

Liquid addition to feeding stuff powders as an aspect of feed quality and safety

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SUMMARY

Technological properties of feeding stuff powders e.g. miscibility and segregation are influenced by the properties of their components like particle size distribution. Adjusting the particle size distribution of powders is possible within technological limits and under consideration of nutritional aspects only. Adding small amounts of liquids (e.g. oil, molasses) into the main mixer shall avoid segregation of macro and micro components. An experimental study was carried out at the IFF Research Institute of Feed Technology to mark up technological parameters and material properties for optimized discontinuous liquid application regarding feed quality and minimisation of cross-contamination.

Keywords: liquid application, mixture homogeneity, mixture stability, segregation

INTRODUCTION

Common feeding stuffs are composed of rough and fine organic and mineral particulate components. Their composition depends on the animal species as well as the period of growth and is currently adjusted e.g. due to the availability of raw materials. An adequate feeding of animals requires besides grain-based feeding stuffs an addition of essential mineral components (e.g. salt, limestone), trace elements and additives, whereby the use of high potential additives is lawfully regulated. Ensuring equitable feeding of all animals in stock, animal health as well as quality demands of food from animal origin, micro components in ppm amounts must be mixed homogeneously with macro components. A high degree of fineness of micro components is necessary to reach an adequate distribution due to a high number of particles. In this fact particulate macro and micro components show big differences in their particle size distribution, material density as well as flowability and dusting behaviour which complicate the production of homogenous mixtures with high mixing stability from feed mill up to trough (Feil, 2009)].

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Well-directed measures to ensure the compliance with product demands are necessary. Adjusting the particle size distribution of powders is possible within technological limits and under consideration of nutritional aspects only (Heidenreich et. al., 2003). Adding small amounts of liquids – 1 to 2 % – like molasses into the main mixer shall avoid segregation of macro and micro components, increase mixture stability and affect a reduction of dusting behaviour leading to a higher animal's acceptance. But depending on the process design, the liquid application system and the amount of liquids added negative effects on product quality – like undesired agglomeration of additives or caking as source of cross contamination – may occur.

The influences of

- the type of the liquid application system,
- the amounts of liquids,
- their properties on particle movements in the discontinuous main mixer

and

- the mixture homogeneity

are not sufficiently characterized until now. In this relation, influences of different liquids respectively different liquid properties on mixture stability are not sufficiently known. Further on, a deeper knowledge on material and process parameters and their influence on the mixing process when adding liquids is missing, especially in the avoidance of undesired agglomerates.

MATERIAL AND METHODS

An experimental study was carried out at the IFF Research Institute to mark up technological parameters and material properties for optimized discontinuous liquid application in the main mixer regarding feed quality (e.g. mixture homogeneity and stability, dusting) and minimisation of cross-contamination – caused by unbound fines on the one and caking on the other hand – of grain-based and mineral feeding stuffs.

Experimental investigations were carried out with different kinds of solid matter mixers in pilot scale (volume from 20 up to 120 l) under use of different commercially available kinds of liquid application systems to find optimized technological, material and process parameters for discontinuous addition of liquids in the main mixer.

Commercially available grain-based feed mixtures for pigs (finely structurized) and layers (roughly structurized) as well as mineral feeding stuffs for pigs (finely structurized) and cattle (roughly structurized) were used as test materials without previous liquid application. An example for the particle size distribution of test materials is given in Figure 1.

For the characterization of the mixture homogeneity, stability and cross-contamination, a particulate organic colourant was used as additives' indicator which can be detected photometrically with a low analytical error. The indicator

was added in a ratio of 1:100,000 or 1:50,000. After the mixing process, samples were taken from the investigated mixer (in general 10 single samples of 20 g), the concentration of the indicator was analyzed and statistically evaluated by the coefficient of variation (CV). The range of a sufficient mixture homogeneity for grain-based feeding stuffs is $CV \leq 0.07$, for mineral feeding stuff ≤ 0.1 (Heidenreich, 1998).

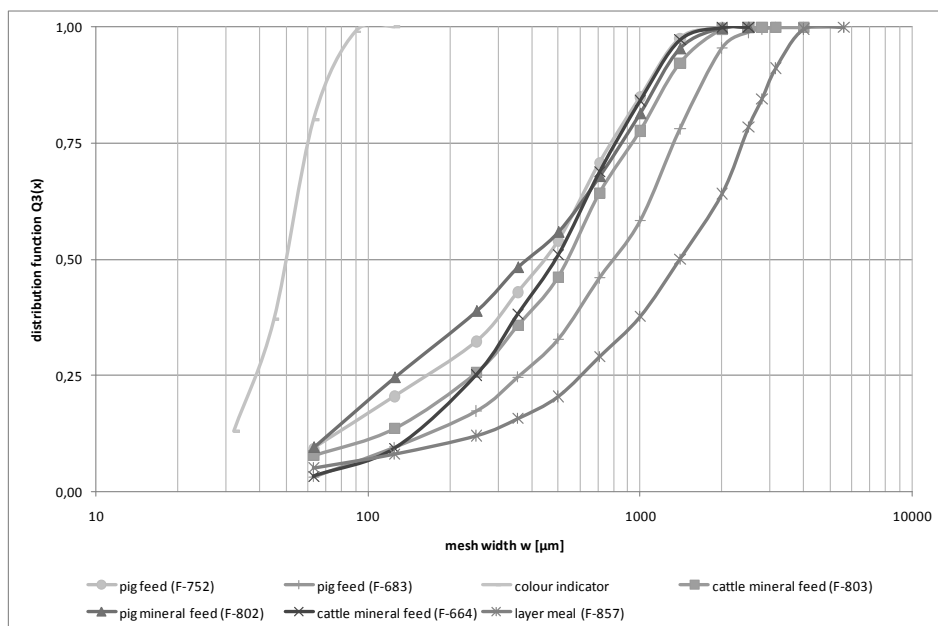


Fig. 1: Particle size distribution of test feeding stuffs and colour indicator

Besides the particle size distribution (sieving according to DIN 66 165), specific surfaces (BET-method according to DIN 66 131), bulk density (DIN 1061) and humidity (4 hours drying chamber at 103 °C), dusting behaviour (single-drop method by PALAS DustView) and flowability (ring-shear test) were investigated for the characterization of the bulk materials.

As liquid macro components especially sugar beet molasses in commercially available qualities and soy oil were used. Viscosity (rotation viscometer), surface tension (tensiometer according to du Noüy), dry matter, ph-value and Brix-degree (refractometer) were measured.

The liquids were added to the feeding stuff powders in amounts between 1 and 3 %. To characterize the influence of the addition of liquids on bulk materials concerning the particle movement in the mixer and the mixture homogeneity, for reasons of comparison, first a dry mixture was produced.

Several variations of technological and process parameters were done, for example

- liquid application by simple pipes,

- liquid application by one and two component nozzles,
- heating of molasses to decrease viscosity,
- change in mass-flow rate of liquids and application time and
- dry-mixing time before liquid application and subsequent mixing time

to characterize the parameter's influence on mixture homogeneity, creation of undesired agglomerates and technological feed quality parameters like dusting behaviour and flowability.

Mixing stability of test mixtures was tested by pneumatical stressing using a pneumatical pilot conveyor (Figure 2). The influence of storage periods from 24 hours up to 3 months due to expected permeation or evaporation of liquids was investigated to create conclusions on enduring mixture stabilization by liquid addition.

After stressing, 10 single samples were taken from the bin (P1) and the concentration of the indicator was analyzed and statistically evaluated by the coefficient of variation (CV).

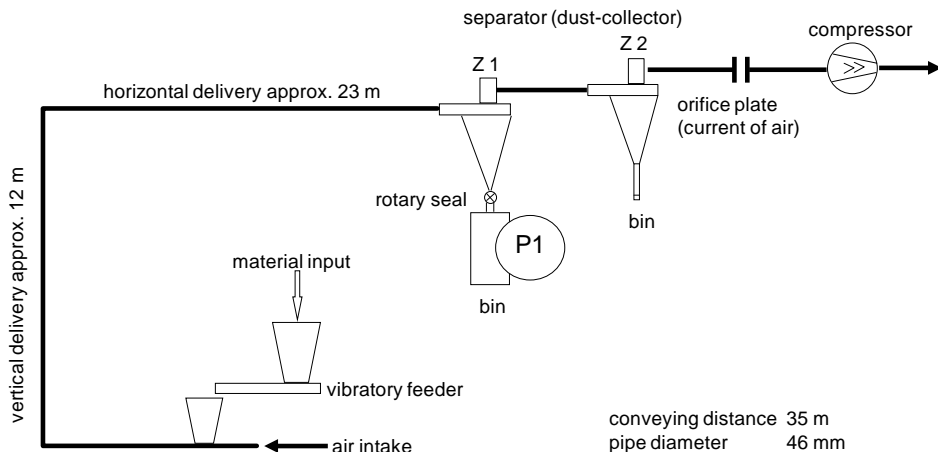


Fig. 2: Pneumatic pilot conveyor (IFF pilot plant station)

Segregation in this test facility is caused by two main effects which have to be considered. During the transport of particles in air gravity and power of resistance as function of relative velocity and c_w -value are effective in relation with particle's diameter and density. In the air cyclone segregation is forced by gravity and centrifugal forces (Schubert, 2003, Weinekötter, Gericke, 1995).

RESULTS AND DISCUSSION

Depending on the type of solid matter mixer, available liquid application systems and the added amount of liquid the mixture homogeneity characterized in the main mixer differ due to several parameters. Based on the findings on mixture homogeneity an optimization of the mixing process will be possible.

However, in consideration of quality and safety of feed and food from animal origin special interest of the following discussion of results will focus on quality of feed regarding *mixture stability*: An addition of liquids to bulk materials causes binding forces between particles leading to agglomeration and influencing the flowability of particles. Depending on the material properties of bulks and liquids different effects on the effectiveness and the endurance of mixture stabilization are expectable and to be quantified by results of systematically trials. As example in Figure 3 results on mixture stability characterized by indicator concentration and coefficient of variation (CV) when applying 1 to 3 % molasses (sugar content of 47 %) to cattle mineral feed after storage periods of 1 hour up to 3 months are shown. They are compared with the dry mixture's stability.

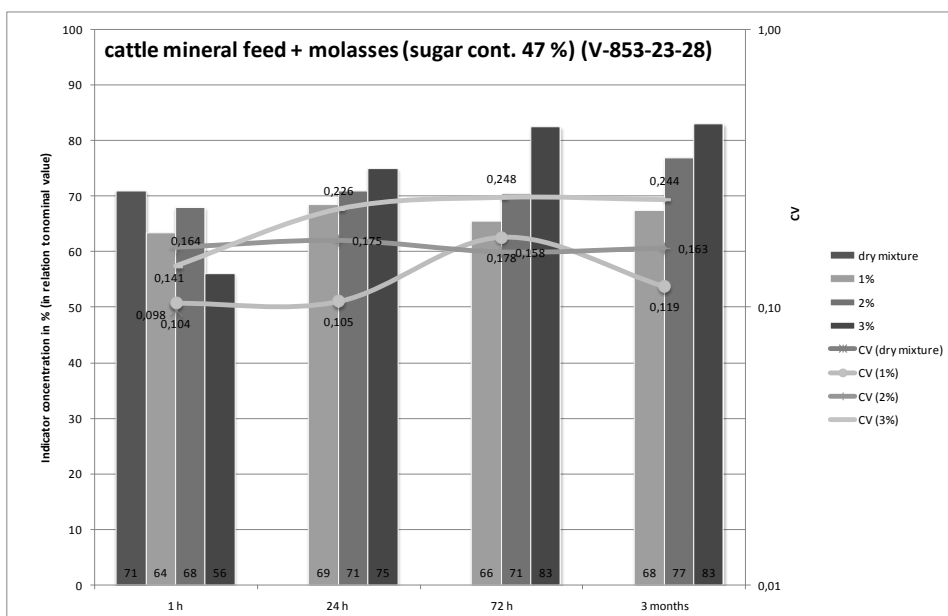


Fig. 3: Mixture stability of cattle mineral feed and molasses considering storage periods

In Figure 4 results on mixture stability are shown when applying 1 and 3 % soy oil instead of molasses to cattle mineral feed.

Due to the applied stressing method (respectively active forces in the air cyclone causing the separation of fines) for the evaluation of the results there should be a special focus on the segregation effect described by indicator concentration in the samples in relation to the nominal value (100 %). Generally, segregation may be evaluated by the coefficient of variation which in this case is not sufficient only.

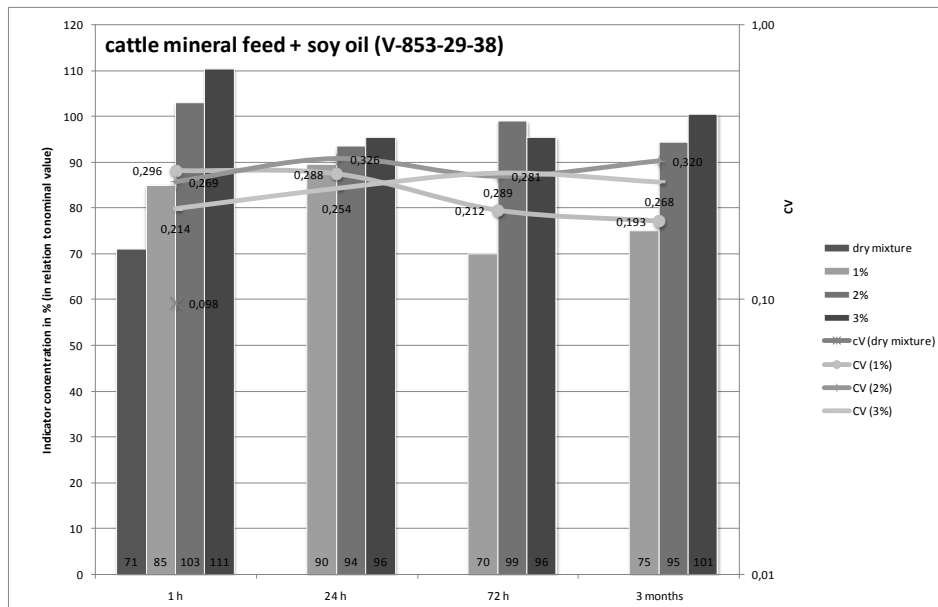


Fig. 4: Mixture stability of cattle mineral feed and soy oil considering storage periods

To mark up a significant and enduring effect on mixing stability – characterized by the indicator concentration – for the considered examples, a minimum amount of 2 % of molasses or soy oil should be added. Differences in stabilization between molasses and soy oil can be found when soy oil is more effective than molasses in the bond of fines directly after the application as well as after a storage period of three months. However, the distribution of the colour indicator respectively the CV is not sufficient in any case.

The effect of stabilization of bulk materials by adding liquids seems to be depending on specific liquid and bulk materials properties, however, not only the particle size distribution. For every bulk material there seems to be a specific minimum amount of liquid forcing formation of liquid bridges and therefore of agglomeration and stability. The interdependencies of all possible material properties of liquids and bulks are not sufficiently known at the moment.

The comparison of the considered examples and the over-all results of the experimental investigations at the IFF Research Institute shows, that a simple explanation on the influence of liquids for stabilization of feed powders cannot be given.

CONCLUSIONS

The expected influences on mixture stability due to different liquid properties and different amounts of liquid could be marked up and suggestions for improving the feed quality can be made. But a general conclusion

concerning a liquid application to feeding stuff powders in the main mixer as an aspect of feed quality and safety is not possible due to several material properties of liquids and bulks. Continulative investigations on the topic are eligible.

REFERENCES

- Feil, A., 2009, Effiziente Verarbeitung von Zusatzstoffen in Mischfutterrezepturen, Schüttgut Vol. 15 (2009), No. 4, pp. 214-224
- Heidenreich, E., 1998, Die Zugabe von Zusatzstoffen und die Gefahr von Verschleppungen, Mühle+Mischfuttertechnik Vol.135 (1998) Nr. 10, pp. 297-300
- Heidenreich, E.; Löwe, R.; Strauch, W., 2003, Verbesserung der Mischungshomogenität und Stabilität von Feststoffmischungen durch Anpassung der Komponentenstruktur, Schüttgut Vol. 9 (2003) No. 3, pp. 172-176
- Schubert, H., 2003, Handbuch der mechanischen Verfahrenstechnik, Band 1, Wiley-VCH Verlag Weinheim, 2003
- Weinekötter, R.; Gericke, H.; 1995, Mischen von Feststoffen – Prinzipien, Verfahren, Mischer, Springer Verlag, 1995