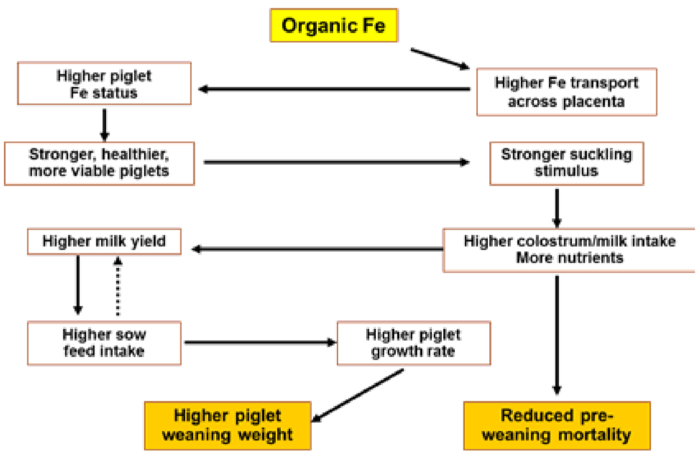

Figure 4: Organic iron and piglet performance: Suggested mode of action. Close (1999).

These responses may be explained on the basis that organic Fe is absorbed into the blood in a form that is readily transferred across the placenta and into the developing embryo. Not only is organic iron more available, but the efficiency with which it is absorbed is also increased.

Selenium Form is Essential

Se is present in plants and grain as organic Se. It has customarily been added to the diet in inorganic form and especially as sodium selenite. Despite this, Se deficiency is prevalent worldwide. The problem is especially noted in piglets born to older, highly prolific sows. This may be related to the depletion of the sow's trace mineral reserves with time as discussed above. Mahan (1995) found that milk Se declined markedly after the second parity in sows that had been reared and maintained on diets containing 0.3ppm Se from sodium selenite (Figure 5). This will of course affect the Se status of the piglet at birth, and Damgaard Poulsen (1993) has shown that the Se concentration in the serum of newborn piglets from parity three and four sows was significantly reduced compared with those from parity one and two sows. This indicates that inorganic sources of Se cannot meet the Se requirements of the modern sow, and it is interesting to note that increasing problems with sows appear from parity three onwards (stillborn piglets, culling rate, wean-oestrus interval, etc.).

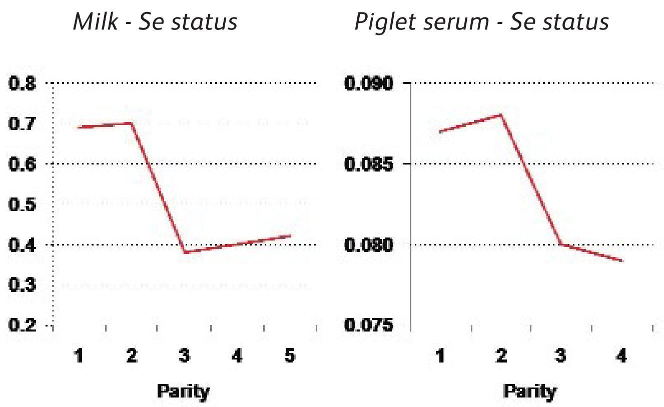

Figure 5: Effect of parity on Se status (ppm)

Compared to sodium selenite, the addition of organic Se (as SEL-PLEX®, Alltech Inc.) to the diet of the sow during gestation and lactation has been shown to enhance both the placental and mammary transfer of Se. Thus, the Se content of the piglet at birth (Table 3) and the colostrum and milk Se content are increased. Table 3 shows the improvement of the Se status of newborn and weaned piglets – as well as colostrum and milk – from several studies when organic selenium was compared with sodium selenite. These show that only organic dietary Se is effectively transferred to colostrum and milk.

Source	Selenite		Organic Se*	
Se (ppm)	0.1	0.3	0.1	0.3
Loin Se (ppm)				
Newborn	0.039	0.055	0.068	0.085
21 days	0.101	0.121	0.129	0.244
Liver Se (ppm)				
Newborn	0.236	0.250	0.283	0.310
21 days	0.352	0.388	0.353	0.509

Mahan and Kim (1996)
* Sel-Plex (Alltech Inc.)

Table 3: Effect of inorganic (selenite) or organic Se on piglet Se status

As illustrated in Figure 6, the colostrum and milk from sows fed 0.15 and 0.30 ppm Se from organic Se (SEL-PLEX), had significantly higher Se content than when sows were fed the same levels of sodium selenite. Sows given 0.15ppm Se as selenite plus 0.15 ppm organic Se have the same milk Se content as those given only 0.15 ppm Se from organic Se. Feeding the sow organic Se improves the Se status of the young piglet at a very critical period when Se deficiency is most likely. The immune status of the piglet is also enhanced, pre-weaning mortality is reduced and piglet performance is improved. The number of stillborn piglets was also reduced. The milk Se content from sows fed organic Se was maintained independent of parity, whereas it decreased with parity with sodium selenite.

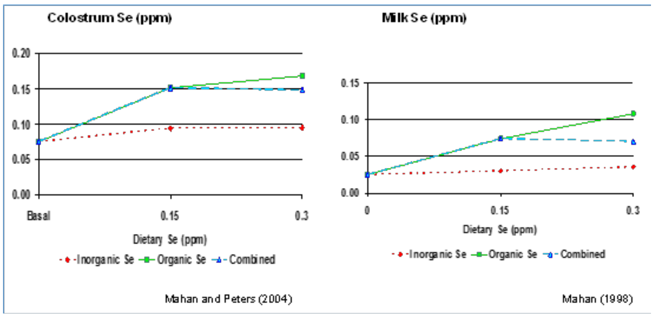

Figure 6: Effect of selenium level and source on colostrum and milk Se content.
*Inorganic Se as sodium selenite; Organic Se as Sel-Plex

Sows fed an inorganic form of selenium have few reserves of Se stored, and as total litter size increases in today's hyperprolic sows, piglets born dead have also significantly increased. When organic Se is included, there are significant reductions in piglets born dead, with a faster explosion of farrowing from increased muscle tone from stored organic Se.

It can be concluded from the results presented that including organic minerals, as well as selenium yeast, in the diet of the breeding sow results in:

- Higher number of piglets born, born alive and weaned
- Higher piglet birth weight and weaning weight; more uniform piglets
- Higher viability and reduced pre-weaning mortality
- Lower wean-oestrus interval and higher farrowing rate
- Higher mineral status of sow and piglet
- Better immune and health status
- Lower culling rate and greater sow longevity
- Overall higher sow productivity

For more information on mineral nutrition log onto www.alltech.com/animal-nutrition.

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