EFFECT OF REPLACING INORGANIC ZINC WITH A LOWER LEVEL OF ORGANIC ZINC (ZINC PROPIONATE) ON PERFORMANCE, BIOCHEMICAL CONSTITUENTS AND MINERAL STATUS IN BUFFALO CALVES

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Introduction

Major contributor of milk (55% of total)

India -first in buffalo population - 56.3% of world population

Buffalo productivity- compromised- great economic loss to farmers

Issues:

- Low growth rates
- High calf mortality
- Poor reproductive efficiency

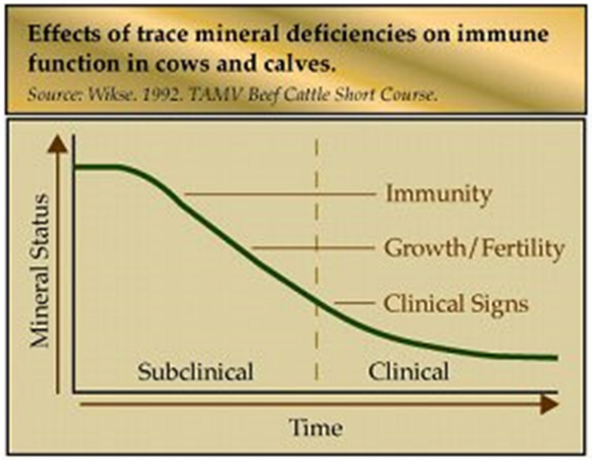
Causes:

- Nutritional
- Managemental

Nutrition

- Min. & Vit. deficiency affect the appetite, growth, immunity & reproduction
- Trace mineral deficiency (Zn, Se, Mn & Cu) - ovarian inactivity, decreased immune response & growth
- Zn, Cu & Se integral component of antioxidant system in body

Figure 1

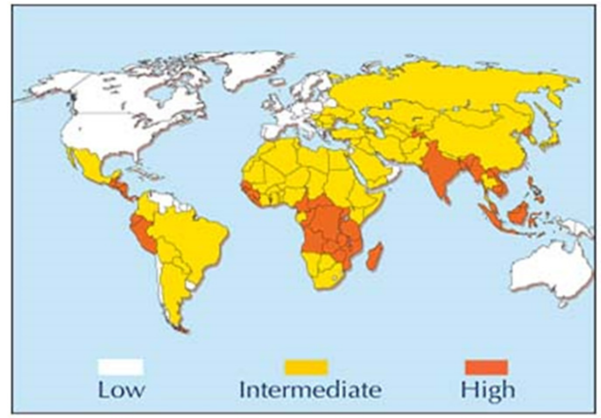


As mineral status falls over time, immunity is affected first, followed by growth and fertility problems, and, finally, clinical signs of trace mineral deficiency.

- Trace mineral deficiency are mostly submarginal to marginal

Zinc- an important mineral

- Zn is very critical mineral
- Need to optimize requirements of Zn for proper growth, immune response and reproduction



- Half of soils in world are Zn deficient (Nielson,2004)
- Same is reflected in feeds & fodder & hence animals

Concentration of Zn in livestock feeds & fodders is critically deficient in AP (Nagalakshmi et al., 2007 & 2009) and most parts of the country (Gowda et al., 2009)

Form of mineral supplementation

Inorganic form (sulphates, oxides, carbonates, chlorides)

Organic form (chelated minerals)

Inorganic minerals

Relatively cheaper

Readily available

Form the basis of NRC mineral requirement

Problems with inorganic minerals

- Low bioavailability 4-22%
- Variable availability in market
- Presence of contaminants (Heavy metals: ZnO & CuSO4 are from residues of steel industry (have high levels of Cd, F and Pb)
- Purity of inorganic salts in market
- Various processing conditions used in manufacturing likely reduce biological availability

These uncertainities: inorganic minerals supplemented 2-10 times NRC requirement

Excess supplementation of Inorganic minerals

Damage in nutrient absorption

Reduces mineral bioavailability

Causes environmental pollution (soil & ground water)

Led to focus on chelated/organic minerals

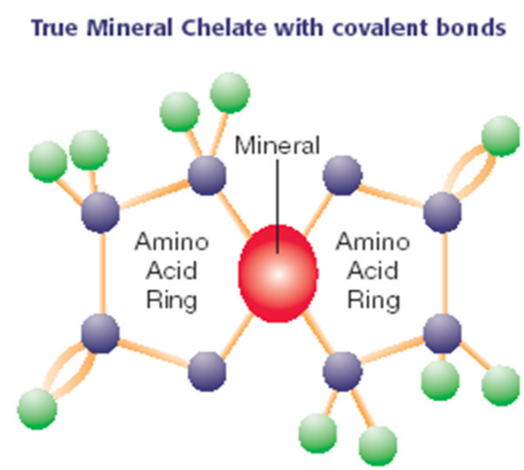
Organic/chelated minerals

Complexing inorganic element with organic compound (amino acid(s), peptides, proteins, polysaccharides, organic acids, vitamins)

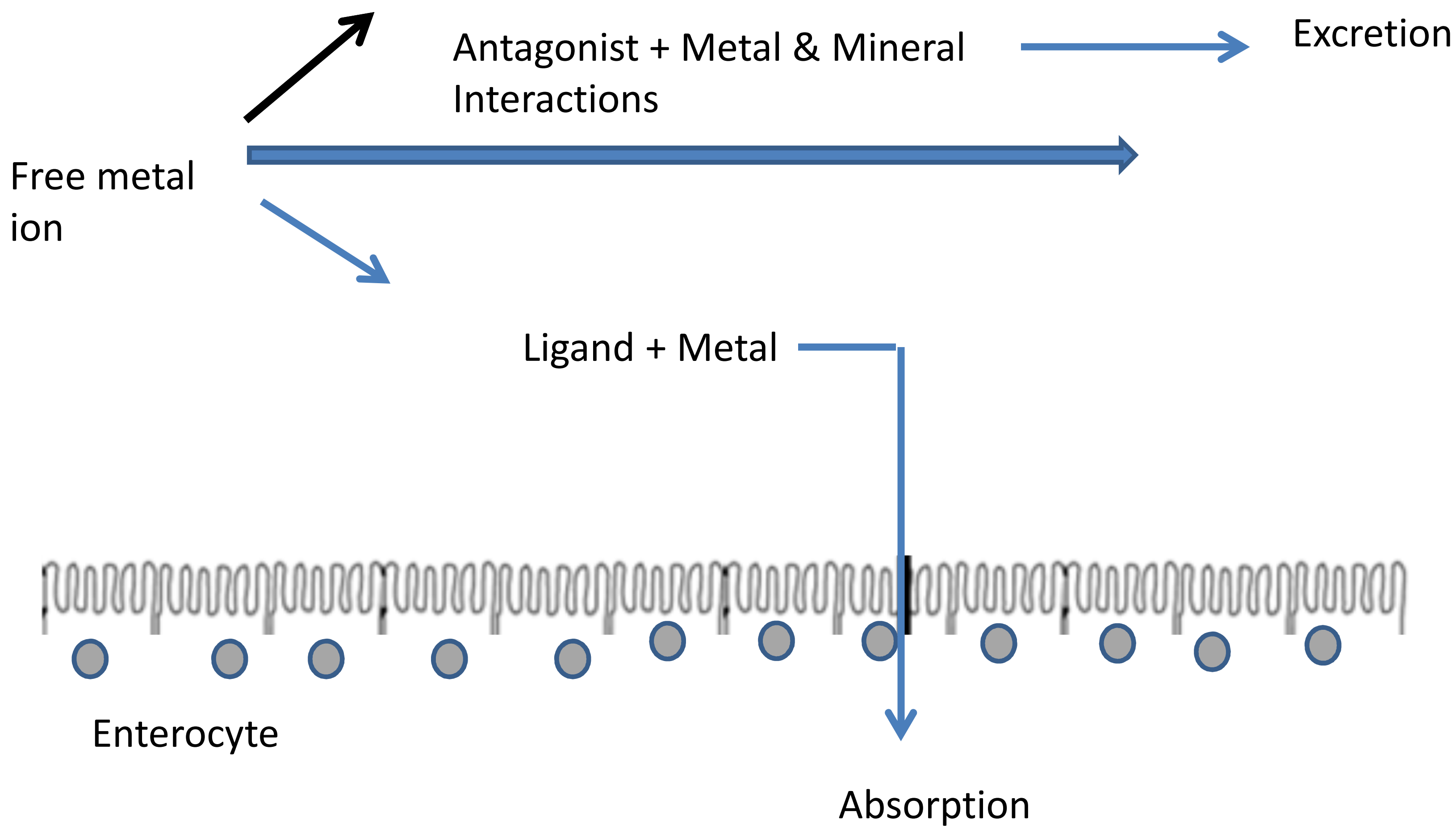
Chelation- complex formed between an organic molecule and a metallic ion. Metal held with in the organic molecule as if by a "claw".

Chelate -Greek word - 'Claw'

Naturally occurring chelates : Chlorophyll, Cytochrome, Haemoglobin, Vitamin B_{12}



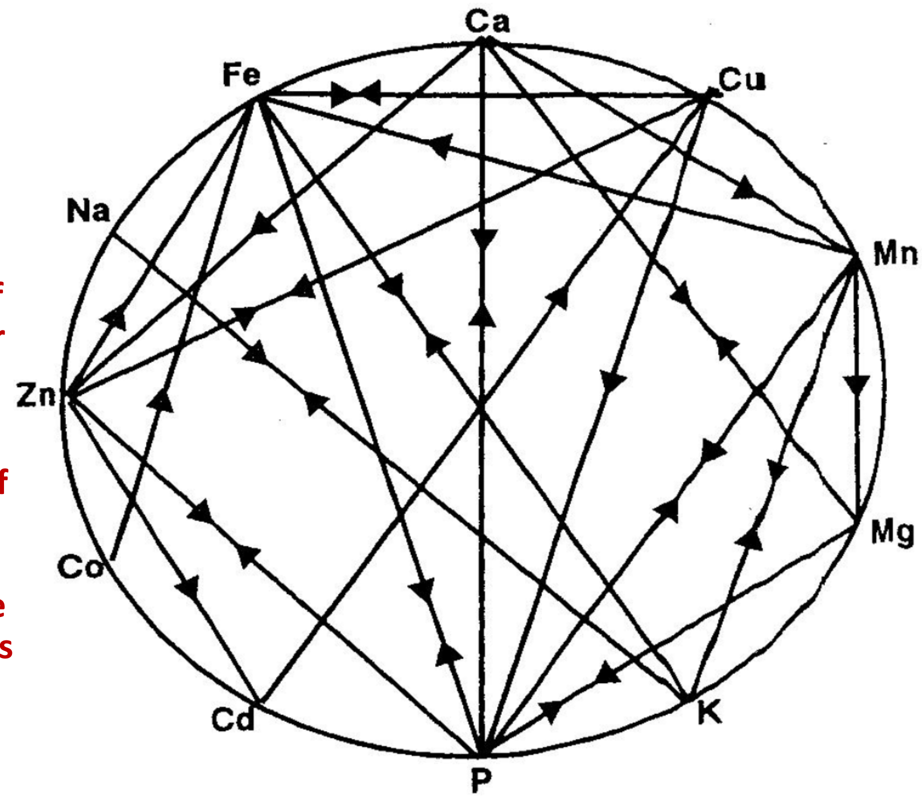
Mineral absorption in gut



Mutual antagonism

Major factor in reducing mineral absorption & metabolic rates

- Mn & Fe compete for similar absorption mech.
- Mo- impairs absorption of Cu & vice-versa
- Ca- impairs absorption of Cu, Zn
- Competition of same or similar carrier protein
- Replacement of 1 metal by another in metalloenzyme molecule affects efficiency



Advantages of organic minerals

- **Reduction of antagonism, interferences and competition among minerals.**
- **Improve the bioavailability of minerals (1.2-1.85 times higher than inorganic)**
- **Counteract antinutritional factors that affect mineral utilization**
- **Hence improvement in performance, health & reproduction**
- **Protect environment by reducing metal pollution.**

Types →

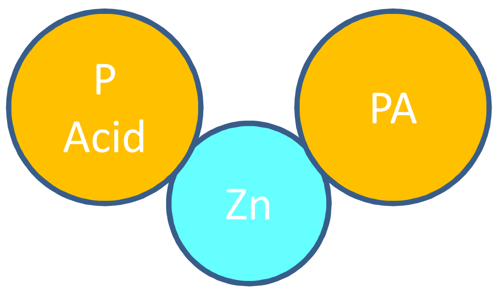
1. **Metal (specific amino acid) Complex**
2. **Metal Amino acid Complex**
3. **Metal Amino acid Chelate**
4. **Mineral proteinates**
5. **Mineral polysaccharide complex**
6. **Metal organic acids**

Metal organic acids

Metal propionate

Resulting of combining soluble metals with soluble organic acids like propionates

Zn-propionate



Organic minerals are costly compared to inorganic source

1. To supplement at lower concentration than the standard recommendation

2. To replace a portion of inorganic minerals with organic source

Experimental Design

Animals	**12 buffalo calves (9-15mon. age)**
Dietary treatments	**2 (6 animals in each group)**
Diets (sorghum stover based complete diet)	**1. 80ppm Zn supplementation- $ZnSO_4$** **2. 60ppm Zn supplementation- Zn-prop**
Duration	**120 days**
Design	**CRD**

Composition of basal diet

Ingredient	Composition (%)
Sorghum stover	40.0
Maize	40.0
Soyabean meal	6.5
Molasses	8.5
Red gram chunni	1.41
Urea	1.0
Limestone powder	0.8946
Mono-calcium phosphate	1.3503
Salt	0.2086
Trace mineral and vitamin premix*	0.2079
Zinc (ppm)	29.72

*Trace mineral premix provided (mg/kg diet): Iron, 41; manganese, 21; copper, 10; cobalt, 0.1; Iodine, 0.27; selenium, 0.3. Vitamin A, D and E were provided to supply 2927 IU; 1097 IU and 39 IU per kg diet, respectively.

Zinc propionate supplementation on fortnightly body weight in buffalo calves

Attribute	ZnSO4-80	Zn-prop-60	SEM	P value
Start	195.6	191.0	68.00	0.912
First	202.1	195.4	66.78	0.870
Second	201.6	195.8	65.51	0.887
Third	208.0	204.1	67.83	0.925
Fourth	210.2	204.8	62.46	0.888
Fifth	225.6	216.4	66.02	0.821
Sixth	234.7	226.5	68.26	0.847
Seventh	245.8	238.2	70.73	0.861
Eighth	257.4	256.0	70.99	0.975
Weight gain (kg)	61.75	65.00	10.649	0.621

Zinc propionate supplementation on performance in buffalo calves

Attribute	$ZnSO_4$-80	Zn-prop-60	SEM	P value
Start BW (kg)	195.6	191.0	68.00	0.912
End BW (kg)	257.4	256.0	70.99	0.975
ADG (g)	514.6	541.7	88.742	0.621
FCR	9.83	9.75	1.859	0.943
DMI/100kg BW (kg)	2.42	2.53	0.562	0.758

Zinc propionate supplementation on serum biochemical constituents in buffalo calves

Attribute	$ZnSO_4$-80	Zn-prop-60	SEM	P value
ALP (U/L)	11.85a	25.23b	9.040	0.003
Total protein (g/dl)	5.81a	7.97b	2.077	0.069
Globulin (g/dl)	2.43	4.35	2.115	0.120
Albumin (g/dl)	3.38	3.61	0.601	0.521
Creatinine (g/dl)	2.53	2.70	0.268	0.296
Glucose (mg/dl)	103.8b	89.01a	13.369	0.049

Zinc propionate supplementation on serum mineral status of buffalo calves

Mineral	$ZnSO_4$-80	Zn-prop-60	SEM	P value
Zinc (ppm)	2.44	2.50	0.424	0.879
Copper (ppm)	0.903	0.854	0.210	0.706
Manganese (ppm)	0.201	0.214	0.0415	0.590
Iron (ppm)	2.67	2.72	0.326	0.797

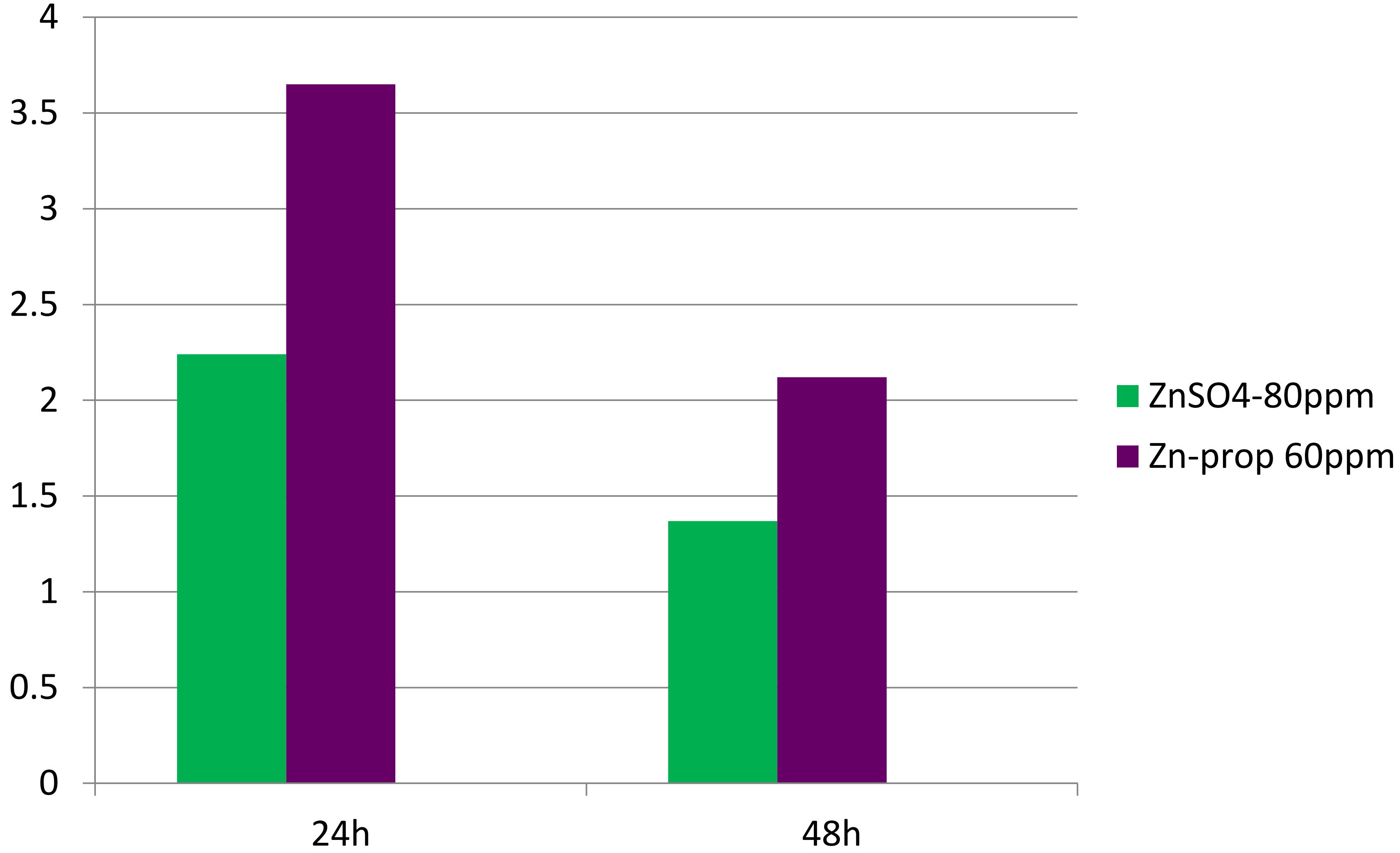
Zinc propionate supplementation on lipid peroxidation and antioxidant enzyme activity in buffalo calves

Attribute	$ZnSO_4$-80	Zn-prop-60	SEM	P value
Lipid peroxidation (µmol MDA/mg Hb)	2.05	1.98	0.170	0.481
Glutathione peroxidase (µmole NADPH oxidized/g Hb/min)	7.64a	20.92b	10.796	0.024
Glutathione reductase (µmol/mg Hb)	6.53	6.91	1.869	0.742
RBC Catalase (mmol/mg Hb)	4.81	5.01	1.686	0.848
SOD (IU/mg protein)	0.118	0.145	0.039	0.233

Zinc propionate supplementation on humoral immune response in buffalo calves

Days PS	$ZnSO_4$-80	Zn-prop-60	SEM	P value
B. abortus (log 2 titres)				
7	7.40a	9.40b	1.549	0.016
14	6.40	7.60	1.304	0.114
21	5.80	6.20	1.282	0.613
28	4.40	4.49	1.062	0.999
Chicken RBC (log2 titres)				
7	6.20	5.80	1.132	0.566
14	5.00	4.60	0.836	0.433
21	3.60	3.62	0.467	0.999
28	2.40	2.60	0.641	0.613

Zinc propionate supplementation on cell mediated immune response (increase in skin fold thickness, mm) in buffalo calves



Conclusion

Organic Zn supplementation in diets as 75% of inorganic Zn had no effect on performance and mineral status in buffalo calves

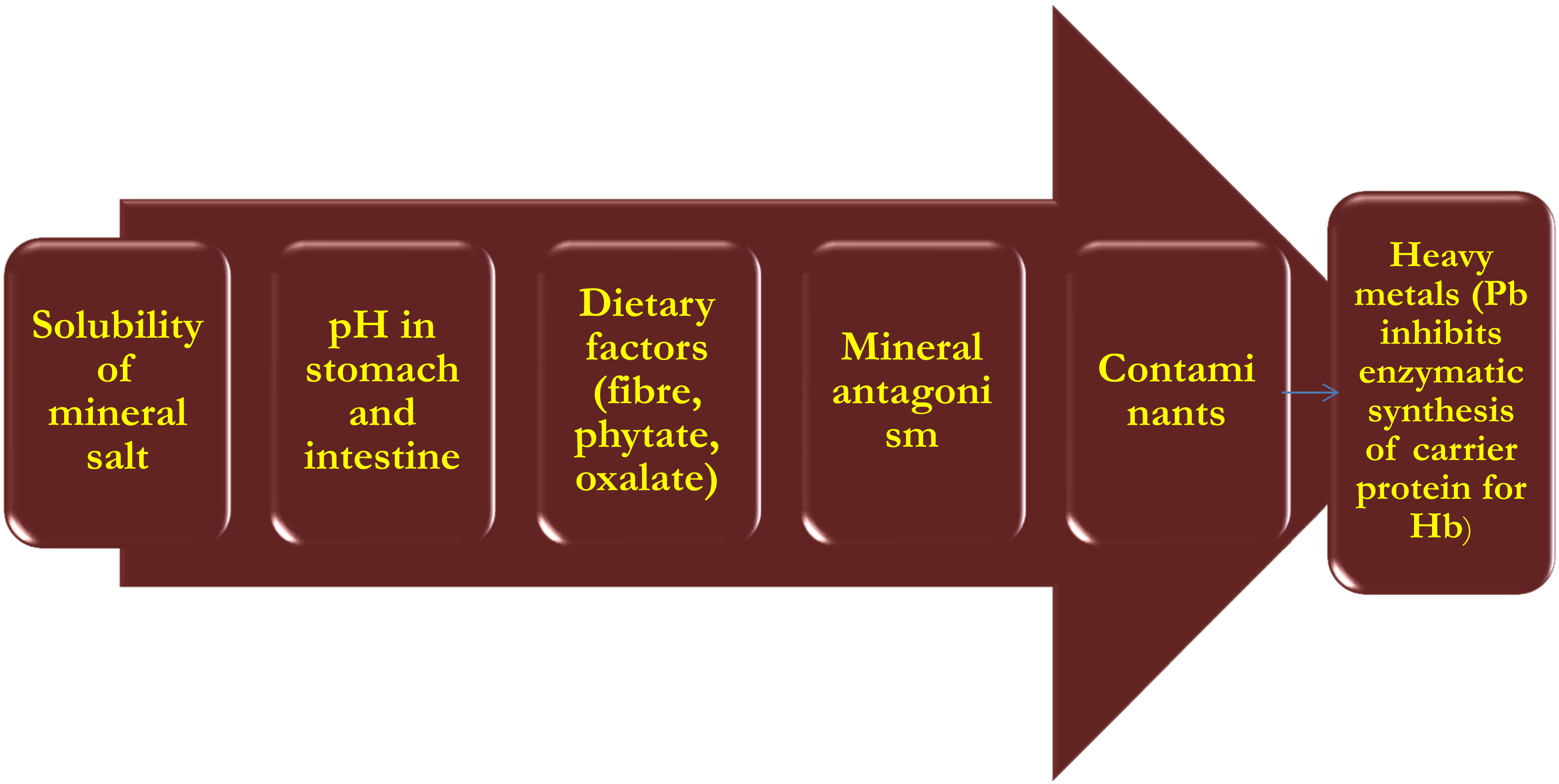
Supplementation of 60ppm Zn propionate resulted in higher immune response in calves than 80ppm Zn from Zn sulphate.


Thank you

Absorption of minerals

- Small intestine- mostly duodenum
- Requires prior solubilisation of mineral (stomach/abomasum)
- Ionized mineral are further transported thru cell membrane using protein carriers
- Absorption depends on capacity of element to bind to transport protein
- Bound minerals are then transported into cell cytoplasm thru active or passive diffusion

Factors affecting mineral absorption



Organic minerals: Bioavailability

More bioavailable: 1.2-1.85 times higher than inorganic

Reasons

Ring structure protects the mineral from unwanted chemical reactions in GIT
Chelates easily pass intact through the intestinal wall into blood stream
Passive absorption increased by reducing interactions between mineral & other nutrients and by increasing water and lipid solubility of minerals
Mineral is delivered in form similar to that found in body
Each mineral in chelate facilitates the absorption of other minerals in chelate
Chelates carry negative charge so absorbed & metabolized more efficiently
Chelation increases solubility & movement thru cell membranes
Chelation increases stability at low pH
Chelates are absorbed by the amino acid transport system