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PREMIXING - AN UNDERSTANDING

Nutrition from feed is never complete without the vital links, the micronutrients, and micro-ingredients are the major sources delivering them in feed. It is critical that these micronutrients are made available in the desired composition for any feed to achieve its designed objectives.

Premixing is the process of ensuring right blend of all the micro-ingredients required for making a complete feed in the right form, proportion, purity, potency and distribution.

Micro-ingredients compose less than 0.5% of livestock and poultry feeds. Nevertheless, these nutrients are an essential part of the complete feed.

Microingredients in general comprise of feed supplements (vitamins, minerals, amino acids, choline salts, etc) and feed additives (anticoccidials, antibiotic growth promoters, antioxidants, mould inhibitors, toxin binders, digestive enzymes, absorption enhancers, gut acidifiers, probiotics, etc).

When these ingredients are added to the feed in the form of premix, care needs to be taken to ensure the proper combination of nutrients are contained in the premix. This is effectively achieved only by a comprehensive, complex and designed process called 'Premixing' - resulting in a highly dense and potent blend of nutrient links called 'Premix'.

For many livestock operations worldwide, a premix remains the most practical option to achieve the nutritional objectives of feeds under design.

This being the importance of a Premix, it is rational to procure them from a reliable, competent and dedicated source. It is this level of sophistication that educated the industry that

- highly specialized equipment is required to produce a high quality premix
- trace minerals aggressively oxidize and deteriorate potency of vitamins when not mixed properly.
- premixing helps reducing animal and human exposure to potentially harmful components by diluting them to approved and safe concentrations.
- ***a specialized carrier is indicated to ensure proper distribution of the microingredients in the final premix and feed.***
- dilution of microingredients needs to be done accurately and carefully under a strict quality control program
- the process of premixing also helps standardizing potency of several products.

The premixing process requires careful attention to each of the following to ensure success:

- Formulation of premix
- Selection of carriers or diluents
- Use of dust control and binding agents
- Type of mixer used
- Sequence of ingredients added to the mixer
- Mixing Time
- Mixer efficiency Testing (Coefficient of Variation – CV)
- Mixer cleaning requirements
- Premix Quality Control
- Selection of packaging material
- Storage.

Formulation

Premix formulation is extremely critical and should be done by a qualified nutritionist or technically trained personnel. The

Eg. 1 : Vitamin A Stability in a Vitamin/Trace Mineral Premix Stored at 104°F and 70% Relative Humidity

Vitamin A Retention %			
Supplier	4 Weeks	6 Weeks	
A	88	72	Cross Linked Gelatin beadlets
B	88	72	Cross Linked Gelatin beadlets
C	88	69	Cross Linked Gelatin beadlets
D	35	23	Non-Cross linked starch beadlets
E	44	26	Non-Cross linked starch beadlets
F	56	34	Non-Cross linked starch beadlets
G	50	44	Non-Cross linked starch beadlets
H	28	11	Non-Cross linked starch beadlets

1 A, B, C: Major manufacturers crosslinked gelatin beadlets.
D-G: European Fringe Formulators non-crosslinked starch beadlets.
Source : Comparative stability of Vitamin A Products – KC 9513 - BASF

formulator should consider various parameters such as - source of ingredients, bulk density & particle size, variants of ingredients, cost, handling characteristics, and possible interactions before final decisions are made.

Nutrient availability and potency of vitamins and minerals vary between sources and this needs to be factored in while formulating high quality premixes. A thorough knowledge of source and potency of the vitamin sources is essential.

Eg.1 :

Several vitamins contain unsaturated carbon atoms or double bonds, both highly susceptible to oxidation. Vitamin A retinal has both a free hydroxy group and 5 double bonds. The esterification of retinol with acetic acid produces retinyl group, which protects the hydroxy group, but still the 5 double bonds need to be protected. For this reason even pure retinyl acetate oil has to be emulsified in gelatin and sugars, and processed into a beadlet containing an antioxidant. Cross linking makes the beadlet insoluble in water and gives it more resistant coating that can sustain higher pressure, friction, temperature and humidity, providing more stability to the vitamin.

However there are several formulations in the marketplace with inferior vitamin A stability. Some Vitamin A formulations contain very low level or no gelatin, which is a critical extender in Vitamin stability. Some beadlets are non-cross linked, further reducing the vitamin A stability.

Eg. 2 : Nutrient Levels of select Vitamin Ingredients

Ingredient	Nutrient	
Name	Name	%
d-calcium pantothenate100%	Pantothenic acid	91.96
dl- calcium Pantothenate 100%	Pantothenic acid	45.98
Choline Chloride 60%	Choline	52.08
MPB 100%	Menadione (K3)	45.40
MSBC 100%	Menadione (K3)	33.00
Pyridoxine Hydrochloride	Pyridoxine	82.30
Thiamine Hydrochloride	Thiamine	89.18
Thiamine mononitrate	Thiamine	91.74

Eg.3:

Menadione, pure vitamin K3 is not utilized in pure form, so it is formulated with sodium bisulfite and its derivatives. Since Vitamin K is an unstable vitamin, there are

significant differences in Vitamin K stability among the various compounds available in the market. The most common compounds used in Industry are MSB, MSBC, MPB, MSB coated and the most recently introduced MNB. MSB is the most unstable formulation followed by MSBC, MPB, MSB coated and the most stable MNB.

Eg.4:

Vitamin stability in water is inversely co-related to the solubility. Thiamine mononitrate with a solubility of 10g/100 ml is significantly more stable in premixes than Thiamine Hydrochloride with a solubility of 100g/100 ml. (Adams, 1982).

Selection of Carrier

a. Types of Carriers

A Carrier is a substance capable of accepting and holding a fine powder without segregation or separation over time. There have been several carriers used over the years in premixes. A better carrier is not necessarily the most common one because the decision to use a carrier is mostly based on economy

b. Particle Size

The carrier particle size should be large enough to produce a premix with good flowability and low dustiness, and small enough to hold the active ingredients without segregation.

c. Apparent Bulk Density

To calculate the amount of densifier to meet a specific premix density is more complicated than it seems, because when mixing ingredients of drastically different particle sizes, the small particles fill in the open spaces between larger particles. Therefore, the premix density would be underestimated just by calculating the weighed average of densities of all premix ingredients. An empiric equation developed from premix densities of known composition gives a more realistic value than the weighed averages of ingredient densities.

Eg: Limestone is the most common carrier for trace mineral premixes while rice hulls is for vitamin and drug feed additives.

d. Moisture

Premix ingredients should have a moisture $\leq 5\%$ to reduce the potential of reduction-oxidation reactions. Rice hulls and limestone have a standard moisture $\leq 5\%$. However, other organic carriers such as wheat bran, wheat shorts and corn cobs have a moisture $\geq 12\%$ which should be dried to 5% before they can be considered as acceptable carriers.

e. Fat Content

Carriers should have $\leq 4\%$ fat content, since fat oxidation destroys several vitamins, especially fat soluble vitamins (A, D3 and E). Inorganic carriers have no fat, rice hulls has 2-4 % and wheat shorts and bran 12%.

f. Flowability

The flowability of a product is very much influenced by the particle size distribution, structure, and static properties. Flowability can be improved by adding flow agents that smoothen the surface of particles and improve their flowability. Liquids form bridges between particles therefore decrease the flow.

g. Premix Flowability

Premix flowability is a critical element of quality. Good flowability reduces labour and improves accuracy. In fact, a premix with good flowability acquires this characteristic due to a larger denser particle size of active ingredients and carriers. Several other factors impact flowability such as moisture and chemical reactions. In a closed container, elevation of temperature will release moisture bound to the carrier or feed additive, which in turn causes caking of the whole premix. In some cases, a chemical reaction between micro ingredients may occur that will

reduce the physico-chemical properties such as assay and flowability. A very common chemical incompatibility exists between d, l-calpan and niacinamide, the most soluble and hygroscopic forms of Pantothenic acid and niacin. The exothermic and hydrophilic reaction degrades d,l- calpan by 10-20% per month and drastically reduces the premix flowability up to caking. This reaction is highly dependent on temperature and humidity. The reaction can be controlled to some extent by using hydrophilic silica (free flow agent) that will remove moisture from the environment, prevent the reaction from occurring and maintain the premix free flowing. Hygroscopic micro ingredients, such as choline, ethoxyquin, niacinamide, calcium dl-pantothenate, spray dried vitamins, sulfate trace elements (copper sulfate) and hydrated trace elements (ferrous sulfate heptahydrate), as well as carriers with 10% moisture, can easily cause the premix to cake (lump) and turn dark.

Dust Control and Binding Agents

Dust is quite undesirable in premix manufacturing since large amounts of active ingredients can be lost in the dust control system and also due to occupational hazards such as smell, skin irritation, and risk of explosion. Therefore, non-dusty products are preferred in the feed industry, and dust should be considered a quality criterion.

For highly dusty ingredients, it is also recommended to use binding agents that are inert in nature and have physical properties compatible with the active ingredients.

Selection of Mixer

Mixing is the most important operation in the process of premix manufacturing. Hence, needs special attention in mixer selection, testing and maintenance. Although premix mixer comes in many shapes, designs and configurations, the mixer selection must focus on the two most important criteria, - mixing time & number and surface area of internal parts.

Mixing time should be minimised to prevent static build-up. Internal parts must be few and have a minimum surface area to reduce scale build-up and to allow easy access and cleaning. Ease of loading, suitability for applying liquids, mixing efficiency, ease of discharge, and clean-out requirements must all be considered. Short cuts in these areas can result in major problems. ***Manufacturing premixes is not the same as manufacturing complete feeds.*** The same equipment is not always suitable for both, especially to ensure mix uniformity and minimize any carryover.

Sequence of Ingredients Added to the Mixer

The sequence of charging ingredients into the mixer has a significant influence on the final quality of the premix produced. Oil balls, chemical interactions, and particle segregation can all result if proper mixer charging is not followed. Poor quality premixes are expensive propositions to the premix manufacturer and also the feed manufacturer and ultimately the livestock producer.

Mixing Time

The mixing time varies depending on the type of mixer used. However, under-mixing will cause poor dispersion of active ingredients throughout the mix, measured by high coefficient of variation among samples of the same batch. Over mixing is sometimes blamed for demixing, which is often due to static principle. Pure crystalline

products develop static charges as they are being mixed. The smaller the particle size, the higher the static charges. Eg. Crystalline Riboflavin 96% and Folic Acid have 5 million to 1 billion particles per gram, making them the most electrostatic vitamins. The individual particles with static charges repel each other, causing segregation and poor distribution throughout the premix. Particles with static charges are also attracted to the metal parts of the mixer, and there is an accumulation and deposit of static particles on the shaft and walls of mixer, forming scales

Mixer Effeciency Testing (Coefficient of Variation – CV)

All mixers should be tested before or immediately after installation, and every year thereafter. Several factors can contribute to poor mixer performance: shafts get out of alignment, internal parts wear out, gates start leaking, changes in mixing time and batch size.

A fool proof mixer test – Coefficient of Variation (CV) involves collecting 10 well-distributed samples from a batch of premix at different mixing times (including the manufacturer's recommended or currently used mixing time). Each group of 10 samples from each mixing time is assayed for a typical active ingredient of premixes made at that mixer. This marker must be indicative of the uniformity of other microingredients in the premix. The assay should carry a low analytical variation, and the assay component must come from a single source. Therefore, the marker must be a typical micro ingredient of the premixes made in that mixer and needs to be assayed by equipment that consistently gives a very low analytical error (high performance liquid chromatography, gas chromatography, atomic absorption, etc). The coefficient of variation for each set of 10 samples is indicative of the mixer performance and the distribution of the microingredients assayed throughout the mix. ***A coefficient of variation below 5% is indicative of an adequate distribution of the active ingredient.***

Mixer Cleaning Requirements

Good manufacturing practices (GMP's) for premixes require very specific cleaning procedures for mixers, conveyors, bins, etc., to prevent contamination from batch to batch. Equipment should be scraped and swept regularly to remove scale build up, especially in the mixer. Hygroscopic (choline, ethoxyquin, spray dried vitamins) or static charged particles (trace elements, riboflavin, folic acid) attach to the shaft and walls of mixers. The scales, after reaching a certain thickness, drop back into a batch and are bagged off, since most surge bins don't have screens. Scales not only affect the premix potency, but also often are rejected by customers.

Premix Quality Control

The many micro-ingredients handled at a premix plant and the cost of individual micro-ingredients assays has gradually changed the GMP's to practice quality assurance during manufacturing. Quality assurance is based on setting up GMP's that allow for continuous checks throughout the process to assure meeting product specifications when the manufacturing process is completed. Quality control is still conducted to verify the GMP procedures. A few common quality control procedures include:

• Physical examination of every batch for appearance (color, texture) against standards.

- One of batches assayed on a rotational basis of 1 active ingredient per month.
- Complete assay of one premix at random every month.
- Retention of batch samples for 2 years.
- Complete traceability of raw materials for every batch.

The potential for numeric mistakes still exists due to the number of micro ingredients, potencies and charge rates that can be as high as 2500 Kg for carriers, and as low as 20 mg for some Micro-ingredients per batch. To further reduce the potential for error, some premix plants have instituted an end of the day straight inventory match against straight requirements from premix labels manufactured. If the inventories check, then the plant knows that all batches meet specifications.

Selection of Packaging Material

Packaging material should be selected based on the type of premix involved. Moisture can be very detrimental to the stability of certain vitamins or other compounds; therefore, a vapor barrier in the packaging material is important. Length of storage and type of handling may also require special packaging consideration.

Storage

Several studies with properly formulated and blended vitamin and trace mineral premixes have shown good stability up to 90 days in storage using accepted analytic assays. However, few situations offer advantages to purchasing and storing premixes for more than 30 days. Any savings for quantity purchases have to be balanced with costs associated with storage and possible stability concerns.

Many premix purchasers feel assaying the final product is their assurance of quality and value. This approach can many times lead to frustration and confusion for all involved. ***Normal accepted analytical variations for various vitamins might be in the range of 5 to 40%.*** With such wide assay variances, it is impossible to judge the value and/or quality of a specific premix with a specific sample. In addition, assay costs can be a significant consideration. This problem with assay variation is an increasing concern with regulatory agencies, as standard procedures may not always adequately account for the level of the vitamins; for example: cross-linked vitamin A is not detected by standard assay procedures. When assays are required, one should be aware of analytical variations and do everything possible to minimize these variations. Proper sampling, use of a reliable laboratory consistently, having a routine sampling program, and properly rotating and storing the premixes will help reduce assay variations.

In view of these limitations, it is always recommended to source premixes from a manufacturer with credibility, competence, knowledge of premixes, infrastructure, and technology that minimize or eliminate the quality risk factors.

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