A Guide to Feed Mixing

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The principal objective in feed mixing is to assure that an animal receives all of its formulated nutrient allowances <u>every day</u>. Most feed manufacturers use the coefficient of variation or CV to measure mixer performance and mixture uniformity. The CV is defined as 100 * standard deviation/mean. A 5% CV is the industry standard for most ingredients. An ingredient mix CV of 5% permits that an animal receive at least 90% of its formulated dietary allowances 95% of the time. However, the magnitude of an acceptable CV will vary depending on the analytic precision for measuring the ingredient and the ingredient ratio in the diet. The CV for an ingredient assay (repeatability of the analytical procedure) should be less than the desired CV for mixer efficiency. With respect to ingredient ratio, the lower the ingredient concentration in the mix, the higher the CV. Thus, the CV is usually higher for trace mineral, vitamins and drugs because their ingredient ratios are low (less than 1:10,000).

Uniformity of particle size and number of particles per unit weight are important considerations for assessing mixing CV of the various micro ingredients. The CV for a particular ingredient is inversely proportional to the square root of the number of particles/sample. In order to obtain a CV of 5% or less a given sample should contain a minimum of 400 particles. Of course, an excess of a given micro ingredient may be added to the mix to assure that this minimum number of particles/sample are achieved. However, many of the micro ingredients (particularly drugs) are expensive and elevated levels may be toxic. Thus, a small uniform particle size is a very important criterion in the selection of micro ingredients.

Physical characteristics and feed mixing

Many of the problems in feed mixing are due to differences among feed ingredients in particle shape, size, and density. Feed ingredients with similar sizes and densities tend to blend easily and quickly. For example, ground or cracked grains have densities similar to that of the oilseed meals. Consequently, there is usually very little difficulty in obtaining a uniform blend of these feed ingredients. Minerals on the other hand have densities which are vastly greater than that of grains and oilseed meals. Drugs have intermediate densities, but very fine particle sizes. Forages have low densities, and highly varied particle shapes and sizes. This diversity of physical form and density of individual feed ingredients complicates the preparation of uniform feed mixes.

Drug and vitamin inclusion

Drugs and vitamins pose a special problem for obtaining a uniform feed mix . Their densities are more similar to that of ground grain and oilseed meals. Thus, uniform mixing should not be so problematic. However, they are included in the mix at very low levels. This presents a unique problem with respect to spacial distribution. The risk of inadequate spacial distribution of critical micro ingredients can be minimized by following a few simple guidelines in feed formulation.

Guidelines for feed formulation

1) Premix Premix micro ingredients such as drugs, vitamins, and trace minerals with a suitable diluent prior to their inclusion in a supplement. Diluents serve to dilute the micro ingredient and thereby facilitate the rate of mixing. Examples of suitable diluents include the macro minerals typically incorporated in a feed mix (ie. salt, limestone, dicalcium phosphate, magnesium oxide). Diluents should be dry in order to permit a more uniform dispersion of individual micro ingredient particles. Moisture must be avoided as it may cause entrainment and clumping (hygroscopic compounds such as urea are not suitable diluents). The premix (micro ingredients plus diluent) should represent 3%, by weight, of the supplement. Premixing may be done by hand in a large container. However, it can be preformed more easily and efficiently by means of a small portable cylinder mixer (cement mixer). Protective clothing, gloves and dust mask should be worn when handling micro ingredients.

2) Supplement Prepare a supplement. This supplement will contain the premix, a suitable carrier, and the remaining minor dry ingredients in the diet including minerals, urea, and supplemental protein sources. Carriers are feed ingredients which combine with the micro ingredients in the premix to alter their physical characteristics. By adsorbing to the carrier, the very fine particles of the micro ingredients are allowed to move more rapidly and uniformly through the mix. This rapid movement of micro ingredients through the mix is important to assure adequate distribution prior to addition of molasses. Carriers should have physical properties comparable to ground grain or oilseed meals. Indeed, both of these may be used as carriers. However, the adsorptive properties of ground grain and oilseed meals are low. This limitation may be overcome by first combining 2% fat to the ground grain or oilseed meal before blending with the premix. The thin film of fat covering the carrier will facilitate adsorption of the micro ingredients in the premix. Excellent carriers for micro ingredients include poultry litter, rice hulls, wheat bran, vermiculite, alfalfa meal, ground corn cobs, and beet pulp. The amount of carrier to include in the supplement will depend on the “space” available in the diet formulation. The supplement should comprise a minimum of 3% by weight of the finished feed. In preparing the supplement, first add the carrier, and then add other major ingredients until they reach the central shaft line, then add the premix and other minor ingredients, and finally add the remaining major ingredients. Mixing volume and mixing time will depend on the specifications of the particular mixer being used. Although some mixers will mix feed very efficiently at low volumes, most do not. Review the literature regarding your mixer and then see that the volume of feed being mixed and mixing times are optimal for the mixer. Be careful not to underfill or overfill the mixer.

3) Finished feed Finished feed may be prepared as follows: 1) add the grain portion of the diet to the mixer; 2) add the dry supplement (remember that the supplement should comprise a minimum of 3% of the finished feed) to the center of the mixer (if possible, add supplement on the opposite end of the mixer to where the feed is discharged); 3) allow feed to mix for a minimum of 1 minute; 4) add forage component of the diet; 5) add fat component of the diet; 6) add molasses or liquid component of the diet; 7) allow to mix for the time specified for the mixer (usually not less than 8 minutes). **Note:** As previously explained, the reason that the supplement is added to the grain portion of the diet prior to the addition of forage is because the grain and supplement have similar particle size and densities. Accordingly, the supplement will distribute itself quickly through the grain. This increased dilution of the supplement prior to the addition of forage and liquid feeds will enhance the spacial distribution of micro ingredients in the complete feed while shortening mixing time.

4) Adding molasses Molasses is a common ingredient in diet formulations. However, it is highly viscous and this presents several problems in feed mixing. Indeed, if added to the diet improperly it can cause marked increases in the CV of the micro ingredients. Molasses should be added to the mixer as the last step in formulation. If the molasses is added to the mixture before the supplement has had a chance to mix with the other major ingredients in the diet it may result in entrainment of sequestering of the micro ingredients. This will increase what is called the "Poisson Error" or the variance associated with decreased spacial distribution of micro ingredient particles. Furthermore, if molasses is added to the mixer before it is adequately filled, it will come in contact with the mixer, itself, adhering to the sides of the mixer and moving parts, thereby decreasing mixer efficiency and, necessitating more frequent cleaning. Whereas the obvious challenge with molasses addition to the mix is the formation of feed balls or clumps, the more real problem in terms of animal performance is the potential increase in CV for micro ingredients if the molasses is not added in the proper order. Black strap molasses (standardized at 80° Brix) is particularly viscous. The efficiency of mixing black strap molasses with other dietary ingredients will be enhanced if it is first diluted with water (ie. dilute to 70° Brix). The viscosity of molasses is markedly reduced by heating. For example, raising the temperature of molasses from 23° C to 27° C (an increase of only 4%) will reduce the viscosity of molasses 50%. Molasses should not be heated to temperatures in excess of 43° C, except for very short periods of time, as this may cause carmelization.

Avoiding mixer problems

Ribbon and auger mixers operate most efficiently if they are filled to 70 to 90% of capacity. With paddle mixers, satisfactory mixing may be obtained at much lower levels of loading (25% of capacity). However the application of fat and/or molasses to mixers that are not adequately loaded may cause coating of the sides of the mixer and mixer bars, resulting in decreased mixer efficiency and contamination. The mixer should not be overloaded. Overloading the mixer will cause some of the feed to float above the mix and not blend properly. With paddle and ribbon mixers the mixer bars should rise at least 12 cm above the level of the mix.

Improper mixing can also occur if the tolerances between the mixer bars and the sides of the mixer are not set properly. Mixers are factory-set with an agitator clearance of .3 to .9 cm. If that clearance increases to 1.3 cm, mixer efficiency will be impaired. Mixers should be visually inspected periodically. Establish a set schedule for inspecting the mixer. Worn paddles and ribbons should be replaced.

Do not deviate from proper mixing times. If possible have mixing time controlled by a timer. Mixing time increases with the level of liquid feed added to the mix. This is because the mix becomes more viscous, slowing down the flow of ingredients through the mix. This problem accentuates when the level of molasses added to the mix exceeds the absorptive capacity of the mix. Thus, the level of molasses employed in a diet formulation should be considered not only with respect to relative cost of the molasses, but also with respect to practical mixing time and the acceptable CV for the limiting micro ingredient in the mix.

Sampling

The sample should be representative of the feed being delivered. Care should be taken to assure that the feed is disturbed as little as possible during sampling. After feed is delivered to the feed bunk or to holding bins some settling of ingredients may occur, making representative sampling more difficult. For this reason, it is best if the sample can be obtained directly as the feed is being delivered from the mixer. Remember that a key factor in obtaining a sample is that the feed is disturbed as little as possible. Scoops or containers used for collecting samples should be of the size and volume to uniformly collect only the amount desired. The sample should be stored in air-tight sealed containers.

Keep in mind that if feed is to be sampled from sacks, bins or feed bunks the sampling variation is increased (that is, it will be more difficult to obtain a representative sample). This increase in sampling variation is due to feed ingredient segregation. The use of a sampling probe may help to reduce some of this variation.

Sample size

Because the principal objective in feed mixing is to assure that an animal receive all of its formulated nutrient allowances <u>every day</u>, the sample size should reflect the expected average daily intake of the animals consuming the finished feed. Accordingly, the sample of finished feed should be approximately 10 kg, representing a composites of 10 1-kg samples taken at random as the feed is delivered from the mixer. The sample of the supplement should be approximately 500 g, representing a composite of 10 50-gram samples of the supplement taken at random as it is delivered from the mixer.

Measuring mix efficiency

Due to costs involved, assays for mixing efficiency should be based on nutrients or drugs whose concentration in the diet, from either a legal or animal performance standpoint, are critical. Drugs make particularly good markers of mixing efficiency because there is usually only one ingredient source of the drug in the mix, and accurate analytical assays are available for most drugs. Because of their high density and low concentration in the diet, trace elements might also serve as markers of mixing efficiency. However, they have the disadvantage that there are usually many ingredient sources of trace elements in the mix.