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FROM PREMIX TO GUT, INTERACTIONS WITH MINERALS CAN BE COSTLY!

“Depending on the markets, the industry is using vitamin premix separately from mineral premix, while others are able to mix all micro-ingredients together. The art of premix consists in mixing all these ingredients homogeneously and to limit the interactions, selecting carefully the raw materials. Interactions between ingredients start at this step but can continue once the premix enter the feed and later when feed is ingested, in the proximal part of the digestive tract, affecting the digestion and metabolism of these ingredients.”

Why waiting for the next crisis on vitamins & ingredients costs to start evaluating the interactions occurring between additives and to revise your trace elements selection? From premix to digestive tract, sensitive and expensive ingredients are systematically entering in contact. It is not acceptable to affect their value or their nutritive profile because a close ingredient is less stable or too reactive. This is very true for vitamins and minerals, most of the time supplied together, but not only! Let’s review the different additives that can be affected by a non-proper micromineral selection and why they are impacted.

INTERACTIONS START FROM THE PREMIX

It is common in our industry to mix vitamins,

minerals and other small inclusion ingredients into a premix, before incorporating it into the complete feed. The advantage of using premixture of feed additives are multiple:

- A premix may contain up to 30 ingredients with some of them to be included at a final rate around 1 gram per ton of feed. Thus, premix is key for accuracy of dosages.
- Due to the very small quantities involved for some ingredients, some regional feed mills may need small amounts of additives, requiring a premix.

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FAT-SOLUBLE VITAMINS FIRST IN THE RADAR

Vitamins are among the most sensitive ingredients included in premix and are usually expensive.

Vitamin's sensitivity to oxidation in premix varies. When it is accepted that both fat- and water-soluble vitamins can be affected, the fat-soluble vitamins (mainly A and E) are the touchiest for the industry. These vitamins are able to dissolve in fatty tissues, and to be absorbed by fat globules. This new compound will be absorbed through the epithelial barrier and later be distributed to the host body.

In addition, vitamins suffer from very strong price fluctuation. Vitamin A is a very good example to illustrate. Its price reached more than 400€/ kg in 2018 while it was less than 30€/kg some months before and is today around 75€/kg (November 2021).

MINERALS ARE OXIDATION CATALYSTS

Several chemical changes induced by premix process, storage or handling can induce ingredients degradation. Of course, presence of oxygen, UV or variable temperatures are accelerating the mechanisms but most importantly the presence of minerals is a real challenge. Indeed, due to their hygroscopicity, some forms of minerals will already release ions in the premix, that will act as oxidizing/reducing agents. This is why minerals are known to be catalyst for the oxidation steps.

Oxidation process of premix ingredients usually follows three main steps:

1. The initiation step consisting in the initial free radical formation (by cleavage of the weak bonds)
2. The propagation step: The generated free radi-

icals will react with stable compounds (fixing to their oxygen-containing functional groups) and generate new free radicals that are also reactive (chain reaction). These new free radicals go on to generate more free radicals, and so on.

3. The termination step: Free radicals can associate to form aldehydes or ketons, very volatile compounds with low molecular weight and responsible for the origin of the bad smell (rancidity) of the oxidised products.

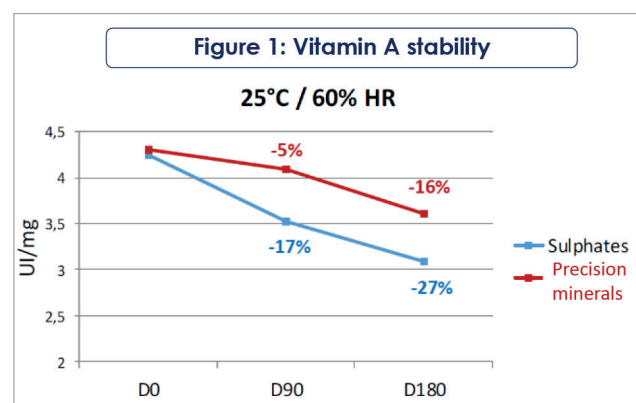
Trace minerals have different redox potential (ability to acquire or lose electrons) and can be ranked according to their reactivity. Divalent copper (comprised in sulfates or certain chelates) is the most susceptible to reaction being a strong oxidizing agent.

USE OF STABLE PRECISION MINERAL

It is commonly accepted that degradation of vitamins will anyway occur (about 30% losses after 6 months on average for Vitamin A). Nevertheless, it is possible to decelerate the kinetics of the losses.

Vitamin A is known as a good marker to study this phenomenon as its stability is well studied and reproducible.

A test at SAFE France (Scientific Animal Food Engineering) studied the vitamin A degradation in a standard piglets' premix for piglets, formulated for an inclusion of 0.5% in complete feed. The test compared the difference between sulfates sources (Cu and Zn) and precision minerals (CoRouge®, Cu and Hizox®, Zn).



Considering an average premix shelf life of 4 to 6 months, the study revealed that precision minerals reduced the pace of vitamin A degradation. How is it possible?

Importance of the mineral nature: Tested precision minerals namely Hizox® and CoRouge® are by their chemical nature less reactive and thus are less interacting with premix compounds such as vitamins. Any quickly solubilized micromineral compounds (sulfates, but also most of chelates) are prone to faster interact with the vitamins.

Tips: Non soluble minerals at neutral pH & highly concentrated minerals sources present less interactions with vitamins

Importance of the mineral concentration & galenic: The mineral concentration itself and particle size characteristics are also responsible for the risk of interactions. Indeed, a highly concentrated source of trace element requires to put less product in premix and thus reduce the chance of contact with vitamins.

LATER IN THE GUT:

SECURE PIGMENTS' EFFICIENCY

The use of carotenoids (mainly xanthophyll incl. zeaxanthin, canthaxanthin) is well established especially in poultry industry for carcass coloration and yolk intense coloration, both considered as consumers criteria for food quality. Pigments' use and efficiency is conditioned by an adequate ingested amount, their absorption and by a proper vitamins supply, so these pigments are not used by the host as precursor of vitamins once in the body.

First, carotenoids are fragile compounds that can be affected by humidity, temperature, acidity - alkalinity, oxidizing & reducing agents (such as trace minerals). They are highly prone to isomerization & oxidation. These degradations are occurring directly during man-

ufacturing, handling and storage of the premix. But once ingested, these compounds are still sensitive.

During recent Animine e-cademy (November 2021), Dr. T. Bohn (Luxembourg Institute for Health) explained the following: "During digestive process, the carotenoids require a micellization step, for their proper absorption, and characterizing their bioaccessibility. This step constitutes most of the time a bottleneck for absorption and thus for bioavailability."

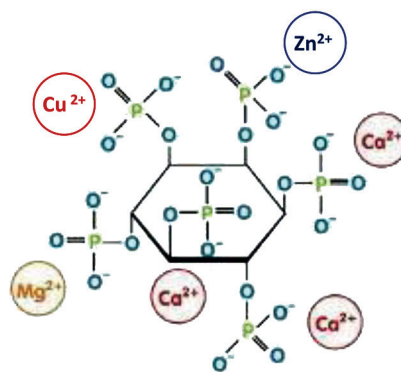
Research in food showed that macro and micro divalent minerals are affecting on various ways the bioaccessibility of carotenoids. The mechanistic insights are still under investigation but the main impact of divalent minerals seems to be on the de-stabilization of the micelles forms, by modifying their zeta potential.

Several aspects are thus to be considered when selecting minerals for animal diets: avoid the divalent forms (when possible) or choose sources with ideal kinetics of ions' releasing.

PROTECT THE PHYTASE EFFICACY

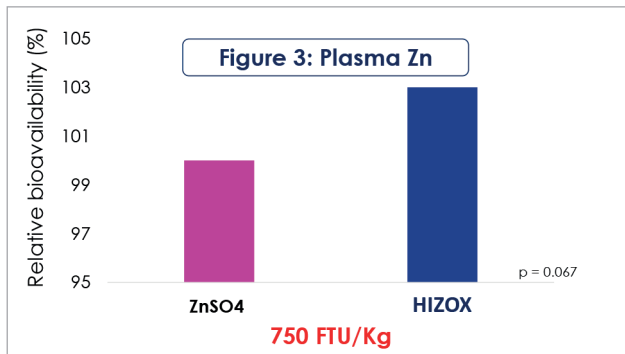
Phytase can be used standalone (as powder or liquid) or be included in a premix. Because phytic acid is a negatively charged molecules, it attracts positively charged cations. Once metals are fixed to the phytic acid, they become potentially "sequestered" in this complex and are not available for host absorption anymore.

Figure 2: phytic acid bound to divalent metals



If there is no clear consensus nowadays about cations affinity (esp. between copper and zinc) with phytate, it is evident that zinc is a major issue be-

cause of the important quantity used in premix or feed (up to 3000ppm in certain piglets' diets).



Safeguarding phytase activity becomes a race in which phytase needs to reach first phytic acid and before cationic metals bind to it. Specific source of zinc, with unique slow dissolution kinetics has already proven its superiority, enabling phytase to act properly. In a study run at INRAe France and presented at PSA 2020, potentiated zinc source HiZox® used at nutritional levels (40ppm total zinc) achieved a higher zinc in plasma compared to the

reference sulfates in presence of phytase supplementation (750 FTU/kg). It demonstrated its Zn²⁺ cations became bioaccessible at the right moment in the digestive tract and did not remain bind to phytate, being significantly more available for the broilers (Ross 308).

HOW TO REDUCE INTERACTIONS RATE?

Achieving a proper trace element nutrition and animal mineral status is not an easy task. When considering all interactions able to occur between additives, from the premix manufacture to the intestinal transporter, the right choice of mineral is crucial. Cations are known to be catalysts of a certain number of reactions and can also limit the bio-accessibility of others noble ingredients. Selecting precision minerals under monovalent form (CoRouge®) or with unique dissolution kinetics (HiZox® and ManGrin®) enable to minimize the undesired interactions and to secure the efficacy of additives such as pigments or phytase.

About Animine

Animine is an independent France-based supplier of added-value precision trace minerals sources for animal nutrition. Certified Fami-QS and ISO 14001, we are present in all continents. Our company invests large resources in R&D, through ambitious collaboration projects with public and private organizations.

Animine products portfolio counts with a range of specialty products, different from other products available in the feed industry.

They all share the same features:

- Highest mineral concentrations (75%)
- Excellent technological features, with high flowability and dust-free products
- High level of safety for animals, workers, consumers and the environment
- High stability, avoiding interactions in the feed and upper part of the digestive tract
- High bioavailability to fulfill animal requirements
- Specific effects on performance of growing and reproductive animals
- The whole range is available for usage in all animal species.

Animine, an international and independent supplier of precision minerals

- High**
- ✓ Concentration
 - ✓ Flowability
 - ✓ Safety standards
 - ✓ Stability
 - ✓ Bioavailability
 - ✓ Animal performance