Keys for perfect application of powders and liquids

Liquid or powder additives application in feed requires proper technology, adapted equipment and good practices. Homogeneity and recovery of these additives in the feed are the main criteria to evaluate the quality of its application in the feed mill.

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Additives are designed to compensate some deficiencies of main raw materials (i.e. amino acids, vitamins, trace elements), or enhance feed quality (i.e. enzymes). They represent a small part of a recipe, but their impact on feed cost is high. Therefore, adding these additives properly is a daily challenge for the feed mill manager, whatever the form, powder or liquid. Proper application of feed additives is measured by recovery and homogeneity. Recovery is expressed in percentage of the theoretical incorporation rate. On one hand, it evaluates the capacity of the feed process to dose accurately and to transfer without loss or carry-over, and on the other hand the stability of the additive to feed process. Homogeneity, expressed by the coefficient of variation between the analysis results for several samples taken from the same batch, evaluates the capacity of the process to mix properly an additive with the other ingredients, without segregation, provided that this additive can be mixed homogeneously (*see box*).

Key factors for powder additives

Adding powder additives is a process that must not be underestimated. Several points need to be taken into account in order to obtain good quality feed.

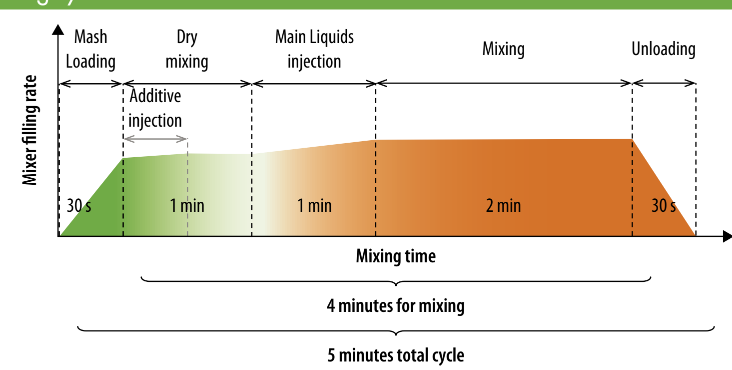
Accurate dosing requires accurate equipment

Depending on the feed mill, the dosing can be done either manually or automatically. In any case, the weighing chain must be adapted to the precision required for the additive in order to reduce the risk of inconsistencies. When an automatic dosing system is installed, all the elements must be designed to ensure the needed accuracy for the additive. The dosing device must be of the adapted size and be operated at an appropriate speed because the faster the dosing the less precise it will be. According to the regulation (EC) No 183/2005, "All scales and metering devices used in the manufacture of feeds shall be appropriate for the range of weights or volumes to be measured and shall be tested for accuracy regularly". This means that the increment of the load cells, which determines their accuracy, must be smaller than the smallest quantity to be dosed. Furthermore, attention must be paid to the quality of the link to the Programmable Logic Controller (PLC) that must be strong and noise free. Finally, the value stored by the Computer-Aided Manufacturing software, must be able to manage the error added by the pre-act weight. When a manual system is implemented, the most important influence will come from the human factor. Therefore, well trained operators but also a sufficiently accurate scale are required. In each case, the weighing installation has to be controlled and calibrated regularly with a thorough maintenance at least once a year. This is particularly true for the automatic systems and concerns all the steps from the dosing device settings to the computer display.

Favour short distance between dosing bin and mixer

Even though appropriate weighing is fundamental, it is not sufficient as other aspects can affect the recovery. Indeed, the carry-over caused by the transport between the dosing system and the mixer has to be taken into consideration because it adds error to recovery and it is source of cross contaminations. Therefore, the whole content of the weighing hopper must be transferred to the mixer with minimal transport. This can be achieved by gravity or by a pneumatic or mechanical transfer system.

Figure 1 - Time length for good homogeneity in a ribbon mixer. The addition of liquid additives (like methionine) does not increase the duration of the total mixing cycle.



Apply proper mixing conditions

The mixer is the only machine giving homogeneity to the mash. If nothing is done to fix the particles together (with pelleting) after mixing, the falls and transfers will contribute to the mixture deterioration (Wilcox R.A, 1976). Thus, a bad homogeneity after mixing will rarely be improved later. Proper mixing results can be achieved with all kind of mixers (ribbon, paddle or plough, single or double shaft). However, compared to the other raw materials, the incorporation rate of an additive is very small and needs to be adapted to the minimal quantity a mixer can blend. Furthermore, a particular attention must be given to the location and the time sequence the additives are loaded. All this will help to avoid the non-mixing phenomenon which can occur if the additive is loaded in a dead area in the mixer (Jean-Pierre Melcion, 2003). Examples of dead areas are, the space between the agitator and the mixers' bottom or the top of the mass when a mixer is overloaded. As with the dosing equipment, mixing accuracy must be controlled at least once a year. "In most cases, a target CV of less than 10% should be achieved" (FEFAC, 2014) for the variation of the additive homogeneity tests.

Attention to segregation risks

Segregation can be defined as the separation of the feed components in the different production steps such as transfer, transportation, blending or any other procedure (Fisher, 1960). This means that segregation will be source of demixing and carry-over. It is caused by three fundamental mechanisms that describe the interactions amongst feed particles: shearing, diffusion and convection (Bertiaux H., 1999). Combined, this mechanisms will not have the same effects on all the feed components because particles differ in size, shape, density and elasticity (Moritz F., 1965). The result will conduct to different characteristic physical phenomena: Particle trajectory, percolation, segregation, elutriation and vibration (Jean-Pierre Melcion, 2003). In order to limit this phenomenon, the design of the installations after blending must focus to reduce the production steps particularly the transfer (Jansen H.D., 1992).

Key factors for liquid additives

In the feed industry, the usage of liquid additives is as frequent as powders. Sometimes, the same precautions apply. In some others cases, specific aspects need to be addressed.

An appropriate dosing for recovery

Dosing of liquids can be done by manual or automatic systems using a weighing scale. For both situations, the same respective precautions as for powders must be taken to ensure the best accuracy possible. The liquid nature of the additive makes it possible to use metering as an alternative technology for dosing. For this, a flowmeter is employed which can be mechanical (measures a volume flow with a gear actioned by the fluid force), electromagnetic (measures a volume flow related the voltage generated when the fluid cuts through an electromagnetic field) or mass (evaluates a mass flow by measuring the deflection caused by the fluid on the sensor tube). While mechanical flowmeters are economical, electromagnetic have the advantage of working without pressure drop. In contrast, mass flowmeters are comfortable as they don't need to be calibrated for the fluids density. All types being sufficiently accurate and requiring very little maintenance. A liquid dosing system using metering is an automated installation. Its overall precision comes from the flowmeter and the chain of measurements from data

Figure 2 - Recovery coefficient of variation (CV) for D,L-HMTBA function of the recovery CV for D,L Methionine (DLM). Powder and liquid were introduced in the same batch at similar or different incorporation rates. Analyses for both additives was performed on the same sample group according to the Mixer Profile protocol. The strong correlation (R^2=0.89) indicates that homogeneity is independent of the nature and inclusion rate when equal conditions are applied.

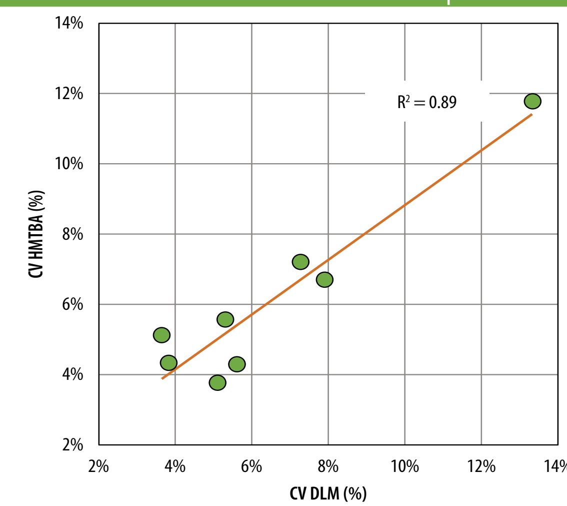
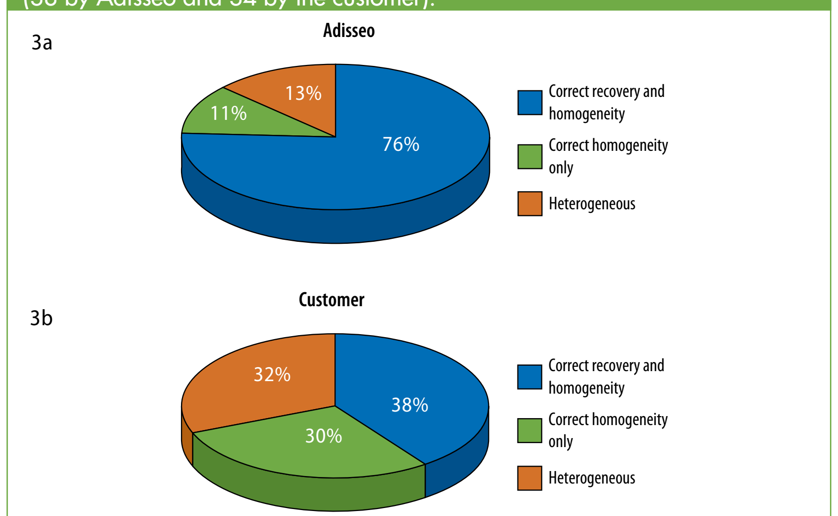


Figure 3a and b - Quality performance for Adisseo and customer installations. Results were obtained after the analyses of D,L-HMTBA from 72 installations (38 by Adisseo and 34 by the customer).



acquirement capabilities of the PLC (working frequency) to valve closing speed. Besides, as for powders, the link to the PLC must be of quality and the value stored by the production software must be correctly entered.

Regardless the dosing technology chosen, a set of pumps and valves adapted to the fluid characteristics must be installed in order to transport the additive. Moreover, maintenance and calibration of the whole system (from the flowmeters' measure to the computer display value) has to be done in a yearly basis.

Good spraying equipment for mixability

When spraying a liquid additive, the installation must be designed to maximise its mixability which is mainly dependent on the droplet number and size (*see mixability*). The first element to consider is the nozzle that must ensure a spraying pattern as wide as possible without mist emission (a flatbed spray nozzle is recommended). Then, the applied pressure must be adequate for a correct droplet formation and dispersion. No air must penetrate the pipes with the risk of flow inconsistencies. When mixing, the position of the nozzles is fundamental. The spray must be directed to the area where the mixing is most vigorous (G.M.A. Engelen, 1999). The spray from different nozzles must not touch and the droplet trajectory must be obstacle free with the risk of spray disturbances. For some liquid ingredients, the temperature is major parameter affecting the droplets development because it can alter the viscosity. Hence, controlled temperature must be applied to the system in order to obtain a constant viscosity adapted to the desired droplet characteristics. As an example for D, L-methionine hydroxy (D,L-HMTBA), the working temperature giving the adequate viscosity is 15-20°C.

Proper mixing conditions

Similar precautions as for powders must be taken. The transfer from the weighing must be ensured without any loses, thus, special attention to leaks must be paid. When possible, short distances between the flowmeter and the mixer should be implemented. The spray must avoid quasi-motionless dead spaces and respect the time sequence. Moreover, experience (from Adisseo) has showed that liquid additives must be incorporated before the main liquids (such as oil) in a short spraying time without increasing the overall mixing procedure (*Figure 1*). Unlike powders, liquid additives present less risk of segregation after mixing, as they are sprayed on all particles.

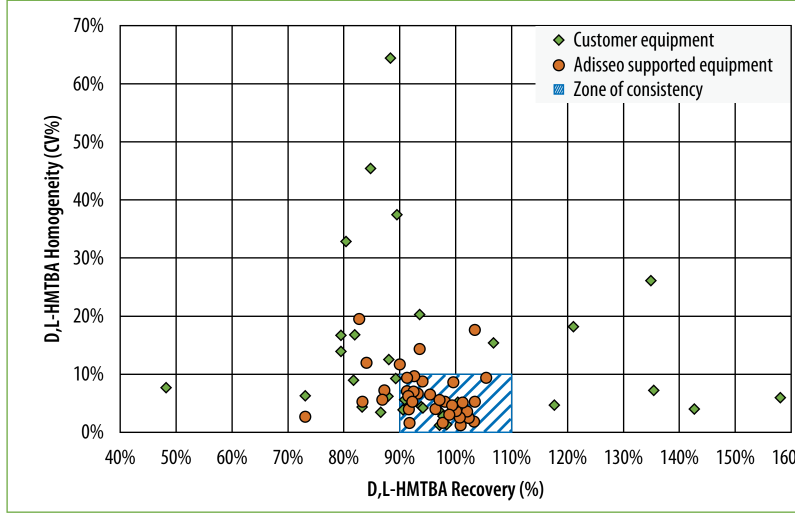
Feed quality proven in the field: focus on methionine

Adisseo has taken advantage of its international presence to perform homogeneity and recovery trials for methionine during the last three years in 44 feed mills in Europe, Middle East and Africa. The collected data demonstrates that the homogeneity is equivalent regardless of the nature of the additive (*Figure 2*). Whenever a consistent result is obtained for powder (D,L Methionine), the same occurs for liquid (D,L-HMTBA) with highly similar results. These trials have also come to the conclusion that every type of mixer can give homogeneous results. Moreover, regardless the incorporation rate, this trials have also shown that the targeted homogeneity can be attained. Nevertheless, the quality of the mixture depends on all previous described criteria.

Adisseo proves its experience

In order to achieve feed quality standards, Adisseo proposes its "Mixer Profile", a service designed to assess recovery and homogeneity, so as to detect deviations if any. The compiled data from this test show that 76% of the installations supported by Adisseo perform according to the expected and almost 90% give homogeneous results (*Figures 3a and 3b*). By contrast, the equipment without this support lead to strongly dispersed results in which only 38% comply with the quality standards (*Figure 4*). This confirms that the respect and control of several key factors lead to high performance of additive application, either under powder or liquid form. Through the programme DIM (Design, Implement and Monitoring), Adisseo guides its customers to properly design their installations to be cost effective and quality efficient. The experts help to install, calibrate and validate the equipment and provide training for its operation. Moreover, with the Mixer Profile, Adisseo assist on the monitoring of feed quality and arrange corrective or preventive actions when needed.

Figure 4 - Homogeneity and recovery for customer and Adisseo designed installations. The results were obtained by analyzing the recovery and the coefficient of variation for D,L-HMTBA. Samples were taken from 72 different mixers.



Mixability for powders and liquids

Mixability is a measure of the degree to which an ingredient can combine or blend into one mass in a homogeneous way. It can be expressed by the size of the individual samples for which 95% will have the expected concentration of an ingredient ± a coefficient of variation of generally 10%. Therefore, the smaller the sample, the more mixable the additive. Mixability depends on the number of particles, and is independent from the incorporation rate (Bruggemann & Niesar, 1965). To predict the mixability of an additive, one must take into account the number of particles per gram of a powder, or the number of droplets per gram of a liquid during spraying (*Figure 5*). These figures can be estimated based on a particle size distribution analysis. For example, powder methionine of Adisseo (Rhodimet® NP99) has an average particle size of 225 µm, and counts about 1,000,000 particles per gram. With such a fine powder, at 2.0 kg per ton of feed, a 12.2 g sample of feed must be taken to have 95% probability to recover 2 ± 0.2 kg /tonne. Comparable result should be obtained with liquid methionine (Rhodimet® AT88) sprayed with the recommended conditions.

Figure 5 - The number of particles is essential for mixability.