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Original Contribution

ALTERNATIVES TO THE USE OF ORGANIC TRACE MINERALS (FE, SE AND CU) IN PREVENTION OF SOME DEFICIENCY STATES IN PIGS
(A review)

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ABSTRACT

The aim of this review is to present the use of organic trace elements (Fe, Se and Cu) in the prevention of some deficiency diseases in pigs. Trace minerals are extremely important for the animal. They play primary functions as tissue structure building material and participate in a number of enzyme systems, regulating the main vital cellular and systemic functions. They stimulate the immune response and improve the reproductive traits, the production of meat and milk. Normally, they are present in the diet, but their bioavailability depends on their content in soil, plants and foodstuff. The trace elements iron (Fe), copper (Cu) and selenium (Se) have an essential effect on health status, which invariably controls the economic output in pig breeding. For example, inadequate levels of these elements result in deficiency diseases, which include iron deficiency anaemia, oesophago-gastric ulcer syndrome prevalent among growing piglets and fattening pigs.

The review of literature shows that the aetiological aspect of those diseases is not adequately discussed as well as the application of organic trace elements in the prevention of these deficiency states in industrial pig breeding.

Key words: pigs, iron deficiency anaemia, ulcer, trace elements, organic trace minerals

INTRODUCTION

Trace minerals are extremely important for the animal They perform primary functions as tissue structure components and, via participation in several enzymatic systems, regulate main vital functions of cells and of the organism as a whole. They stimulate the immune response and improve the reproductive properties, the meat and milk productivity (1-3).

Normally, they are present in the diet, but their bioavailability depends on their content in soil, plants and foodstuff (4,5). The trace elements iron (Fe), copper (Cu) and selenium (Se) have an essential effect on health status and productivity of pigs. Their shortage results in disease states like iron deficiency anaemia and oesophago-gastric ulcer syndrome prevalent mostly among pigs in industrial pig breeding where rapid growth is an essential property (6-8).

Iron deficiency anaemia is one of the commonest diseases in newborn piglets. They are very sensitive to such deficiency arising from iron shortage in the placenta and its inadequate transfer from mother to the newborn through the breast milk (4). This is a characteristic disease for piglets, because they are born with limited stores of the trace element iron, a vital component of red blood cells. If they do not receive iron during the first 2–3 weeks, the capacity of red blood cells to absorb oxygen is highly reduced (8, 9).

The principal signs observed in piglets are pale skin, fast exhaustion, sometimes pale yellow colouring of the skin, pale periocular mucous membranes, haemorrhagic signs, muscle weakness, etc. The disease should be distinguished from zoonoses, gastric ulcers resulting in significant loss of blood, porcine

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enteropathy, rectal prolapse, gastric and intestinal torsion and unbalanced nutrition (10).

The diagnosis is made on the basis of clinical signs, decrease in haemoglobin content and erythrocyte counts (11, 12).

The oesophago-gastric ulcer syndrome affects predominantly growing and fattening pigs. The disease is mainly characterized by oesophago-gastric ulcerations in the non-glandular part of the oesophagus (a small part of the stomach near the oesophagus). There is limited information about the herd incidence of the oesophago-gastric ulcer syndrome but the available studies point out that in more than 50% of slaughtered pigs, there are gastric erosions and lesions (13). Its cause is still unclear but it is supposed that the ulcer is closely related to offering very finely ground feeds. As predisposing factors, some diet components, stress, congenital diseases and bacterial infection could be also involved. Because of the difficulties related to the experimental reproduction of the disease, the recent studies determined it as being of poly-aetiological origin (13,14). According to Mitov et al. (15) the presence of spiralled bacteria in porcine stomachs is one of possible causes. Some studies substantiated the relationship between these microorganisms and the ulcerative lesions of the oesophageal part of the stomach in pigs (16,17), whereas others do not observe such an association (18). In spite of contradictory data, the prevailing opinion is that the bacterial aetiology of the disease is related to the presence of *Helicobacter spp*. in porcine stomach with predominance of *H. helmannii* type 1 and type 2 (4,19).

Clinically, the disease could be seen in several forms (**Table 1**) and should be differentiated from some diseases with a similar course.

Table 1. *Clinical forms of gastric ulceration (PHMS, 1989)*

Clinical form	**Differential diagnosis**
Peracute – completely healthy animals regardless of their age are found dead or collapsed following exercise or excitement. The corpses are most commonly pale, the stomach is thinned, distended and full of clotted blood. Blood clots are partially attached to eroded blood vessels located at the ulcerated margin of cardiac mucosa.	Traumatic rupture or torsion of internal organs, liver, small intestine. Mulberry heart disease Intoxication with chemical weapon
Acute – weakness, refusal to stand up, pale mucous membranes, anaemia, dyspnoea. The haemoglobin and erythrocyte counts are reduced. The animals are anorectic; haematemesis and melena are observed	Haemorrhages from internal organs Proliferative haemorrhagic enteropathy (acute campylobacteriosis) Dysentery Intoxication with chemical weapon Coccidiosis
Subacute or chronic – stunted growth due to inappetance or complete loss of appetite, weight loss are observed. Occasional discharge of dark faeces. Blood analysis shows signs of microcytic anaemia.	1. 1. Other enteric conditions (for example campylobacteriosis, dysentery). 2. Pneumonia. 3. Residual effect of post weaning coliform enteritis
Subclinical – in most cases, there are no clinical signs	

Usually, the diagnosis is made post mortem during the investigation of stomach mucosa and detection of erosions, ulcerations and other changes of gastric mucosa in the acute form.

According to Pond et al. (20) and Dilov & Vrigazov (21) the treatment of sow dams with iron preparation orally or parenterally, results in increased iron concentrations in milk and thus, preserves piglets from anaemia (22). Another approach for prevention is the injection of piglets with iron preparations + vitamin B_{12}, immediately after birth (19,23). According to Gabrashanski (24) the aetiology of the disease comprises not only iron deficiency but also copper insufficiency, as both elements are synergistic.

Both the acute and chronic cases should be isolated and separated in order to decrease stress caused by bad-tempered or fiery animals. The key point in the treatment is the administration of iron, vitamin K and some other substances, stimulating erythropoiesis. In addition, coarsely ground forages or antibiotic therapy is given if pulmonary oedema or pneumonia is present, (6,13). When a hereditary cause is suspected, the animals should not be bred (25,26).

As prophylactic measures, the ordinary diet of pigs is traditionally supplemented with trace element premixes present as inorganic sulphates, chlorides, carbonates and oxides. Their antagonism with other trace and macroelements results in decreased absorption and reduction of their activity (27). The assimilation of trace elements is often limited by their utilization. During feeding, the inorganic trace elements are combined with nutritive components and are turned into insoluble complexes.

The last trends in modern pig breeding are related to application of organic trace elements for improvement of health and reproductive status and stimulation of productivity in animals (4, 12). Their detection and application in animals help in the prevention and treatment of deficiency diseases in industrial pig breeding. Trace minerals are responsible for protecting cells from the so-called oxidative stress via their inclusion in the antioxidant function of enzymes glutathione peroxidase (Se), superoxide dismutase (Zn, Cu, Mn) (28,29,30). The organic forms however, are utilizable peptides or amino acids that are directly assimilated by the intestinal tract (12). Inorganic forms of selenium are absorbed intact through the intestinal mucosa, the mucous cell membranes and pass into the plasma (31).

The information on the application of organic iron in pigs is relatively few. Lewis et al. (32) reported that the addition of iron under the form of iron methionine has a better biological activity than the iron sulphate. Moreover, the effect of iron is closely related to that of copper. The latter is needed for utilization of iron under the form of ceruloplasmin, increasing its ferooxidase activity (14).

There are various sources of organic copper comprising, amino acid chelated copper (33,34), copper-methionine complex (9) and copper-lysine complex (27). In their studies, Apgar et al. (35) reported that copper concentrations in the liver of fattening pigs were higher after supplementation of organic (copper-lysine) compared to inorganic copper ($CuSO_4$). The application of organic copper under the form of Cu-lysine in the feed of weaned pigs results in enhanced growth and decreased morbidity rates. This is due to the increased mRNA activity of pituitary growth hormone and the immune system (36).

Selenium is an integral part of porcine diet and, combined with vitamin E, is vital for the optimal productivity and animal health (37,38). Organic forms of selenium include selenium amino acid complex, selenomethionine and selenocysteine (39). In monogastric animals, 70-80 % of inorganic selenium intake is not utilized (40). The organic forms, however, are presented for microbial degradation and are utilized far better (60-70 %) than inorganic ones (41).

In their studies, Vendeland et al. (42) showed that selenium-amino acid complex is absorbed in the small intestine via a sodium-dependent system that is related to the metabolic pathway of selenomethionine and selenocysteine. Selenomethionine is a precursor of selenocysteine that is consecutively metabolized to selenide, assisted by the β-liase. Selenides from all selenium sources are extremely important and play a key role in the metabolism of this trace element (10).

The biological effects of organic selenium are various: prevention of oxidative stress, improved function of the thyroid gland, maintenance of the cellular redox-system, maintenance of the immune system, detoxication of heavy metals and some xenobiotics. Some methylated selenium components have an anticarcinogenic effect (11, 43) All these make organic selenium better in the prevention of almost all porcine diseases (28).

Aside their high biological activity and utilization, the excretion of organic trace elements from the organism is very little compared to inorganic ones. This is associated with better environmental protection (7,33).

The application of inorganic trace minerals in the form of either Sel-plex (Alltex, Inc.) or Bioplex (Alltex, Inc.) growth promoters in pig breeding industry is well studied (28,31,44,45). Yet, there are no sufficient data on the application and the effect of organic forms of trace minerals in the prophylaxis of diseases, such as iron-deficiency anaemia and the oesophago-gastric ulcer syndrome. Future studies in this field would add to the prevention programmes aimed at eradicating iron-deficiency anaemia, ulcerative diseases and other trace elementoses. All these would contribute to considerable reduction of losses associated with pig breeding.

REFERENCES

1. Dimitrov,M.,S.Yotov,N.Vassilev,P.Georgiev,I.Ivanova,F.Dimitrov.,Effect of organic selenium Sel-plex upon to productivity of swine dams and newly born piglets. In Proceedings of Scientific Conference with International Participitation,7 years RVMI-V.Tarnovo.121-127,2003.
2. Henman, D .,Organic mineral supplements in pig nutrition: performance and meat quality, reproduction and environmental responses*: In Proceeding of Alltech, 17 Annual Symposium. Ed. T. P Lyons and K. A Jacques,* 297-304,2001. Nottingham, United Kingdom, NUP
3. Mateos, G., G., Cozaro, R., Astilliero, J. R., Perez, M., Trace minerals: What books don't tell you. : *In Redefining mineral nutrition*, ed. J. A Taylor-Picard and L. A Tucker, 21- 62, 2005.
4. Acda. S. P. and B. J. Chae, A review on the application of organic trace minerals in pig nutrition. *Pakistan J. of Nutrition*, 1 (1), 25-30, 2002
5. Ammerman, C. B., Henry, L., Bioavailability of nutrients for animals: amino acids, minerals and vitamins. *California, V S Academic Pres Inc,*1995
6. Kopinski, J., Gastric ulcers in pigs. *Br J Nutr*,Nov; Vol. 62 (3), pp. 751-9, 1998.
7. Revy, P. S., Jonderville, C., Dourmand, J. Y., Nys, N ., Le zinc dans lalimentation du porc: oligoelement essential et risqué potential pour l"enviroument. INRA *Production Animals*, 16: 3-18, 2003
8. Webster, W. R.., Evaluation of oral iron galactan as a method of iron supplementation for intensively housed sucking piglets. Australian veterinary journal. *Aust Vet J.* 54 (7) p. 345-348, 1978.
9. Bunsh, K. J., McCall, J. T., Speer, V. C., Hays, V. W., Cooper supplementation for weanling pigs*, Journal of Animal Science*, 24,995,1965.
10. Berry, M.J., Banu, L., Harney, J.W. and Larsen, P.R., Functional characterization of the eukaryotic SECIS elements which direct selenocysteine insertion at UGA codons. *EMBO J.* 12, 3315–3322. 1993
11. Arthur, J.R., McKenzie, R.C. and Beckett, G.J.. Selenium in the immune system *.Journal of Nutrition* 133, 5, 1457-1459, Suppl. 1. May,2003
12. Ashmead, H. D., Comparative intestinal absorption andsubsequent metabolism of metal amino acid chelates and inorganic metal salts. In: The roles of amino acid chelates in animal nutrition. *Noyes Publishers, New Jersey*, 306-319, 1993
13. Barbosa A. J., Silva J. C., Nogueira A M., Paulino E. Jr. and Miranda C. R., Higher incidence of Gastrospirillum spp. in swine with gastric ulcers of the pars oesophagea. *Vet. Pathol*. 32, 134-139, 1995
14. Queiroz, D. M. M., G. A. Rocha, E. N. Mendes., S. B. Moura, A. M. R. Oliveira and D. Miranda, Association between Helicobacter and gastric ulcer disease of the pars oesophagea in swine. *Gastroenterology* 111:19-27, 1996.
15. Mitov, G., N. Tsanev., Y. Docheva.,R. Avramova and I. Mitov*, Microbiology*, 1998.
16. Queiroz, D. M. M ., G. A.Rocha., E. N. Mendes., A. P. Lage., A. C. T. Carvalho and A. J. A. Barbosa, A spiral organism in the stomach of pigs. *Vet. Microbiol*. 24,199-204, 1990
17. Young K. Choi., Jeong H. Han and Han S. Joo., Identification of novel Helicobacter species in pig stomachs by PCR and partial sequencing. *J. Clin. Micro*., 9, 39, 3311-3315, 2001
18. Park, J. H., Lee B. J. Lee, Y S. and Park, J. H, Association of tightly spiraled bacterial infection and gastritis in pigs. J. Vet. Med. Sci, 62 (7) ,725-9, 2000
19. Petkov, P., Application of Dextrofer-100 and vitamin B12 in newly born piglets. *Veterinary Science (Sofia*), XXI,5, 71-75, 1984.
20. Pond, W. G., Lowerey, J. H. Maner and J. K. Loosi, Parenteral iron administration to sows during gestation or lactation. *J. Anim. Sci*., 20,747, 1961.
21. Dilov, P. and Vrigazov, A., Comparative pharmacokinetic studies after peroral administration of iron dextran preparations in pigs.*Veterinary Science (Sofia)*, . XV, 10, 68-76, 1978.
22. Dilov, P., S. Yotov, N. Vassilev, P. Georgiev, I. Ivanova and F. Dimitrov, Effect of organic selenium "Sel-plex" upon the productivity of swine dams and newly born piglets. *In*: *Proceedings of Scientific Conference with International Participation*, *70 years RVMI-V. Tarnovo,* 121-127, 2003.

23. Dilov, P., Comparative studies on the absorption, antianaemic effect and the effect on growth of FV-82 and Dextrofer-100 in pigs. *Veterinary Science (Sofia*), XXI, 5, 77-85, 1984.
24. Gabrashanski, P and V. Kovalski, Trace elements and trace elementoses in industrial animal husbandry, 1979.
25. Cantet, F., C. Magras., A. Marais., M. Federighi and F. Megraud, Helicobacter species colonizing pig stomach: molecular characterisation and determination of prevalence*. Appl. Environ. Microbiol*, 65,4672-4676, 1999.
26. Hynes, M. J. and M. P. Kelly, Metal ions, Chelates and proteinates. In: Biotechnology in the Feed Industry. (T. P. Lyons and K. A. Jacques, eds.). Nottingham Press, Nottingham, UK., 233-248, 1995. Feed on the safety and efficacy of the product Sel-Plex®2000 as a feed *additive according to Regulation, The EFSA Journal 348, 1-40, 2006.*
27. Coffey, R. D., Cromwel, G. L., Monegue, H. J., Efficacy of cooper lysine complex as a growth promotant for weanling pigs. *Journal of Animal Science, 72, 2880-2886, 1994.*
28. Close, W. H., Organic minerals for pigs: an update. In: Biotechnology in the Feed Industry. (T. P. Lyons and K. A. Jacques, eds.). *Nottingham University Press. Nottingham,UK., 51-60, 1999*
29. Carlson, M. S., Boren, C. A., Wu, C., Huntinth, C. C., Bollinger, D. W., Veun, T. C., Evaluation of various inclusion rates of organic zinc either as polysaccharide or proteinate complex in the growth performance, plasma and excretion of nursery pigs. *Journal of Animal Science*, 82,1359-1366, 2004.
30. Rincher, M. J., Hill, G. M., Link, J. C., Rowntree, J. E.,Effects dietary iron supplementation of growth performance, haematological status and whole-body mineral concentration of nursery pigs. *Journal of Animal Science*, 82,3189-3197, 2004
31. Power , R. and K. Horgan, Biological chemistry and absorption of inorganic and organic trace metals. In: *Biotechnology in the Feed Industry*. (T. P. Lyons and K. A. Jacques, eds.). Nottingham University Press, Nottingham, UK.,277-291, 2000.
32. Lewis, A. J., H. Y. Chen and P. S. Miller, Bioavailability of iron in iron proteinate for weanling pigs*. J. Anim. Sci*.,77,61 , 1999.
33. Lewis, A. J., P. S. Miller and C. K. Wolverton, Bioavailability of iron in iron methionine for pigs. *J. Anim. Sci.,* 73 ,172, 1995.
34. Lee, S.A., Cho, S.C., Chae, B. J., Lee, J. K., Acda, S. P., Evaluation of metal-amino acid chelates and complex of various levels of cooper and zinc in weanling pigs and broiler chicks. *Asian-Australian Journals of Animal Science*, 14,1734-1740, 2001
35. Apgar, G. A., Kornegay, E. T., Linden, M. D.,Notten, R.,Evaluation of cooper sulphate and a cooper lysine complex as a growth promoters for weanling swine*. Journal of Animal Science*, 73,2640-2646, 1995
36. Luo, X. G., Khand, X., Li, Q. H., Fi, J. F., Crenshaw, T. D., Lin, B., Shao, G. Z., Yu, S,. X., Dietary cooper source and level increases pituitary growth hormone mRNA levels in weanling pigs. Journal of Animal Science ,398, 2001
37. Goehring, T. B., I. S. Palmer, O. E. Olson, G. W. Libal, and R. C., Wahlstrom. Effects of seleniferous grains and inorganic Selenium on tissue and blood composition and growth rofer-100 with B12 and Dextrofer-100 – comparative pharmacological and clinico-pharmacological studies*, Veterinary News*, .XXI, 6, 91-100, 1984.
38. Mitsumoto, M., S. Ozawa, T. Mitsuhashi, and K. Koide., Effect of dietary vitamin E supplementation for one week before slaughter on drip, colour and lipid stability during display in Japanese black steer beef. *Meat Sci*. 49,165–174, 1998
39. Maner,J.H. and J. K. Loosi, Parenteral iron administration to sows during gestation or lactation. *J. Anim. Sci*., 20,747, 1961
40. Wolffram, S., Absorption and metabolism of selenium: differences between inorganic and organic sources. In: Biotechnology in the Feed Industry (T.P. Lyons and K.A. Jacques, Eds*.), Proceedings of the 15th Annual Symposium, Nottingham University Press, Nottingham, UK*., 547-566, 1999.
41. Van Ryssen, J.B.J. and Schroeder, G.E.. Effect of heat processing of protein sources on the disappearance of their selenium from mobile bags in the digestive tract of dairy cows*. Anim. Feed Sci. Technol*. 107, 15-27, 2003
42. Vendeland, S.C., Butler, J.A. and Whanger, P.D.,Intestinal absorption of

selenite, selenate, and selenomethionine in the rat. *J. Nutr. Biochem*. 3, 359-365, 1992.
43. Kohrle, J., Selenium and the control of thyroid hormone metabolism. *Thyroid* 15(8), 841-853, 2005
44. Kim, Y.Y. and Mahan, D.C., Comparative effects of high dietary levels of organic and inorganic selenium on selenium toxicity of growing-finishing pigs. *J. Anim. Sci*. 79, 942-948. 2001
45. Robert Roosendaal, Jan H. Vos., Thijs Roumen, Rene van Vugt, Giovanni Cattoli, Aldert Bart, Henricus L. B. M. Klaasen., Ernst J. Kuipers, Christina M. J. E. Vandenbroucke-Grauls, Johannes G. Kusters, *J. Clin. Microb*., 7,38,2661-2664, 2000.