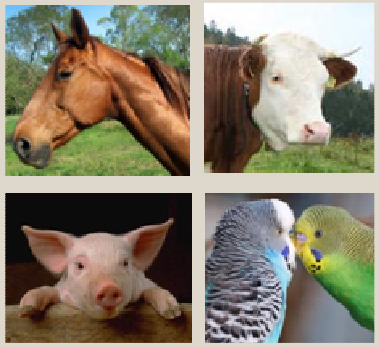
Stiftung Tierärztliche Hochschule Hannover
University of Veterinary Medicine Hannover, Foundation

Trace Elements in Animal Nutrition – their use from veterinary point of view



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Arrangement

- **intake of/supply with trace elements**
- **primary reason: avoiding deficiencies**
  - ➔ **basic supply for health and performance**
- **further reasons: intended welcome „side effects“**
  - ➔ **extra supply (above requirements)**
- **examples for use of higher trace element levels**
  - ➔ **above minimum requirement/conventional levels**
- **don’t ignore/forget: susceptibility for**
  - ➔ **intoxication/poisoning by trace elements**
- **summary/conclusions**

Intake of/supply with trace elements

basic contents in the different ingredients/feed materials

- ➔ marked variation due to diverse influences (soil, fertilizer, …)
- ➔ interactive effects between distinct elements (Fe → Cu; Ca → Zn)
  - reduced utilization rate

specific supplementation with trace elements (diverse supplementary feeds in diverse forms)

- ➔ mineral supplements (including boli, needles …)
- ➔ as a part in complete diets/rations or applicated as „top dressing“ a. s. o.
  - challenges: palatability/demixing processes

Intake of/supply with trace elements

Unintended „supplementation“ with trace elements

- use of phosphates (containing fluor)
- drinking water (contamination by iron, manganese, copper)
- housing techniques/technical equipment (source of zinc)
- algae powder (excessive iodine content)

Bypass of restrictions from feed legislation

- use of zinc oxide as carrier for drugs
  (avoiding E. coli diseases in reared piglets;
  side effects are similar to antibiotics)
- litter material (enriched by several trace elements
  like copper sulfate, zinc oxide a. s. o.)

Primary reason for use of trace elements in animal feeding: avoiding any deficiency/marginal supply (→ health, performance!)

- **Iron** : Anemia, especially in new born animals (piglets!)
  in general: low Fe levels in milk and milk byproducts
- **Copper**: Anemia; widespread deficiency due to low Cu levels in feeds (depending on type of soil), especially in „alternative farming“ → sheep, goats, cattle; maybe secondary deficiency due to counteracting effects of molybdenum, sulfur, iron, …
- **Zinc** : typical deficiency = parakeratosis (widespread in „alternative farming“); individual cases due to excessive Calcium contents in the diet
- **Selenium**: deficiency with marked effects regarding integrity of muscles, antioxidative capacity; retentio secundarum, white muscle disease; susceptibility regarding oxidative stress

Primary reason for use of trace elements in animal feeding: avoiding any deficiency/marginal supply (→ health, performance!)

- **Iodine**: known as endemic goiter, diverse effects due to envolvement of thyroidea metabolism (hypothyreosis), interactive effects of glucosinolates from rape seed
- **Cobalt:** Vitamin B_{12} (cobalamin) deficiency in cattle in regions with very low Co levels in the soil; resulting in anemia, poor development! question: low availability? reduced cobalamin production by ruminal microflora in cattle fed high concentrate diets
- **Manganese**: its deficiency repeatedly discussed as disturbances/ diseases of skeleton, poor development, reduced fertility

Supplementation of trace elements above requirements

Dietary zinc supply:

minimum requirement	**= ~ 30**	**mg/kg dm**
recommended levels	**= 50 - 70**	**mg/kg dm**
upper limit (EU feed legislation)	**= 170**	**mg/kg dm**
(150 mg/kg diet, as fed)		

Reasons for higher dietary levels of zinc (i. e. above requirements):

- **horses:** improving hoof horn quality
- **dairy cows:** improving udder health, reducing cell counts in milk
- **pigs:** treatment of E. coli diseases (diarrhea, edema disease)
- **sheep/goats:** improving health of claws
- **poultry:** improving health of foot pad (FPD↓)
- **dogs/cats:** skin protective effects, improving healing

Special effects of supplementation of dairy cows‘ rations by organic trace elements compounds → reducing counts of somatic cells in the milk? (Kinal et al. 2005)

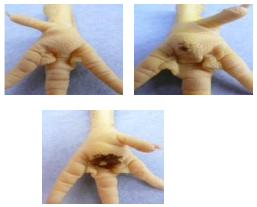
groups of cows supplementation (Cu/Zn/Mn)	I	II	III
inorganic sources	+++	++	+
organic sources	- - -	+	++
total content (Cu/Zn/Mn)	⟵	11.8/59.4/52.4	⟶
milk production (kg/305 d)	6466	6520	6816
milk fat (")	250	258	267
milk protein (")	211	211	220
somatic cells (1x10³/ml)	409^{A}	306^{B}	270^{B}
- summer time	337	308	284
- winter time	435^{A}	304^{B}	260^{B}

Special effects of trace element supplementation from organic sources to improve claws health in sows (field study in 6 herds; Rapp et al. 2009)

period	1	2
feeding (Zn, Mn, Cu)	inorganic sources (control diet)	organic sources (experimental diet)
Scoring (claws‘ health) - feet/sows (n/n)	before change 700 / 350	after change 700 / 350
proportion of healthy claws (%)	9.4	43.5
without claw splits at the margin to sole/pad (%)	56.4	88.7
without alterations in/of the white line (%)	60.4	81.7
without vertical splits in the claws‘ wall (%)	82.2	92.9
without abnormous elongation of tiptoe (%)	93.7	95.5

Zn concentrations in organs and tissues of reared piglets fed diets with different supplementations (zinc contents measured after 35 days of treatment; WANG et al. 2011)

	Zinc-Supplementation			
parameter	**without**	**zinc glycine chelate**		**zinc oxide**
basal zinc content	**24.9**			
zinc supplementation (mg/kg)	**-**	**+ 50**	**+ 100**	**+ 3000**
zinc content				
- serum (µg/dl)	**80.3**	**90.3**	**90.5**	**123**
- liver (mg/kg)	**194**	**204**	**212**	**291**
- spleen (mg/kg)	**174**	**166**	**167**	**169**
- muscles (mg/kg)	**115**	**112**	**102**	**117**



Side effects of trace element supplementation in poultry fattening → adding zinc to improve foot pad health

animals	diet composition (Zn, mg/kg)		foot pad scores (scores from Mayne et al. 2007)		authors
young turkeys	control diet	experimental diet	control diet	experimental diet	
- dry litter	45.8	145	2.0^{a} ± 0.91	0.93^{b} ± 0.45	Youssef et al. 2009
- wet litter[1)]	45.8	145	5.79^{a} ± 0.27	5.43^{a} ± 0.45	
fattening turkeys	(ZnO)	(Zn-Met)			
- rearing (< day 39)	110	158	1.7^{a} ± 0.74	1.52^{b} ± 0.7	Abd El-Wahab et al. 2012 (unpublished)
- fattening (> day 39)	111	180	5.63^{a} ± 1.2	5.06^{b} ± 1.2	
fattening chicken[2)]	(ZnO)	(Zn-Met)			
- trial 1	181	202	4.1^{a} ± 1.2	3.6^{a} ± 1.7	Abd El-Wahab et al. 2012
- trial 2	180	178	4.2^{a} ± 1.0	3.7^{b} ± 1.0	

1) adding water to achieve 73 % moisture in the litter, 8 h exposed daily;

2) in both trials: „critical moisture“ within the litter of all groups (by adding water, 35 %)

Special side effects of trace element supplementation for dairy cows
→ adding Selenium to improve udder health/somatic cell counts in milk

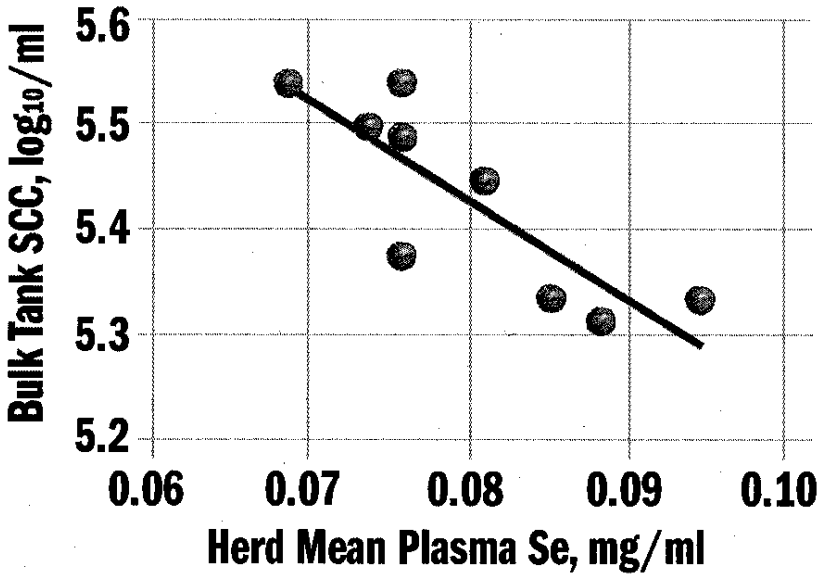


Figure 4: Relationship between herd mean Se concentration in plasma and bulk tank somatic cell counts (Weiss *et al.* 1990). Used by the permission of the *Journal of Dairy Science* 73, 381.

→ similar positive effects:

- vit. E and Se: reduced prevalence of mastitis (activity of polymorph granulocytes↑, protection of membranes)
- zinc or zinc-methionine-supplementation (improved regeneration/activity of keratocytes; somatic cell counts ↓)

Review of D. O'ROURKE 2009

A field study regarding the copper content in rations of dairy cows during dry period

(DUSEL et al. 2007)

Investigations on 40 dairy farms in south-west of Germany

av. Cu content	n	%
< 10 mg/kg dm	24	60
10 - 20 mg/kg dm	12	30
> 20 mg/kg dm[1)]	4	10

[1)] **never 40 mg/kg dm were found**

⇨ **there was no correlation regarding copper supply and performance (milk/fertility)**

Special side effects of trace element supplementation
→ increasing dietary copper supply in fattening turkeys

(GRUIS 2004)

Intended: Avoiding losses due to aortic rupture in turkeys

Improving „gastrointestinal stability“ (antimicrobial effects)

→ similar effects as observed in reared piglets

Hypothesis: Aortic ruptures in turkeys are caused by low Cu supply (?)

Investigations on chemical composition of aortic tissue:

	Cu content (mg/kg dm)
healthy animals, common dietary Cu levels (n = 60)	4.09 – 4.91
healthy animals, reduced dietary Cu levels (n = 40)	3.52 – 5.63
healthy animals, reduced dietary Cu levels	
- only inorganic sources of copper (n = 12)	3.65 ± 0.70[a]
- only organic sources of copper (n = 12)	5.63 ± 1.62[b]
turkeys, necropsy findings	
- aortic rupture (main finding; n = 15)	4.56 ± 0.47
- without aortic rupture (n = 25)	4.77 ± 0.68

⟹ **the hypothesis was rejected, finally!**

Estimating the requirements regarding trace elements
What were/are the parameters indicating sufficient supply?
→ examples: Scores of feather coat/foot pad health?

Role of feathers regarding retention of trace elements estimated in growing canaries (from hatching to adult stage)

parameter	accretion in the total feather mass (%)[1)]
dry matter	~ 18.7
Calcium	1.15
Zinc	34.6
Copper	36.8

[1)] of total accreted amounts in the whole body

Kamphues et al. 1996

Is there a need for higher trace element supplementation in feeding laying hens? Effects on performance, product composition as well as on the quality of the feather coat (RICHTER et al. 2006)

parameter	groups (dietary treatment)			
	A	B	C	D
basic levels (mg/kg dm)	36 Zn / 50 Mn / 6 Cu			
use of organic trace elements	-	+ (Zn)	+ (Mn)	+ (Cu)
supplemented levels	40/40/4	40	40	4
final dietary levels (mg/kg dm)	91/104/12	90/108/12	89/109/12	89/104/12
egg production (%)	88.7	86.8	90.7	84.7
FCR (kg/kg)	2.07	2.15	2.06	2.24
yolk composition				
- Zn (mg/kg)	76.5	78.2	78.3	74.3
- Mn (mg/kg)	2.32	2.38	2.34	2.38
liver composition (mg/kg dm)	14.2	12.9	13.1	15.2
Scores for feather coat?[1)]	2.4	2.0	1.7	2.0

[1)] 1 = best score; 4 = feather losses in highest form (worse value)

Is there a need to check critically the trace element supply of animals, even at special conditions in housing and feeding?

→ different case reports in veterinary literature!

- cattle, sheep, horses: at pasture, i. e. in grazing animals
- dry cows, heifers: before inclusion in the group of fresh lactating cows
- sheep, goats: low input production systems, resign on mineral supplements
- pigs: in alternative farming (high Ca levels, without mineral supplements, resulting in secondary zinc deficiency, parakeratosis)
- laying hens: at highest dietary calcium levels low trace element supply?
- fattening poultry: high levels of macro minerals, low trace element levels?
- dogs, cats: trend for home made diets; feeding concepts like B.A.R.F.

Trace element supply – influenced by several mechanisms related to animals‘ health

- **scours at start of the grazing season (laxative effects of grass constituents like NO_3, sulfates)**
- **gastrointestinal infections by different organisms (impairing utilization of trace elements/absorption/losses↑)**
- **periods of increased requirements – besides normal performance (for example: moulting → nutrients for regrowth of feather losses)**
- **housing conditions that are challenging like wet floor/litter (for example: zinc supplementation for hoof/claw/foot pad health)**
- **higher intake of counteracting constituents in feed/drinking water**
  - **grass silages with excessive iron contents → copper utilization**
  - **higher levels of S, Mo → copper utilization**
  - **high proportions of rape seed products → Iodine**

Iron contents in drinking water for animals – counteracting the utilization of manganese?

(Fürll et al. 2004)

Case reports regarding Manganese deficiency in cattle

- indicated by clinical signs (skeleton, joints)
- low levels of Manganese in the hair
- low levels of Manganese in the serum

- due to high levels of iron in the drinking water
  - variation of 1.24 – 16.9 mg Fe/l ?

- due to missing data on the total Mn intake difficult to decide whether those findings were caused by long lasting oversupply with iron!

Aspects and effects that should not be ignored when trace element supply is on debate:

Iodine: its dietary levels influence the iodine content in food, i. e. there might be secundary effects on human health

Iron: inspite of „normal“ levels in the diet there are species that are prone to iron poisoning (like beos, tukans, …)

Copper: marked species differences regarding susceptibility for copper intoxication (especially in sheep, but not in goats)

Zinc: Main reason for excessive dietary Zn levels is edema disease in reared piglets (zinc oxide instead of antibiotics?)

Some ingredients contain excessive levels of trace elements – careful use is recommended: algae powder as an example

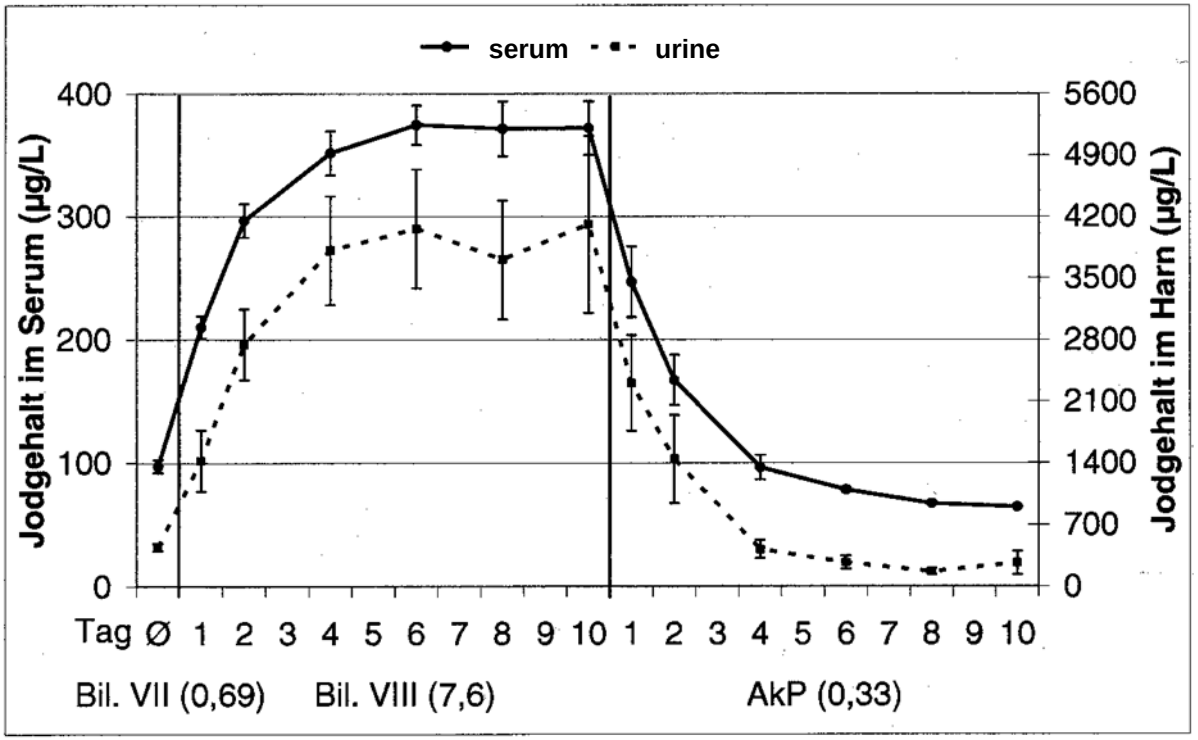


Figure: Development of Iodine levels in serum and urine of bulls fed algae powder[1)] as „natural“ iodine source

Witzmann 2011

[1)] Iodine content in the product: 916 mg/kg dm

Summary / conclusions regarding trace element supply from veterinary point of view

- **Inspite of a general supply that meets the requirements, there are – even today - specific conditions resulting in an insufficient supply**
- **Trace element supply exceeding „normal“ requirements may result in markedly positive effects (benefits) for animals’ health**
- **There are differences regarding the effects within animals/products that are related to the source (organic/inorganic sources) of trace elements**
- **Trace elements have to be dosed carefully, since a lot of case reports indicate the toxic capacity of some elements - especially of Selenium, Iodine and Copper!**