Chelates maximise investment returns

The main aim of using chelated trace elements as opposed to their inorganic forms is not always to increase performance, but rather to maintain high levels of performance whilst conforming to ever tightening regulations to protect the environment. This means using lower levels of these metallic elements in a more available form. However, in some cases, productivity does also improve.

By Stéphanie Coté

Over recent years some major changes have transformed the animal nutrition industry, reflecting public concerns and market anxiety. Globalisation of the industry and aggressive competition from emerging countries that are now exporting a significant quantity of products onto the market, threatens to destabilise the established industrialised producers. Within the parameters of profitability, the mission of the modern nutritionist is to produce feed at the lowest cost possible whilst optimising the parameters of health with respect to the applicable standards in medicines and feed additives.

Soil minerals cause concern

Copper and zinc are normally added to feed rations for pigs in the oxide or sulphate form and the proportion of the dietary addition that is not absorbed is excreted in the faeces. Copper is used as a growth promoter, while zinc is an essential trace element that plays a part in most biological functions of animals and is also involved in prevention of skin diseases such as parakeratosis.

The environment has become a critical concern in areas where the excretion of excess nutrients in the faeces of animals has to be reduced as much as possible in order to reduce environmental pollution. In Europe, the SCAN has established new inclusion rates for zinc and copper in animal feed, as a direct result of the increase of these trace elements in the ground. In the Brittany region of northwestern France, for example, intensive rearing of pigs results in the spreading of a high quantity of liquid manure on a limited surface area of land. Besides the problems related to nitrates and phosphate application to the soil, spreading manure also increases the levels of copper and zinc in the ground. In their studies into soil quality, researchers from the French national research institute INRA demonstrated that this increase is occurring relatively rapidly, to the point of raising concerns over toxicity for plants by the end of this century. Researchers studied soil samples from a farm of 100 acres, which produces more than 11,000 pigs every year. They analysed the content of the soil in metallic elements at an interval of eight years: in 1989 and 1997. Copper and zinc are the only metallic elements whose total content in the soil increased over this period, by an average of 1.3%. This increase was much greater than had been predicted using the mineral content of the manure that had been spread. Furthermore, by analysing the same type of soil without manure application, the researchers established the natural content of the soil in the two elements. They calculated that applying manure to cultivated land, the total copper content had increased from 15 to 35 mg/kg and that of zinc from 70 to107 mg/kg. But more disturbing is the rapid increase in bioavailable copper and zinc over and above the rate that they can be extracted by plants using EDTA. The bioavailable content increased, between 1989 and 1997, from 6.5 to 9.2 mg/kg for copper and from 6.6 to 10.6 mg/kg for zinc. With this rate of increase, soil levels of bio-available copper and zinc harmful to the environment could be reached in the next 150 years. However, with the rate of pig production in this area still increasing, much sooner estimates may be more realistic.

Curbing potential problems

A depression in agricultural productivity caused by problems of toxicity in plants could appear before the end of the 21st century. The intensive rearing of pigs that is common now in Brittany will not be able to continue at the same level for very long without damaging crop harvests. Researchers at INRA in Rennes are now studying feeding regimes for pigs with a view to minimising pollution of the soil, especially with copper and zinc, when their manure is applied.

All the parameters of profitability, welfare and the environment that have to be satisfied challenge the nutritionist to find solutions, using the many new raw materials becoming available, such as:

- acidifying agents to substitute the growth promoters;
- antioxidant polyphenols;
- trace-element chelates to improve their absorption.

New ingredients stemming from biotechnology do arouse considerable zootechnical interest, but in practice nutritionists are often reticent in using them to their full potential, because these products increase the cost of the feed. Because of this, there is a real need to examine the technico-economic factors that influence inclusion of some of these products in practical diets.

Trace element chelates in focus

In the past, trace element chelates were mainly used in diets for dairy cattle to improve animal health. Other studies in chickens have shown that adding organic selenium to the diet significantly reduced mortality. Optimising health in intensive animal production has a direct impact on the profitability of the enterprise. For pigs, the practical application of trace elements chelates has been less well studied.

For porcine species, genetic improvement by selective breeding has resulted in today's highly prolific sows. However, concentrating on such improvements in zootechnical performance has generated reduced resistance of these animals to some very virulent viral and bacterial infections. One of the principal elements of this immuno-deficiency is probably a deficiency in certain trace elements, because it has been demonstrated that metallic ions play a very important part in metabolism.

In fact, the absorption thresholds of mineral salts and inorganic trace elements are generally lower than 20%, due to negative interaction with other feed components, so their supplementation in the diet can often generate low blood levels, in spite of a high content in the feed, which can result in impaired metabolic processes. Because inorganic trace elements are not highly bioavailable, they can result in significant level in urine and faecal excretion.

Using trace element chelates in porcine nutrition (especially for gestating and lactating sows and their piglets) may offer an effective future solution. Their high bioavailability, due to a high rate of absorption across the intestinal epithelium combines with a protective effect of the stable chelate structure that protects the metal ions from oxidation and reduction reactions with other feed components in the digestive system. They also appear to have positive effects on the immune system through their peptide component and finally, a positive effect on the environment, because the animals' physiological requirements can be satisfied using a much lower dose. Combining this with the enhanced resistance to various pathogens and an inclusion rate of trace element chelates clearly lower than that of sulphates or oxides, enables producers to meet all the necessary production criteria in a highly demanding commercial and political environment.

Trace element provision for weaners

Since 1987, Canadian company Protinov International has been producing amino acid chelates of trace elements for feed applications. The company uses non-GMO hydrolysed soybean protein to form chelates with a metallic ion: amino acid ration of between 1:2 and 1:3 and with a molecular weight lower than 1000Da. Chelating trace elements with peptides in this way results in a concentration of metal ions of between 20 and 22%.

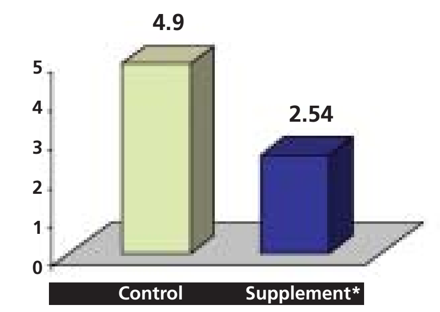
Charette *et al.* (2002) investigated the effect of feeding a number of peptide-chelated trace elements: iron, copper and zinc (T.E.P., Protinov International, Canada) on the growth response, serum concentrations of these metal ions and the levels of CD4 and CD8 lymphocytes (representing the piglets' ability to combat infection) on weaner piglets. The experiment was designed to establish whether limited supplementation over a limited time (two weeks) with selected low molecular weight peptide-chelated trace elements could influence these biochemical parameters compared to a group receiving the same trace elements in an inorganic form.

Twenty male Duroc piglets were distributed randomly into two stalls and fed one of two (organic or inorganic) mineral treatments. The two groups were given the same feed until they weighed 11.5 kg. The dietary concentration of iron was 350mg/kg feed, copper at 125mg/kg feed and the zinc at 500mg/kg feed. After this weight, the control group remained on a ration conforming with the recommendations of the Development Center of Quebec, with regard to the trace elements and vitamins, except copper and zinc which were 30 and 100ppm, respectively, in the form of copper sulphate and zinc oxide. The treated group received the same levels of copper and zinc, but in the form of peptide chelates (T.E.P, Protinov International, Canada).

The animals were weighed at the beginning of the experiment (day 0) and 14 days later (day 14). A blood sample was taken from five pigs in each stall in order to measure the percentage of serum iron and from 20 subjects for serum copper and serum zinc. To measure immunological parameters (CD4 and CD8 lymphocytes), samples were taken from 10 subjects per stall.

Table 1 shows the growth performance over the two-week period. The animals on the inorganic treatment were heavier at the beginning of the experiment. However, after two weeks, there were no significant differ-

Figure 1 - Sow mortality (%)

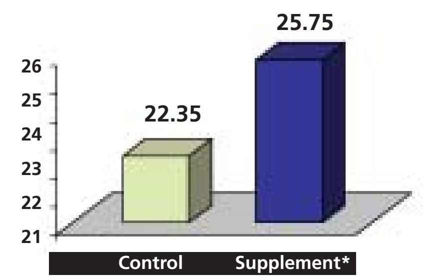


*Diets supplemented with T.E.P Feed Gestation during gestation and T.E.P Feed Lactation during lactation (Protinov, Canada), containing organic chelated iron, copper and zinc.

Table 1 - Growth performance

Treatment	Day 0	Day 14	Average daily gain (kg/day)
Inorganic	12.14±1.23	18.78±2.056	0.474±0.0722
Organic	11.18 ±1.25	17.81±1.797	0.473±0.100

Figure 2 - Piglets weaned/sow/year

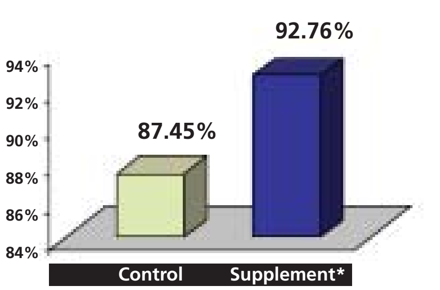


*Diets supplemented with T.E.P Feed Gestation (Protinov, Canada), containing organic chelated iron, copper and zinc.

Table 2 - Serum iron content

Treatment	Serum iron		Unbound iron binding capacity (UIBC)		Total iron binding capacity		% transferrin saturation	
	Day 0	Day 14	Day 0	Day 14	Day 0	Day 14	Day 0	Day 14
	28.0	27.83±	60.0±	64.33±	88.0±	92.17±	32.11±	30.04±
Inorganic	±8.80	9.41	12.86	9.11	7.97	7.68	10.33	9.44
	(n=5)	(n=7)	(n=5)	(n=7)	(n=5)	(n=7)	(n=5)	(n=7)
Organic	20.6±	25.14±	58.6±	64.14±	79.2±	89.28±	26.30±	28.38±
	3.21	4.74	9.016	11.57	8.70	12.48	4.71	5.086
	(n=5)	(n=6)	(n=5)	(n=6)	(n=5)	(n=6)	(n=5)	(n=6)

Figure 3 - Percentage returns to service within 7 days



*Diets supplemented with T.E.P Feed Gestation during gestation and T.E.P Feed Lactation during lactation (Protinov, Canada), containing organic chelated iron, copper and zinc.

Table 3 - Serum copper and zinc

Treatment	Copper (mmol/l)			Zinc (mmol/l)			GPX
	Day 0	Day 14	△	Day 0	Day 14	△	
Inorganic	34.74±	34.60±	-0.14±	11.10±	12.07±	0.97±	4253.6±
n=20	4.40	4.76	4.22	2.05	1.13	2.34	669.69
Organic	34.18±	32.53±	-1.65±	11.03±	11.83±	0.80±	4189.6±
n=20	4.13	5.94	4.48	2.29	2.64	2.40	459.73

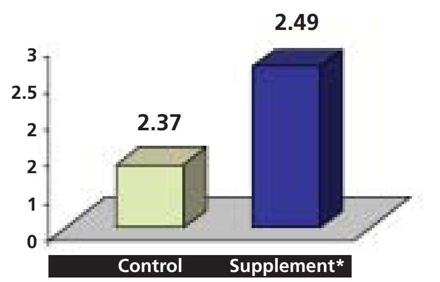
Table 4 - Lymphocyte characteristics

	White Globules	Lymphocytes	CD4	CD4 %	CD8	CD8 %	CD4/CD8
Inorganic	21.96±	11.37±	2.70±	24.1±	1.71±	15.2±	1.85±
n=10	4.41	2.32	0.43	2.51	0.99	7.37	0.66
Organic	26.02±	12.47±	2.75±	22.1±	2.12±	17.2±	1.37±
n=10	6.54	2.40	0.53	2.35	0.44	3.61	0.42

ences in weight between the two groups and average daily weight gain was also unaffected, indicating that copper, iron and zinc can be supplied to growing pigs in the form of peptide chelates without any adverse effects on growth performance. *Tables 2* and *3* show the results of the blood analyses. Serum iron, copper, and zinc were unaffected by the form in which these trace elements were supplied in the diet. The serum lymphocyte measurements are shown in *Table 4*. The CD4 lymphocyte count represents the ability of the immune system to respond to microorganisms, such as bacterial and viral pathogens, whilst the CD8 count indicates the number of "killer" T-cells that destroy infected cells. A significant difference was only observed for the CD4/CD8 ratio, but as this remained above the "normal' threshold value of 1, both diets were considered able to maintain normal immune function.

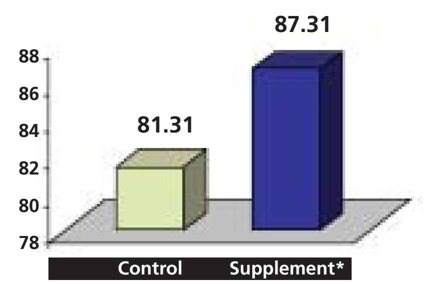
Although the copper, iron and zinc levels obtained in the ration in this experiment were higher than expected, the levels in inorganic feed are closer to current practice in Quebec. The results reflect what was observed in the literature, knowing that we can decrease the contribution of copper, iron and zinc by means of peptide chelates without negatively affecting animal performance, blood levels of the trace elements or immune function.

Figure 4 - Number of litters/ sow/year



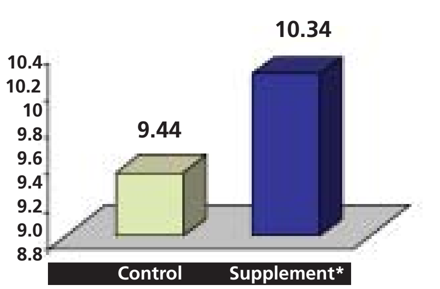
*Diets supplemented with T.E.P Feed Gestation during gestation and T.E.P Feed Lactation during lactation (Protinov International, Canada), containing organic chelated iron, copper and zinc.

Figure 5 - Farrowing rate (%)



*Diets supplemented with T.E.P Feed Gestation (Protinov, Canada), containing organic chelated iron, copper and zinc.

Figure 6 - Number of piglets per litter



*Diets supplemented with T.E.P Feed Gestation (Protinov, Canada), containing organic chelated iron, copper and zinc.

Micro nutrition for sows and piglets

In 1999, an extensive study of producers began Quebec, Canada (St-Pierre *et al*., 2002). The study followed the reproductive performance of eight commercial breeding farms using either chelated trace element supplements specifically formulated for gestating (T.E.P.-Feed-Gestation, Protinov International, Canada) or lactating (T.E.P.-Feed-Lactation) sows and for piglets (T.E.P.-Feed-Porcelet), or inorganic trace element supplements. The performance of a total of 5705 hyperprolific sows was studied.

The size of the breeding herds used in the study varied from 250 to 2500 sows, housed in standard buildings. The criteria for selection of the farms centred mainly on herds affected by PRRS. Before the dietary treatments were offered, 80 % of the stock breeders were vaccinated for PRRS. Feed was either manufactured on-farm or bought from a feed mill, but in both cases where the chelated trace elements were used, the premix and feed formulation were otherwise unchanged.

Feeding the chelated trace elements to breeding sows was found to significantly improve the sow mortality rate from 4.9 to 2.54% (*Figure 1*) and the number of weaned piglets/sow/year increased from 22.35 to 25.75 as a result of inclusion of chelated copper, zinc and iron (*Figure 2*). The significant increase in the number of pigs weaned per sow per year appears to be the result of a non-significant decrease in the rate of returns to oestrus of the sows after farrowing (*Figure 3*), which increases the number of litters per sow per year (*Figure 4*) as does the increased farrowing rate (*Figure 5*); combined with the number of pigs per litter (*Figure 6*). This increase is achieved using a lower dietary inclusion of copper, zinc and iron, compared to the diets incorporating these trace elements in inorganic form. ●