a new generation of organic trace minerals

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October 2013

Introduction

Organic trace minerals (OTM's) are widely used in animal nutrition and play an important role in today's high performance animal, especially when taking into account the genetic improvement of production animals. Animals became more sensitive to the concentration and quality of different dietary nutrients. Essential trace minerals are part of those nutrients, affecting animal performance, fertility and health. The natural dietary trace mineral contents and their availability are highly variable; furthermore, individual trace mineral requirements fluctuate depending on animal age, production stage etc. (Schlegel, 2006).

The industry offers a wide variety of forms of OTM's, which are mostly difficult to identify and differentiate between due to lack of official analytical methods. Definitions used to describe an OTM vary (Table 1), which does not make differentiating between products easier. Therefore lab bench, *in vitro, in vivo* and animal production studies have been conducted in the past 30 years to evaluate potential benefits of OTM's (Ammerman et al, 1995; Spears, 1996; Jongbloed et al, 2002). General conclusions on the benefits of OTM's were positive, but highly variable. This is mainly due to different OTM product compositions, trial designs and individual variation in animals and environment.

These defined categories (Table 1) would help to describe the identity of each source. But since most available organic trace minerals have so far not been successfully analysed on their chemical structure or at least on their "chelation" or "complexation" degree (Gou et al, 2001), their categorisation remains fully theoretical. This lack of identification, as well as the mostly imprecise product descriptions used in scientific literature, contributes to the varying data obtained in animal studies (Schlegel, 2006).

The interest in using metal chelates with proteins or amino acids has increased considerably due to their higher bio-accessibilities in comparison to inorganic sources (Spears, 1996). The efficiencies of organic sources may vary with regard to the type of ligand involved (Cao et al. 2000). Chelates or complexes with glycine (glycinates) represent one of the most efficient organic sources of trace minerals in terms of bioavailability (Hansen et al, 2008)

Categories for the commercially available/authorized organic sources have been defined (Table 1) by the Association of American Feed Control Officials (AAFCO 2001) and Official Journal of the European Community (OJEC 2003).

Table 1. Official definitions of OTM to be used in feed stuffs.

AAFCO[1] (2001)	OJEC[2] (2003)
Metal amino acid complex Product resulting from complexing a soluble metal salt with an amino acid(s)	
Metal (specific amino acid) complex Product resulting from complexing a soluble metal salt with a specific amino acid	
Metal amino acid chelate Product resulting from the reaction of a metal ion from a soluble metal salt with amino acids with a molecular ratio of 1 mole : 1 – 3 (preferably 2) moles of amino acids to form coordinate covalent bonds. The average weight of the hydrolysed amino acids must be ± 150 and the resulting molecular weight of the chelate must not exceed 800.	**Metal chelate of amino acids hydrate** M $(x)_{1-3}$ * n H_2o with x = anion of any amino acid derived from hydrolised soya protein. Molecular weight not exceeding 1500
Metal polysaccharide complex Product resulting from complexing a soluble salt with a polysaccharide solution	
Metal proteinate Product resulting from the chelation of a soluble salt with amino acids and/or partially hydrolised protein	

[1] Association of American Feed Control Officials
[2] Official Journal of the European Community

To be able to make an informed decision on the OTM product(s) that will perform the best under specific circumstances, one has to make sure about the following: stability and homogenousity of product, ability to analyse product to prove bond between mineral and ligand, solubility, bioavailability, animal performance response etc.

The aim of this paper is to provide more technical information on the B-Traxim 2C range of OTM so that an informed decision can be made regarding the use of B-Traxim 2C in animal feeds.

History of B-Traxim 2C

In 1990 Dr Scribante, chemist and founder of Pancosma, decided to develop an OTM range. The first OTM manufactured used either L-methionine, L-Lysine.HCL or Glycine. 1 mole of metal was chelated (bound) by 1 mole of amino acid in solution and then spray-dried with 1% silica to get a thin powder. The product was named B-Traxim. Several problems derived from using this product. The product was hygroscopic, thus tending to cake. It was also dusty, which made it difficult to handle. To solve these problems, their

objectives were to develop a product which was stable in humidity, bioavailable and with a clear chemical identity, enabling them to prove (analyse) the chemical structure.

For a year Pancosma systematically investigated the chemical behaviour of glycine chelates and trials were performed in order to solve the hygroscopicity issue. Of the 3 potential amino acid candidates (glycine, methionine and lysine.HCl), glycine was chosen. The reasons were its high solubility, its absence of enantiomery (one of two stereo-isomers that are mirror images of each other but are not identical) and its low molecular weight, permitting them to get a high metal ratio. Moreover, glycine is odourless. But the main reason was that glycine chelates exhibited the best physical properties – when produced in the right way. During the tests, chelation reactions were conducted with different molar ratios, at different pH levels and with different starting metal sources. The best results were obtained by reacting 1 mole of metal sulphate with 1 mole of glycine in neutral conditions.

In November 2000 unique crystals were obtained during a laboratory experiment. These crystals had a different infra-red (IR) spectrum to the equivalent spray-dried product. Their chemical structure was therefore different. Moreover, these crystals, even when finely milled, were stable in humid conditions. They decided to focus on these crystals to determine their chemical structure and a find a way to produce them. As the products were crystalline, they were able to determine its structure by X-ray diffraction. It was found that the metal was bonded to glycine. The chemical structure as well as the manufacturing process was then patented worldwide. During this phase of development, several key points were observed:

- Methionine based chelates could not be crystallised. The crystals obtained were a mix of methionine and sulphate
- Each metal requires a specific process as it has unique properties
- All the crystals obtained by crystallisation resisted to humidity

Properties of B-Traxim 2C

Different properties of B-Traxim 2C proved to enhance the performance of the trace mineral. Several properties of B-Traxim 2C are discussed below.

Unique chemical structure

B-Traxim 2C has a **unique chemical structure** (Fig 1). It consists of only 1 glycine, 1 metal and 1 sulphate. It is important to note that there is no carrier or diluent in the product. This allows the product to have a much higher metal content (Table 2) compared to other OTM's. The molecular weight of the amino acid also plays a role in the metal content of B-Traxim 2C. The bigger the amino acid (ligand), the less mineral can be bonded. By using glycine, which is the smallest amino acid, the mineral content of metal glycinates is the highest that can be reached, compared to other synthetic amino acids or to hydrolysed proteins.

Fig 1. The chemical structure of B-Traxim 2C

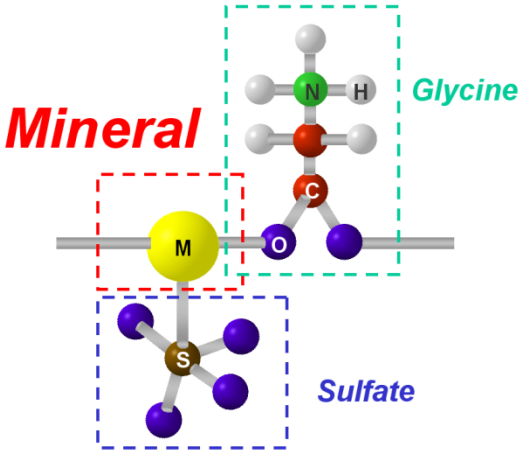


Table 2. Mineral content of the different B-Traxim 2C products

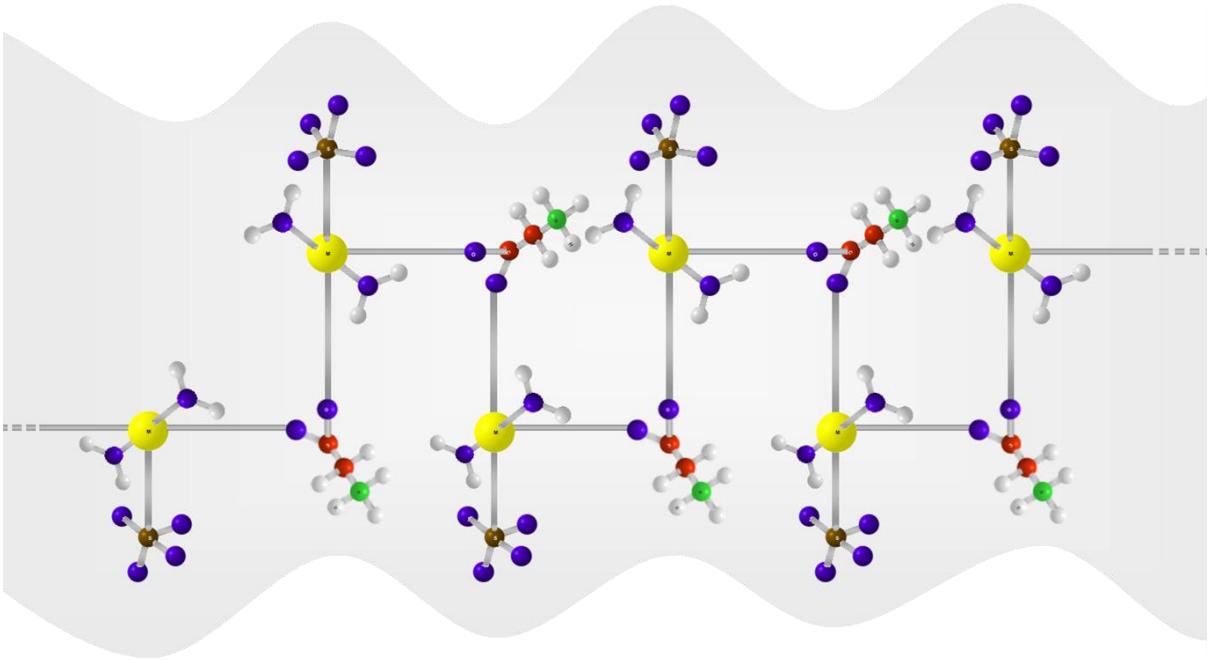
Product	Mineral content (%)
B-Traxim Zn	26
B-Traxim Cu	24
B-Traxim Fe	22
B-Traxim Mn	22

Unique crystalline structure

B-Traxim 2C is manufactured by unique and innovative technology processes developed by Pancosma. This produces a premium **crystalline structure** (patented) (Fig 2). Due to this crystalline structure, it is possible by X-ray diffraction, to define its molecular structure and demonstrate the genuine organic form of the mineral. Everything on earth has a specific frequency by which it vibrates. This includes the bond between the glycine and the mineral. By using both X-ray as well as Infrared analysis, Pancosma is able to prove the bond between the glycine and the mineral by "vibrating" the bond between them, which is then measurable. In this way **one is able to prove the most significant characteristic of an OTM, the bond between the mineral and the amino acid.** Because of its crystalline structure, compared to other products which are amorphous, B-Traxim 2C is probably the only organic mineral where this critical measurement can be made.

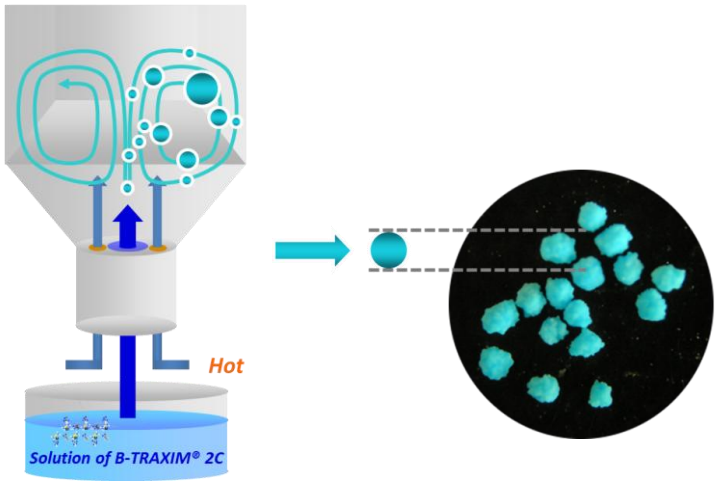
The crystalline structure also improves the stability of the product, therefore reducing the chance of the mineral and the amino acid dissociating.

Fig 2. The Crystalline structure of B-Traxim 2C



Unique physical properties

B-Traxim 2C is **dust free** and this minimises the risk of contamination in the feed plants and contributes to the safety of the workers. It's **free-flowing** properties as well as **small range in particle size** improves the mixing ability of the product. Increase in **humidity** does not have a negative effect on B-Traxim 2C; thereby prevent caking of the product. B-Traxim 2C is **odourless**, and therefore has no negative effect on palatability of feed. B-Traxim 2C relies on a unique manufacturing proses using spouted bed technology. Water, glycine and metal sulphate are mixed together. It is then pumped into chamber and with the help of hot air, circulated in the air. New B-Traxim 2C solution attached itself to the existing particles, thereby evenly increasing the particle to the correct particle size:



Solubility of B-Traxim 2C

Solubility of an OTM is very important to maximise its bioavailability. If the OTM is not 100% soluble, the risk of precipitation is increased, thereby decreasing the bioavailability. B-Traxim 2C is 100% soluble in an aqueous solution at a neutral pH (TB 322, 2009) and no precipitation occurs. However, while solubility is very important, it is even more important to prove that the OTM **complex stays intact** (mineral bond to the amino acid) when an OTM is solubilised in an aqueous solution. Pancosma is able to prove that B-Traxim 2C is 100% soluble, and also that the B-Traxim 2C complex stays intact. This was made possible by the use of the X-ray / Infrared as well as an Electrospray QqTOF mass spectrometer. If the OTM complex does not stay intact in an aqueous solution, it becomes a mixture of amino acids and inorganic trace minerals.

pH and its effect on B-Traxim 2C

When absorbed by an animal, B- Traxim 2C faces different conditions of acidity, ranging from pH 3 to 7. Change in pH levels has an effect on the stability of the OTM complex. A reduction in pH could lead to an increase in the dissociation of the mineral and ligand. (Cao et al, 2000). It was therefore important for Pancosma to prove the level of **stability of the OTM complex at different pH levels** (TB 323, 2009). Due to the technology that was developed by Pancosma to measure the bond between the mineral and glycine, they were able to prove the stability of the B-Traxim 2C complex at different pH levels (Fig 3 - 6). From the results it is clear that the B-Traxim 2C complex is affected by the change in pH, but even at a pH of 2, there is a certain amount of B-Traxim 2C complex intact. Please take note that this is not calculated, but actual measurements.

Fig 3. Stability of B-Traxim Fe complex at different pH levels

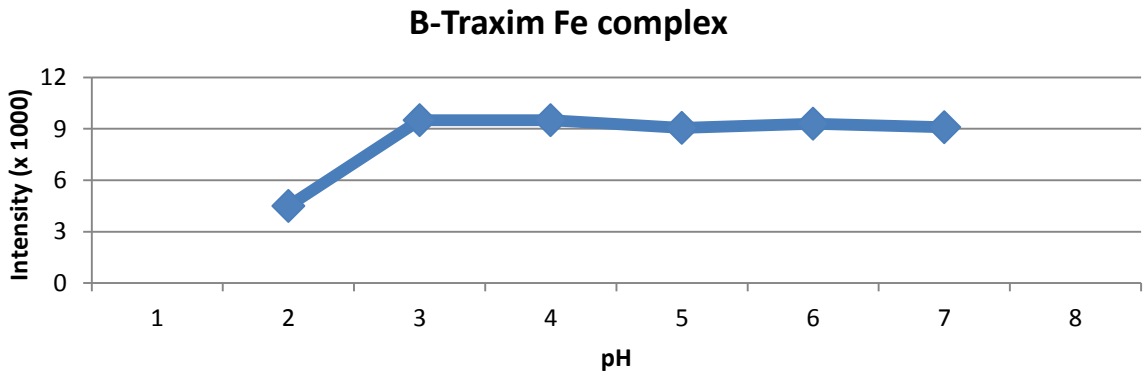


Fig 4. Stability of B-Traxim Zn complex at different pH levels

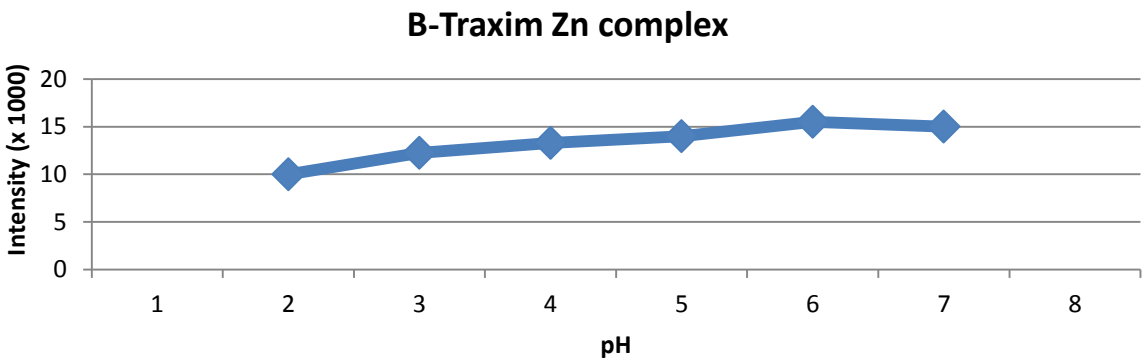


Fig 5. Stability of B-Traxim Cu complex at different pH levels

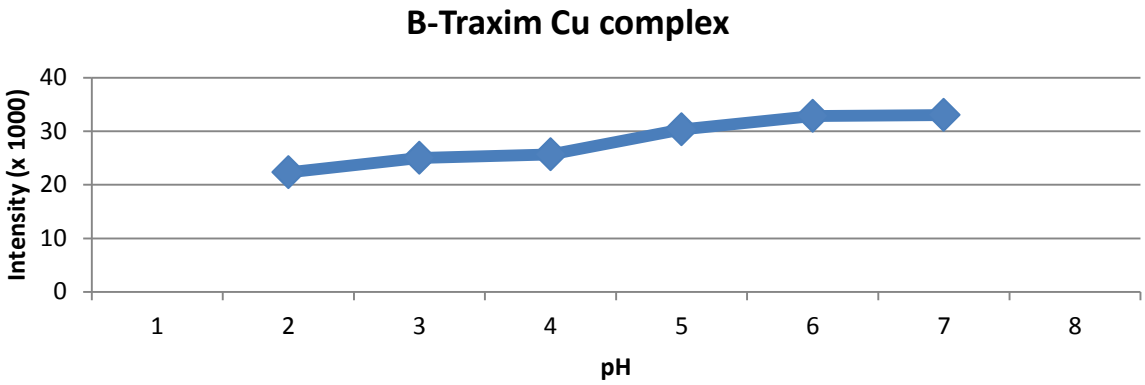
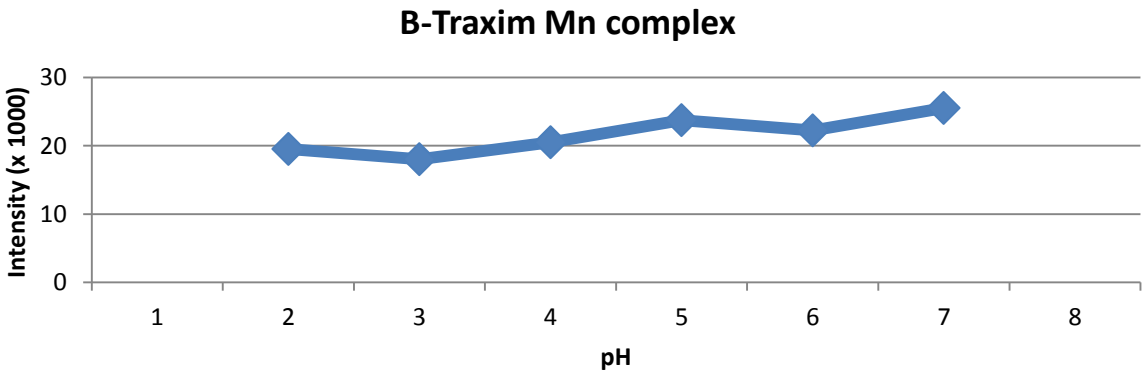


Fig 6. Stability of B-Traxim Mn complex at different pH levels



Analyses of B-Traxim in premixes and in vitro gastric simulations

Including OTM's into animal feed is one thing, but does the OTM stay in its complex form in the final mixed feed? OTM glycinate complexes are introduced in feeds, but to date, there was no analytical method enabling their identification and quantification in such matrixes. This was one of the questions that

Pancosma faced with B-Traxim 2C. Vacchina et al, 2010, developed a method, using Electrospray Q-TOF-MS/MS and capillary electrophoresis-ICP-MS. With this method, they were firstly able to differentiate between B-Traxim 2C and sulphate bonded minerals. They then developed the method further and were able to identify / **quantify the glycinates OTM (B-Traxim 2C) in the feed samples**.

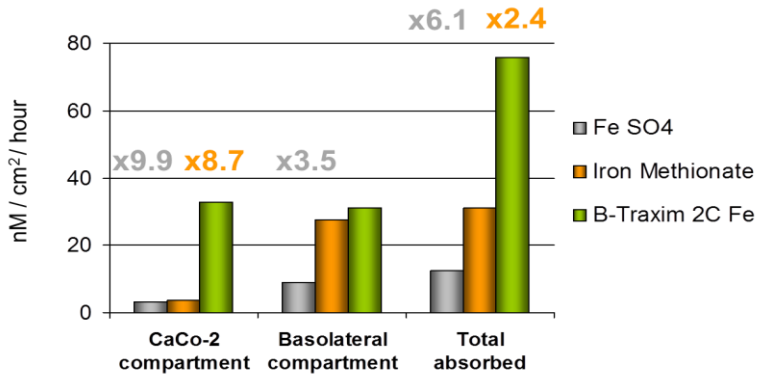
To go one step further, Ionescu et al, 2011, used Capillary Electrophoresis coupled with Inductively Coupled Plasma Mass Spectrometry (CE-ICP-MS) to determine the identification and quantification of Copper and Manganese glycinate complexes in gastric and gastro-intestinal **in vitro simulations**. B-Traxim Cu and B-Traxim Mn spiked feed samples were subjected to gastric and gastro-intestinal simulations. The measurement of the total Cu and Mn content showed that both elements were in a bioavailable form (79 - 94% was extracted). The extracts obtained were then analysed by CE-ICP-MS and the electropherograms showed that both B-Traxim Cu and B-Traxim Mn complexes were present after gastro-intestinal simulations. However quantitative glycinates data were difficult to obtain due to the presence of other minerals.

Research results on B-Traxim 2C

General

University of Zurich, Switzerland

The objective of this study was to determine the absorbability of B-Traxim 2C compared to inorganic sulphate linked minerals and Fe-methionine. An *in vitro* study was conducted, using Caco-2C cells as medium. The Caco-2 cell line, derived from a human colorectal carcinoma, has become an established *in vitro* model for the prediction of drug absorption across the human intestine. When cultured on semi-permeable membranes, Caco-2 cells differentiate into a highly functionalized epithelial barrier with remarkable morphological and biochemical similarity to the small intestine columnar epithelium. B-Traxim Fe was 6 times better absorbed compared to $FeSO_4$ and 2.4 times better absorbed compared to Fe-methionine. (Pancosma Report: B-Traxim FAQ02, 2003)



Schlegel et al, 2006

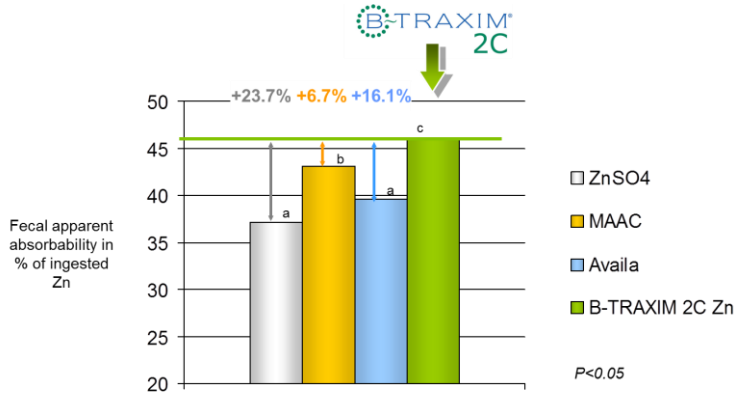
The objective of this study was to quantify the bioavailability of zinc (Zn) from sulphate and glycinate as representatives of inorganic and organic zinc sources. The semi-synthetic basal diet contained 2 lg/g of native Zn and was fortified with pure sodium-phytate (8 g/kg) in order to simulate conditions of common cereal-based meals. The basal diet was supplemented with either 53 lg/g of Zn from sulphate (control) or 10 lg/g of Zn from either sulphate (ZnSulphate) or glycinate (ZnGly). Twenty-four ^{65}Zn-labelled, growing rats weighing 133 g were allotted to the three diets (eight animals per treatment) and were kept pair-fed to ZnSulphate for 15 days. Zn contents in blood plasma, femur and whole body, as well as plasma alkaline phosphatase activities were reduced compared to the control group, indicating a zinc deficiency in ZnSulphate and ZnGly treatment. This allowed their differentiation in zinc bioavailability. True absorption of dietary Zn was significantly higher with ZnGly than with ZnSulphate (51% vs. 44%) while losses of endogenous faecal Zn and urinary Zn were not affected to a quantitatively relevant extent (mean: 17% and 2% of intake). This resulted in a +30% significantly improved Zn retention for ZnGly (33% vs. 25%) and a lower severity on Zn deficiency symptoms compared to ZnSulphate. Metabolic utilisation accounted for 95% of absorbed dietary Zn for both Zn sources. Overall, the bioavailability of zinc glycinate was significantly superior by 16% to zinc sulphate (49% vs. 42%), mainly because of a higher absorptive potential presence of a strong anti-nutritive component (phytate) in the diet. (Schlegel et al, 2006. Bioavailability of zinc glycinates in comparison with zinc sulphate in the presence of dietary phytate in an animal model with ^{65}Zn labelled rats. J. Anim. Phys Anim Nutr, 90: 216 – 222)

Monogastric

Manner et al, 2006

A study was conducted to investigate the effect on mineral bioavailability (absorbability, performance, plasma concentrations) of three trace mineral sources (sulphates, chelates, glycinates (B-Traxim 2C)) for iron, manganese, zinc and copper in restrictively fed weaned piglets after a 14-day-depletion period. Forty early weaned piglets (24 days of age) were used from day 24 to 45 of age. All piglets were fed a basal diet with 14.1 MJ ME/kg and 192 g/kg of crude protein restrictively (0.77 MJ ME/kg0.75) for the first 14 days after weaning which was formulated to meet the GfE requirements for piglets except iron, manganese, zinc and copper with concentrations of 48.0, 15.3, 24.6 and 3.8 mg/kg feed, respectively. After the depletion period pens were randomly allocated to 4 treatments: Control (no supplementation), sulphates, chelates (based on hydrolysed soya) and glycinates (crystalline complexes). The three supplemented sources of Fe, Mn, Zn and Cu were included into the basal diet to reach 90% of NRC recommendations. Feed intake was similar across the treatments. Apparent absorbability of all 4 minerals tested was significantly improved ($P < 0.05$) when sulphate based minerals were replaced by B-Traxim (Fe: +21.5%; Mn +24.8%; Zn +24%; Cu +48.8%). Haemoglobin concentrations were also significantly improved when B Traxim replaced the sulphate based minerals. Body weight gain and feed efficiency performance were the best in the B-Traxim supplemented groups. (Manner et al, 2006. Effects of different iron, manganese, zinc and copper sources (sulphates, chelates, glycinates) on their bioavailability in early weaned piglets. M Rodehutscord (Hrsg.):9.

Tagung Schweine –und Geflugelernahrung, 28 – 30 Nov 2006. Universitat Helle-Wittenberg.ISBN: 3-86010-833-6)



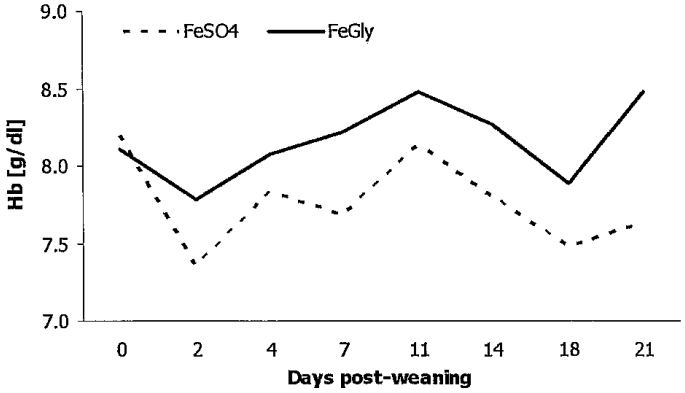
Ettle et al, 2007

Two experiments were conducted to investigate the iron bioavailability of different sources and supply levels in piglets. In experiment 1, the influence of feeding an iron deficient basal diet or the basal diet supplemented with 28 ppm Fe either in form of Fe-chelate, crystalline Fe-glycinate, or Fe-sulphate on apparent iron digestibility and on blood parameters was determined. In experiment 2, a dose-response approach was used to determine the effect of supplementing an iron-deficient basal diet with 30, 60 or 90 ppm of Fe either in form of crystalline Fe-glycinate or Fe-sulphate on digestibility of Fe, growth and blood parameters. In experiment 1, comparison of iron sources revealed a tendency ($0.05 < p < 0.1$) for a higher Fe digestibility from Fe-glycinate (40.9) compared to Fe-chelate (30.8) or Fe-sulphate (30.7). Fe-balance was higher ($p < 0.05$) for Fe-glycinate compared to Fe-sulphate but iron balance was similar for iron sulphate and iron chelate. However, these results were not reflected in blood parameter data. In experiment 2, iron digestibility, blood parameters and performance were significantly ($p < 0.05$) influenced by iron supply. Effects of iron source on digestibility of iron were lower than observed in the first experiment. (Ettle et al, 2007. Investigations on iron bioavailability of different sources and supply levels in piglets. Journal of Animal Physiology and Animal Nutrition. P 1 – 9.)

Schlegel et al, 2007.

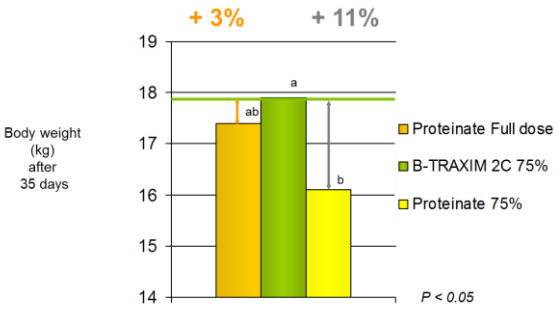
384 twenty-one day old weaned piglets (± 6kg live weight) were blocked according to body weight, gender and litter origin into two blocks of 16 slotted pens each. Piglets were fed ad lib, a basal weaner diet (D1-21) followed by a basal starter diet (D22 – 42). Treatment 1 was basal diets plus 100 mg $FeSO_4$/kg feed and treatment 2 was basal diets plus 100 mg B-Traxim 2C Fe/kg feed (FeGly). Blood samples were taken on day 0, 21 and 42. On day 21, piglets fed FeGly had increased haemoglobin (Hb) levels (+15%, $p < 0.05$); increased haematocrit (Ht) (+12%, $p < 0.001$) and increased red blood cell (RBC) count (+5%, $P < 0.1$)

compared to $FeSO_4$. On day 42, Hb and Ht were again increased ($P < 0.001$) for FeGly compared to $FeSO_4$. Number of piglets with anaemia on day 42 was also reduced ($FeSO_4$ = 41.4%, FeGly = 10.7%). These results suggest that feeding FeGly instead of $FeSO_4$ to piglets reduced the proportion of anemic piglets. (Schlegel et al, 2007. Iron status evolution of weaned piglets either fed iron sulphate or iron glycinates. Boku-Symposium, Tierernahrung.)



CCL Research, Laverdonk, Netherlands

The objective of this study was to measure the effect of trace mineral source (soy based chelates vs glycinates (B-Traxim 2C)) and a 25% reduced supplementation on performance of weaned piglets. 342 piglets were allocated to 36 pens, based on body weight, gender and litter. 4 dietary treatments included supplementation of Soy-based chelates trace minerals as 100% and 75% of recommended levels and glycinated trace minerals (B-Traxim 2C) at 100% and 75% of recommended levels. Final body weights of piglets were similar for B-Traxim (75%) compared to Chelate (100%) and B-Traxim (100%) and significant higher than Chelated (75%).



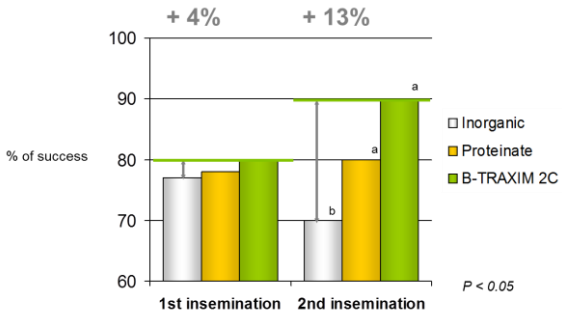
Feed intake, ADG and FCR were significantly improved ($P < 0.05$) when B-Traxim 2C supplemented piglets were compared to Chelated supplemented piglets. This study demonstrated that B-Traxim 2C (glycinated) improved post weaning performance when compared to soy-based chelated trace minerals. It also demonstrated that a reduced trace mineral supplementation of ± 25% using B-Traxim 2C permits keeping animal performance while reducing trace mineral supplementation. (Pancosma report: TB 326, 2009)

Commercial Pig Farm, France

280 piglets weaned at 28 days were randomly allocated to either Control (mixture of iron and copper sulphate and zinc and manganese oxide) or B-Traxim 2C (70% inorganic trace minerals + 30 % B-Traxim 2C for iron, copper, zinc and manganese). Similar diets were fed to both treatments (digestible energy 15.4 MJ /kg, 19.5% CP). Piglets stayed in the trial for 14 days. Average daily gain were between 366 and 387 g/d. Only FCR were significantly ($p < 0.05$) improved (1.22 vs 1.18). (Pancosma report: TB 304, 2000)

Fuchs, J. University of Wroclaw, Poland

Sows were equally allocated to 3 dietary treatments on their insemination day (artificial insemination; semen from one boar for all sows): 1.Control: inorganic trace mineral supplementation at common practice levels. 2. Chelate: reduced trace mineral supplementation partially replaced with organic soy-based chelates. 3. BT2C: reduced trace mineral supplementation partially replaced with organic glycine-based complexes (B-TRAXIM® 2C). Reducing the Cu, Mn and Zn supplementation and using to half OTM in gestating and lactating sows did not negatively affect their performance nor the ones of their offspring. In contrary, the treatments Chelate and BT2C even increased ($P<0.05$) success of artificial insemination 30 days after farrowing. The offspring from sows fed OTM's were heavier ($P<0.05$) at birth, which induced less removals ($P<0.05$). There was no significant difference between Chelate and BT2C to these parameters, but there was a consistent numerical advantage for BT2C. Trace mineral contents in sow milk remained similar between treatments, but milk protein and albumin contents were increased ($P<0.05$) with BT2C compared to Control and Chelate. Plasma albumin was increased ($P<0.05$) by respectively 20% and 41% in gestating sows and piglets when using BT2C compared to Control and Chelate. Urea contents in sow plasma were reduced ($P<0.05$) when feeding OTM. The same was measured as a tendency in weaned piglets. It can be concluded that the results indicates that a reduced trace mineral supplementation, partially in organic form had no negative impact on animal's trace mineral status when compared to Control. This clearly indicates that "the more the better" is not valid for trace mineral nutrition with dosages above physiological requirements. (Pancosma report: TB 08BT-TS09, 2009)



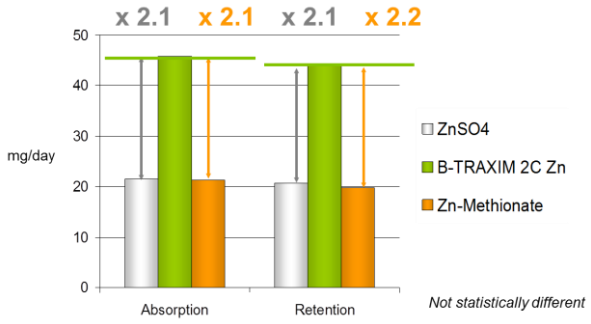
Ionescu et al, 2011

The objective of the study was to check if a combination of metal-glycinate complexes (Copper, Zinc, Manganese and Iron as B-TRAXIM® 2C) could beneficially replace inorganic sources and modifies carcass quality even in adequate to high trace mineral concentrations. 384 one day old male broiler chickens (Ross 308) randomly allocated to 2 treatments consisting of 6 replicates of 32 birds each at a density of 14.2 birds/m2. Performance and carcass quality was measured. All diets contained 10 ppm flavomycin as an antibiotic growth promoter and 60 ppm of Salinomycin as a coccidiostat. Animals were fed a starter (1-19 days) and a grower/finisher diet (20 - 42 days). Animals have been allocated to 2 treatments, either inorganic or organic trace elements (B-Traxim 2C). The total replacement of inorganic trace minerals by an organic source at levels higher than the recommended NRC levels did not improved total body weight gain, DMI of FCR for the overall trial period. The absence of difference between inorganic and organic trace minerals at those levels of supplementation indicates that broilers had sufficient trace mineral supplementation to cover their growth needs whatever the source used. The impact of organic source compared to inorganic can however be seen when looking at some specific carcass parameters. Dressing percentage was improved in organic treatment (76 vs. 69%, $P < 0.001$). Drumsticks percentage was improved when using organic trace elements ($P < 0.001$). Breast and abdominal fat percentage were not modified by treatment. These results indicate that even at high doses, when no differences could be found on performance, the use of other criteria such as carcass quality could represent an indicator parameter for the efficient use of the trace mineral involved in a multitude of metabolic processes. (Ionesco et al. 2011. Feeding organic trace minerals source instead of inorganic source at high trace mineral doses improves broiler carcass quality. Poster 602 - 2011 PSA Annual Meeting, St Louis, USA.)

Ruminants

Spears et al, 2004

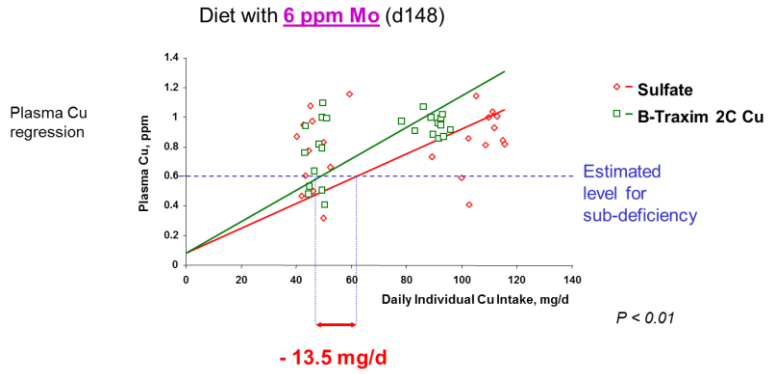
Twenty-four Angus steers were used to determine the effects of dietary zinc (Zn) level and source on Zn metabolism and ruminal volatile fatty acid (VFA) patterns. All steers were fed a low Zn diet (18.8 mg Zn per kg) for 42 days prior to assignment to dietary treatments. Treatments consisted of: (1) control (low Zn diet), (2) Zn sulphate (ZnSO4), (3) Zn methionine complex (ZnMet) and (4) Zn glycine complex (ZnGly). The Zn sources were added to provide 20 mg of supplemental Zn per kg diet. A 5-day total collection of faeces and urine was conducted beginning on day 14 of the study. Liver biopsy samples were obtained on days 0 and 42 for Zn analysis, and ruminal fluid was collected on day 42 for VFA and ruminal soluble Zn determination. Plasma samples were obtained on days 0, 2, 19, 21, and 42 for determination of plasma Zn and alkaline phosphatase activity. Urinary excretion of Zn was higher ($P < 0.05$) in steers supplemented with ZnMet or ZnGly than in controls. Apparent absorption and retention of Zn were not significantly affected by treatment, but tended to be higher in steers receiving ZnGly.



Liver Zn concentrations were higher (P < 0.05) on day 42 in steers supplemented with ZnGly, compared to steers receiving control, ZnMet or ZnSO4 treatments. Plasma Zn concentrations were higher (P < 0.05) for the ZnGly and ZnMet treatments compared to the control on day 42. Plasma alkaline phosphatase was not affected by treatment. Ruminal soluble Zn concentrations were higher (P < 0.05) in steers fed ZnMet compared to those fed the control or ZnSO4 diets. Total VFA concentrations were higher (P < 0.05) in steers fed the control and ZnSO4 treatments than in those receiving ZnGly or ZnMet. Steers supplemented with ZnMet had a higher (P < 0.05) molar proportion of propionate and lower (P < 0.05) molar proportions of butyrate and valerate than controls. Compared to the control treatment, valerate was the only VFA affected by ZnSO4 or ZnGly supplementation. Results suggest that Zn from ZnGly was more bioavailable than ZnSO4 or ZnMet. However, ZnMet supplementation resulted in the highest ruminal soluble Zn concentrations and altered ruminal VFA proportions to the greatest extent of the Zn sources evaluated. (Spears et al, 2004. Bioavailability of zinc from zinc sulphate and different organic zinc sources and their effects on ruminal volatile fatty acid proportions. Livestock Prod. Sci. 90: 211 – 217)

Spears et al, 2008

Sixty Angus (n = 29) and Angus-Simmental cross (n = 31) steers, averaging 9 months of age and 277 kg of initial BW, were used in a 148-day study to determine the bioavailability of copper glycinates (CuGly) relative to feed-grade copper sulfate (CuSO4) when supplemented to diets high in S and Mo. Steers were blocked by weight within breed and randomly assigned to 1 of 5 treatments: 1) control (no supplemental Cu), 2) 5 mg of Cu/kg of DM from CuSO4, 3) 10 mg of Cu/kg of DM from CuSO4, 4) 5 mg of Cu/kg of DM from CuGly, and 5) 10 mg of Cu/kg ofDM from CuGly. Steers were individually fed a corn silage-based diet (analysed 8.2 mg of Cu/kg of DM), and supplemented with 2 mg of Mo/kg of diet DM and 0.15% S for 120 d (phase 1). Steers were then supplemented with 6 mg of Mo/kg of diet DM and 0.15% S for an additional 28 d (phase 2). Average daily gain and G:F were improved by Cu supplementation regardless of source (*P* = 0.01). Final ceruloplasmin, plasma Cu, and liver Cu values were greater (*P* < 0.05) in steers fed supplemental Cu compared with controls.



Plasma Cu, liver Cu, and ceruloplasmin values were greater ($P < 0.05$) in steers supplemented with 10 mg of Cu/kg of DM vs. those supplemented with 5 mg of Cu/kg of DM. Based on multiple linear regression of final plasma Cu, liver Cu, and ceruloplasmin values on dietary Cu intake in phase 1 (2 mg of Mo/kg of DM), bioavailability of Cu from CuGly relative to CuSO4 (100%) was 140 ($P = 0.10$), 131 ($P = 0.12$), and 140% ($P = 0.01$), respectively. Relative bioavailability of Cu from CuGly was greater than from CuSO4 ($P = 0.01$; 144, 150, and 157%, based on plasma Cu, liver Cu, and ceruloplasmin, respectively) after supplementation of 6 mg of Mo/kg of DM for 28 d. Results of this study suggest that Cu from CuGly may be more available than CuSO4 when supplemented to diets high in S and Mo. (Spears et al, 2008. Bioavailability of copper from copper glycinates in steers fed high dietary sulfar and Molybdenum Cu and Molybdenum Steers. J Anim Sci 86:173 – 179)

To summarize, Table 1 present a list of the bioavailability of the different trace minerals tested in the different studies that were published.

Table 1. Summary of studies done on the relative bioavailability of iso-dosed trace mineral sources.

Specie	Mineral	Sulfate	Glycinate [1)]	Methionine	Chelate [2)]	TB[3)]	Reference
Beef	Zn	100	146	104	-	308; 319	Spears J. W. et al., 2004. Livestock Prod. Sci., Vol 90, 211-217
Horse	Zn	100	110	-	-	-	Wichert B, et al. 2002. J. of Nutrition, Vol 132, 1769-1770
Piglet	Zn	100	122	-	113	315; 316	Männer K.et al. 2006. 9. Tagung Schweine- und Geflügelernährung, Halle, November 2006. 25-27
Rat	Zn	100	115	-	107	307; 312	Schlegel P. and Windisch W. 2006. J. of Animal Physiology and Nutrition, Vol 90, 216-222
Average	**Zn**	**100**	**126**	**104**	**113**		
Piglet	Fe	100	124	-	102	309; 320	Ettle T. et al. 2007. J. of Animal Physiology and Nutrition, *submitted*
Piglet	Fe	100	107	-	-	-	Ettle T. et al. 2007. J. of Animal Physiology and Nutrition, *submitted*
Piglet	Fe	100	105	-	-	310	-
Piglet	Fe	100	118	-	112	315; 316	Männer K.et al. 2006. 9. Tagung Schweine- und Geflügelernährung, Halle, November 2006. 25-27
Average	**Fe**	**100**	**114**	**-**	**107**		
Beef	Cu	100	125	-	-	318; 321	Hansen S. L. et al, 2006. Journal of Animal Science, Vol 84, Suppl. 1
Piglet	Cu	100	147	-	127	315; 316	Männer K.et al. 2006. 9. Tagung Schweine- und Geflügelernährung, Halle, November 2006. 25-27
Average	**Cu**	**100**	**136**	**-**	**127**		
Average	**Mn**	**100**	**123**	**-**	**116**	315; 316	Männer K.et al. 2006. 9. Tagung Schweine- und Geflügelernährung, Halle, November 2006. 25-27
Average	**all**	**100**	**123**	**104**	**114**		

[1)] Representing the B-TRAXIM 2C range from Pancosma
[2)] Originating either from Alltech, Zinpro, Albion or Pancosma (B-TRAXIM TEC range)
[3)] Technical Bulletin released by Pancosma

Conclusion

There are different types of organic trace minerals available in the market. Each has its benefits and disadvantages. Therefore it is important to make sure that firstly one understands the physical and chemical properties of the OTM, be able to measure the bond between the mineral and the ligand, know how it reacts in different pH levels and to determine its solubility. This information should then be supported by in vitro, in vivo and production studies to supply information to the user to make sure that the OTM will suit his specific demands. B-Traxim 2C proved to be an effective and well researched OTM product that will play a significant role in improving animal production when applied correctly.

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