

Effect of ribbon mixer fill rate on animal feed homogeneity –Tecaliman trials

The growing use of animal feed additives, active at low concentrations and incorporated at low rates, means that increasing attention is being paid to the control of homogenisation operations. Against this background and driven by trade (manufacture of small batches) or economic (increase in plant production rates) constraints, there is a need for greater insight into how mixer fill rate impacts on homogenisation quality.

1. General

It is important to stress that manufacturers may have differing perspectives and methods for determining the concept of fill rate.

Very few publications provide any insight into how this factor actually affects the homogeneity of mixed animal feeds. The Animal Nutrition industry tacitly recognises the instructions given by equipment manufacturers and summarised by Drevet (1970) i.e. *fill to a level above the internal coil and below the external coil; this is not, however, backed up by any scientific evidence.*

2. Trough-shaped ribbon mixer

2.1. Pilot trials

Table 1 sets out the conditions for carrying out these trials. Using coloured iron particles (microtracers F-red), the results of the first two pilot trials (Trial No. 1: Figure 1 and Trial No. 2: Figure 2), gave slightly different results (blank plot points indicate significant variance analyses). For Trial No. 1, the CV_{total} for plot point 1 can be explained by a high residual variance. The increase in heterogeneity is only apparent though; using CV_{homogeneity} values suggests that homogeneity does not vary according to fill rate. For Trial No. 2, the same tracer indicated enhanced performance when the fill rate was increased from 29 to 73%. This difference could perhaps be explained by the difference in experimental conditions, as Trial No. 1 used wheat flour, while Trial No. 2 used piglet feed.

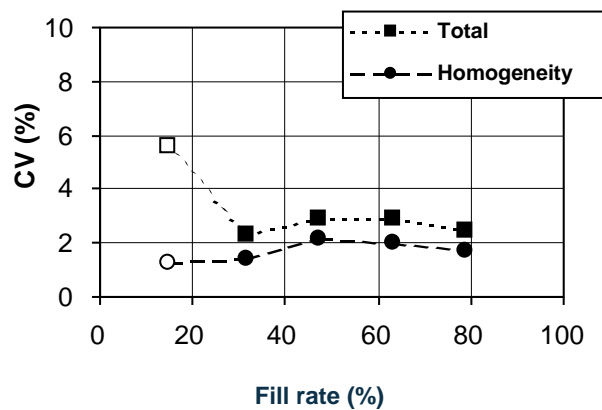


Figure 1: Results of Trial No. 1

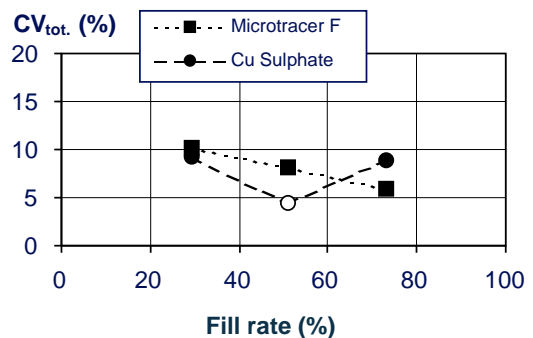
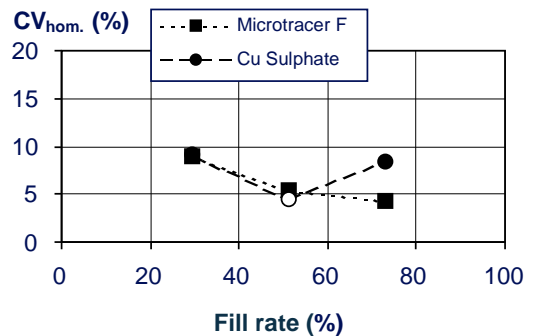


Figure 2: Results of Trial No. 2

| | Trial No. 1 | Trial No. 2 | Trial No. 3 |
|---------------------------|-----------------------------------|---------------------------------------|-----------------------------------|
| Mixer | Gondard ribbon mixer - 224 litres | Gondard ribbon mixer - 224 litres | Gondard ribbon mixer - 224 litres |
| Matrices | Wheat flour (634 g/l - 530 µm) | Piglet feed (630 g/l - 600 µm) | Wheat flour (652 g/l - 338 µm) |
| Tracer type | Microtracer F-red | Copper sulphate (330 µm - 240 ppm Cu) | Microtracer RF-blue |
| Particle size | (300 µm- 2000 ppm) | Microtracer F-red (300 µm- 1000 ppm) | 250 ppm |
| Incorporation rate | | | |

Table 1: Conditions for carrying out pilot trials on a trough-shaped horizontal pilot mixer

The findings of Trial No. 2 also demonstrate that the respective behaviours of the copper sulphate and the microtracers diverge when the fill rate is 73% (Figure 2). The copper appears to reveal the existence of a focal point around which performance levels would be higher.

Trial No. 3 explains this apparent fluctuation (Figure 3) as being due to an issue with the reproducibility of the trials. In this trial, homogeneity was determined 7 times for each of the three fill rates, and gave observable variations in the results (the vertical bars correspond to +/- two standard deviations, i.e. 95% of the population). Overall however, the mean value and the position of the group of CV plots decreased as fill rates increased. This variation applied within a fairly narrow spread of 1% around the means. The variation was masked by the use of CV_{total} (Figure 3, bottom) and only became clearly evident when $CV_{homogeneity}$ (Figure 3 top) was used. As the trials were not repeated the meaning of this variation could not be clearly identified.

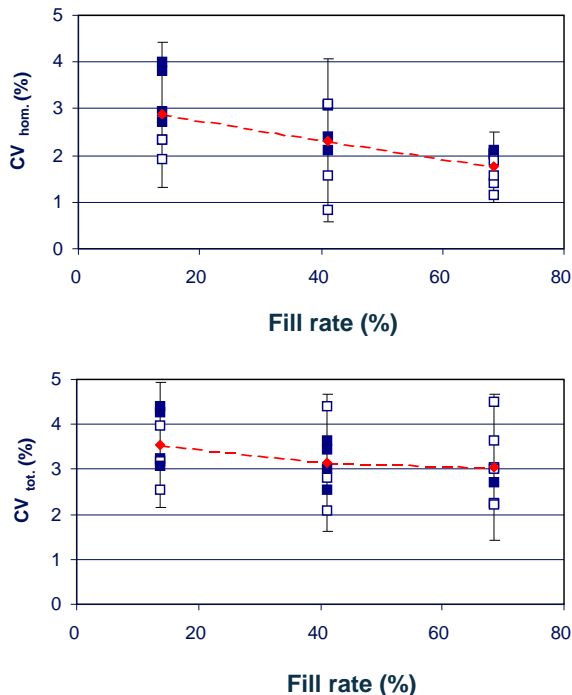


Figure 3: Results of Trial No. 3

2.2. Industrial trials

The results of the 2 industrial trials, the experimental conditions of which are given in Table 3, showed a slightly different set of changes (Table 2 and Figure 4). The tracers indicate that the changes are variable, which tends to argue in favour of performance stability in the areas of variation under study.

| | Fill rate | | | | | |
|------------------|--------------|-------------|----|--------------|-------------|----|
| | 33 % | | | 83 % | | |
| Tracers | CV_{total} | $CV_{hom.}$ | | CV_{total} | $CV_{hom.}$ | |
| Dmz | 2.3 | 1.5 | S | 2.7 | 1.4 | NS |
| Chlorides | 5.8 | 0 | NS | 5.9 | 0 | NS |
| Zinc | 4.1 | 1.0 | NS | 4.5 | 0 | NS |
| Manganese | 2.1 | 0 | NS | 2.6 | 0.9 | NS |

S: significant difference with a 95% confidence interval - ns: no significant difference with a 95% confidence interval

Table 2: Coefficients of variation for Trial No. 4 - Industrial trough-shaped mixer

In Trial No. 4, while the CV_{total} all appeared to increase slightly, all $CV_{homogeneity}$ values were practically of the same order of size, i.e. between 0 and 1.5%. These findings indicate the strong performance of the trialed mixer. The absence of any significant differences in 7 cases out of 8 also indicates that the mixer was operating at the upper limit of the analysis capabilities using the chosen tracers.

The results of Trial No. 5 also varied widely (Figure 4), particularly in terms of CV_{total} . These results demonstrate that it would be rash to define mixer performance based on a single tracer and 10 single analyses (without studying the residual variance). The dimetridazole appears to indicate that mixer performance declines by nearly 4% as the fill rate increases. The copper and microtracer F point rather at the stability of $CV_{homogeneity}$. While microtracer F did identify a slight 2% increase in CV, pilot Trial No. 3 demonstrated, however, that this type of variation could be due to issues with assessment variability.

| | Trial No. 4 | Trial No. 5 |
|---|---|---|
| Mixer | Trough-shaped ribbon mixer 10000 litres | Trough-shaped ribbon mixer 12000 litres |
| Rotation speed | 250 kW - 22 rpm | 250 kW - 17 rpm |
| Mixed product | Duck feed (600 g/l - 525 µm) | Piglet feed (600 g/l - 500 µm) |
| Tracer type | Dimetridazole (37 µm - 300 ppm) Sodium chloride (195 µm- 4000 ppm) Manganese sulphate (120 µm - 200 ppm) Zinc sulphate (390 µm - 1000 ppm) | Dimetridazole (360 µm - 1000 ppm) Copper sulphate (330 µm - 600 ppm) Microtracer F (300 µm - 500 ppm) |
| Particle size and incorporation rate | | |

Table 3: Conditions for carrying out trials on trough-shaped horizontal industrial mixers

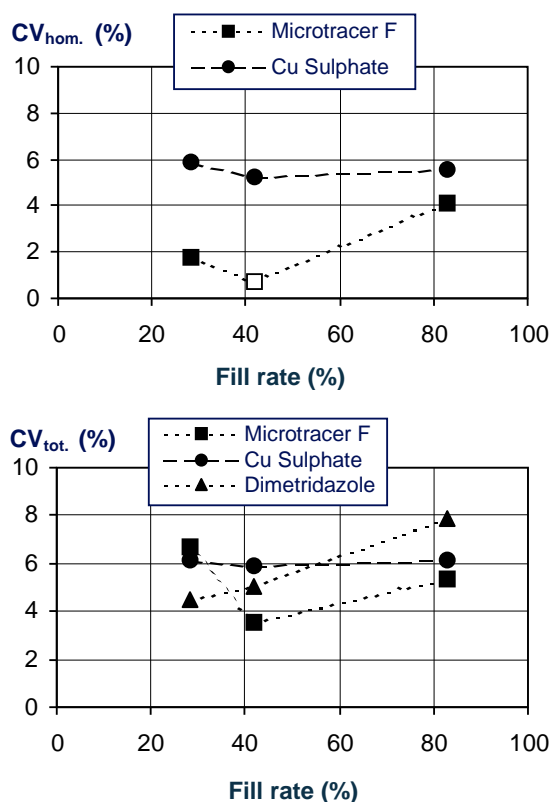


Figure 4: Results of Trial No. 5

2.3. Conclusions

The results of the pilot trials suggest that the performance of the trialled mixer also improves up to a fill rate of 70%, while remaining acceptable throughout the whole area of study. All the results appear to be consistent with a performance that remains stable within a range of 25-80% in volume. However, performance levels may decline outside of this range.

3. Drum-shaped ribbon mixer

All the trials run on drum-shaped mixers were carried out in an industrial setting (Table 4). Trial No. 6 studied the effect of fill rates of between 68 and 92%. The results (Figure 5) demonstrate that chloride homogeneity shows only minor variation within the studied area. However, the chosen tracer is vehicled in part by the raw materials, which prevents any meaningful tests on this mixer's performance levels.

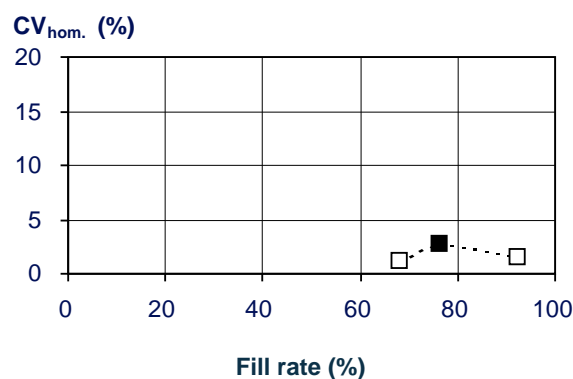


Figure 5: Results of Trial No. 6

Trial No. 7, carried out with a mixing time of 120 seconds (Figure 6) or with a range of mixing times (Figure 7), explores a wider variation area (from 20 to 140% of the maximum volume recommended by the manufacturer i.e. 8500 litres for 100%) using a mixer of an identical design but lower capacity.

| | Trial No. 6 | Trial No. 7 |
|---|--|---|
| Mixer type | Drum-shaped ribbon mixer -18000 litres | Drum-shaped ribbon mixer - 12000 litres |
| Rotation speed | 250 kW - 15 rpm | 250 kW - 15 rpm |
| Matrices | Piglet feed (610 g/l - 560 µm) | Soya rate - Rapeseed rate (590 g/l - 660 µm) |
| Tracer type | Sodium chloride (466 µm - 4000 ppm) | Microtracer RF (90 µm- 125 ppm) Manganese sulphate (120 µm - 1000 ppm) |
| Particle size and Incorporation rate | | |

Table 4: Conditions for carrying out trials on industrial drum-shaped ribbon mixers

Figure 7 illustrates that while this factor does not impact on homogeneity at fill rates of between 20 and 100%, there is a risk of uneven mixing at a fill rate of 140%, and that this risk is particularly significant for manganese. While this trend is confirmed by the microtracer, it is nevertheless not as strong. There is a minor impact, mainly evident in the short homogenisation time (78 s.) (Figure 7). Increasing the mixing time thus significantly reduces the impact of fill rate on mixing quality.

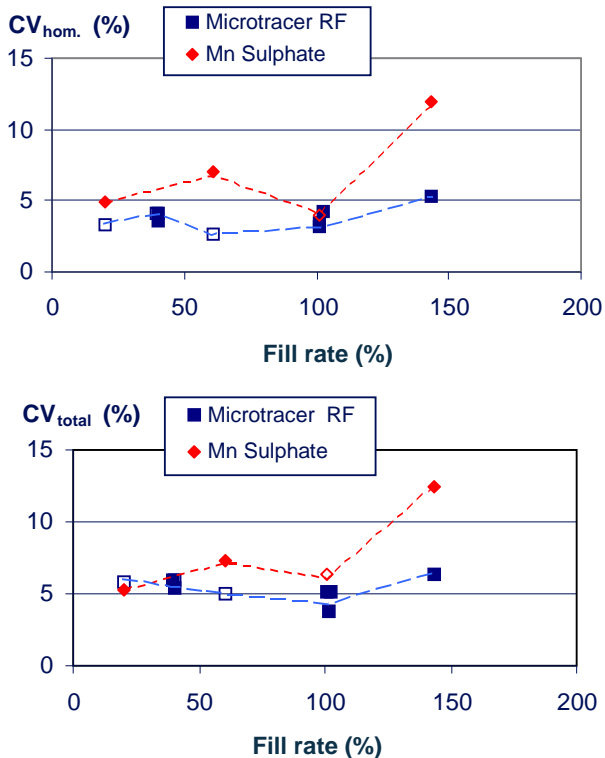


Figure 6: Results of Trial No. 7 using 2 tracers - Industrial drum-shaped mixer

This shows that at 162 seconds, the recorded coefficients of variation are virtually identical, whatever the fill rate. Lastly, within the limits of the manufacturers' specified fill rates, the performance of drum-shaped mixers is very similar to that of trough-shaped mixers. However, drum-shaped mixers appear better able to produce even mixtures at low fill rates.

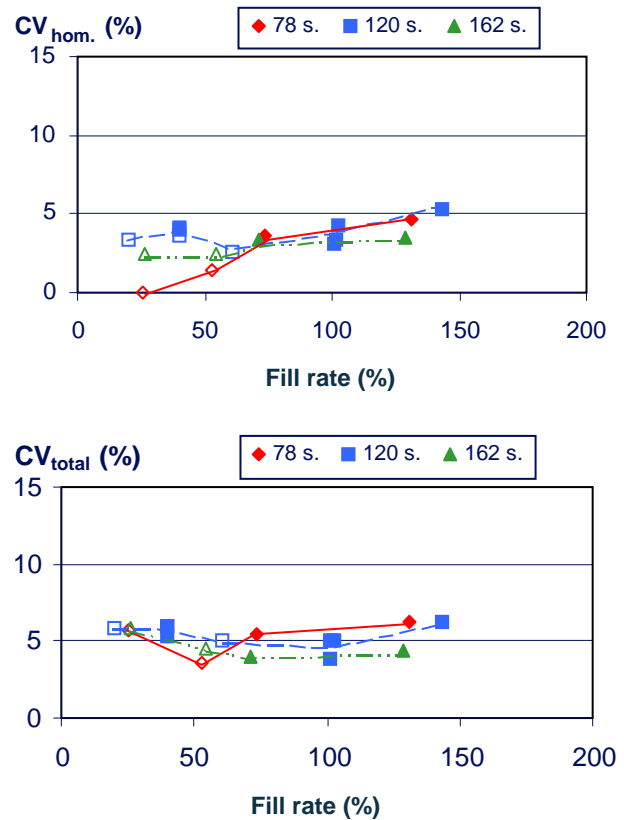


Figure 7: Results of Trial No. 7 carried out using microtracer RF according to fill rate and mixing time - Industrial drum-shaped mixer

4. General conclusion

These findings on the impact of mixer fill rates therefore demonstrate that this parameter has little impact on homogeneity within the standard operating range (20 to 80%) for the two types of mixer studied.

All the studies suggest that reverse ribbon mixer fill rates may vary widely without adversely affecting mix capacity. For trough-shaped mixers, the risk situation appears to relate to over-filling rather than under-filling. It is only this first case that apparently cannot be counterbalanced by increasing the mixing time.

Lastly, by repeating the pilot trials, it was possible to demonstrate that the variation in homogeneity measurement results was more closely linked to the measurement conditions rather than the variation in fill rates.

5. Bibliography

Drevet S., 1970. The mix. UCAAB seminar. 8.