

Effect of premixer or premix usage on feedstuff homogeneity

1. Context

The animal feed industry makes widespread use of micro-ingredient premixers and premixes. Several authors have described the advantages of these techniques. Coelho (1994) considers that *the main reason for using premixes is to optimise the dispersion of ingredients*. Raghavan (1997) also considers that this rationale is one of the 4 main advantages of using premixes:

- dilution of active products
- facilitation of in-mix dispersion
- lower carry-over risk
- Improved storage stability.

The review PBE Int. (1998), which defines the term "Premixing" as a mix of a formulation of minor or micro ingredients in a premix (also referred to as a "master batch") that is subsequently added to a larger final batch, states that this process helps to homogenise the ingredients in the final batch.

Several authors consider that the low incorporation rates for additives or drug substances require feedstuffs to go through several premixing phases (Bloom and Livesey, 1953 - Konen, 1958 - Hotchkiss, 1960 - Hamilton, 1960 - Pierce, 1960 - Benson, 1966 - Gondard, 1978 - Laffolay, 1980 - Keller, 1987 - Melcion and Janet, 1992). Jansen (1992) also believes that dispersion is facilitated by the use of pre-diluted additives, and stresses that being able to weigh larger quantities improves dosage accuracy. Axe (1995) adds another advantage, that of minimising behavioural differences between ingredients with extremely different characteristics.

Wilcox (1985) also recommends the use of premixes aimed at limiting the coefficient of variation of a product's dispersion pattern. However, he also states that *diluting a premix cannot compensate for errors in mixer design, equipment wear and tear, or for deficiencies in design or operating practices, but it can limit the variation between the manufactured feedstuffs*.

McElhiney and Tangprasertchai (1983) trialled premix manufacture in a 110-kg mixer, and then placed a portion of these premixes into final mixes

produced in a 454-kg mixer. Double-ribbon horizontal mixers were used in both cases. After a 3-minute final mixing time, 20 samples of 900 g were taken, and then divided into 4 sub-samples on a riffle splitter for each of the subsequent analyses.

Three tracers were used: one drug, sodium chloride, and coloured iron particles (F-microtracer). The tested premix dilutions involved direct injection of the traced products at ratios of 1/1, 1/5, 1/10, 1/25, 1/50. Their results (Table 1) show that premixes do not systematically improve dispersion patterns in the final feedstuff, and often give comparable dispersion results.

Dilutions	Cv _{drug} (%)	Cv _{chlorides} (%)	Cv _{F-microtracer} (%)
Direct	6.59	9.67	18.82
1/1	4.34	6.98	23.34
1/5	6.56	26.42	22.87
1/10	6.64	9.04	30.09
1/25	7.17	9.36	21.11
1/50	4.97	8.74	25.38

Table 1: Extract of the results table (according to McElhiney and Tangprasertchai, 1983)

Heidenreich and Strauch (2000) also state that tests conducted with a Forberg brand mixer and a double-trough/double-ribbon mixer were unable to confirm whether the use of a tracer premix had any significant effect on the homogeneity of the final batch. Of all these publications, only McElhiney and Tangprasertchai included their test results, while other authors stated their opinions or referred to findings without publishing their test results.

There is a possibility though that premixes do indeed facilitate dispersion. One likelihood is that while the premix may not provide any significant advantage when using free-flow powders, it may facilitate the dispersion of cohesive powders which can then be pre-dispersed.

The most likely assumption is that using a premix phase may help to reduce mixing times in a given mixer. Pfost (1967) indicates that a more diluted premix, incorporated at 30%, would be

homogenised quicker than a premix injected at 11%. Friedrich and Jansen (1974) trialled two techniques - direct incorporation or the use of 1 or 2 premix phases. Their findings revealed that where shorter mixing times are concerned, tracers disperse faster when using a premix. The visible variances for short mixing times (60 seconds) disappeared at 240 and 300 seconds.

This suggests that the findings of McEllhiney and Tangprasertchai (1983) might be explained by the fact that carrying out the tests on a small mixer over a sufficiently long mixing time (3 minutes) effectively erased the advantage of using the premix in this case.

For nearly 20 years now, Tecaliman has been carrying out tests designed to provide insight into these issues.

2. Premixer tests

Tecaliman carried out its first tests in 1989. At this time, and at an industrial site, Tecaliman studied the effect of an initial premix phase on the incorporation of medicated premixes at 0.5%. The tracer was copper, injected at approx. 130 ppm via copper sulphate (500 ppm). The premix time was set at 3 minutes (12.5 kg of medicated premixes in 37.5 kg of soyabean cake). Two tests were carried out: one used the premixer, while the other injected the copper directly into the mix. The mixing time was set at 4 minutes for both 2.5-t batches. Fifteen 1.2-kg samples were taken at the elevator output downstream of the mixer. The calculations made at the time gave comparable variances. The study therefore concluded that there was no need to use a premixer for this type of incorporation at the plant in question. These conclusions were confirmed by running the data through a subsequent variance analysis, based on the randomised model, which gave a $CV_{\text{homogeneity}}$ of 0.0% without using the premixer, and of 2.9% when using the premixer.

3. Premix tests

In 2003, Tecaliman carried out tests similar to those of McEllhiney and Tangprasertchai, but that also stimulated the "mixing time" factor.

3.1. Equipment and apparatus

3.1.1. Mixers

The mixes were produced in a 100-l blade mixer, with a blade rotation speed of 45 rpm. The premixes were produced in a Kenwood brand laboratory mixer.

3.1.2. Feedstuffs

Two feedstuffs were used: dairy cow and broiler chickens (Table 2).

	Dairy cow	Broiler
Median diameter (μm)	427.5	621.1
Bulk density (g/l)	656.7	593.2
Angle of repose ($^{\circ}$)	23.1	41.4

Table 2: Feedstuff characteristics

3.1.3. Tracer

The test used the RF-blue lake microtracer, with Rofelys as the premix excipient.

3.2. Method

3.2.1. Preparing the premixes

Table 3 gives the proportions of the 3 premixes.

	Premixes		
	50 %	12.5 %	5 %
Microtracer	250 g	62.5 g	30 g
Rofelys	250 g	437.5 g	570 g
Total weight	500 g	500 g	600 g

Table 3: Preparing the microtracer premixes

3.2.2. Incorporating the premixes

Each premix or pure microtracer was incorporated in exactly the same way: with the machine stopped, in the centre of the mixer, placed flat above the feedstuff. Incorporation rates were set so as to obtain a final microtracer concentration of 250 ppm.

3.2.3. Test plan

The **first series** of tests involved eight 40-kg mixes of dairy cow feed with 2 mixing times (2 min. and 30 s.) x 4 incorporation methods (pure, and premixes at 50%, 12.5% and 5%). In each case, 20 samples of 250 g each were taken in the form of quartered sub-samples at the mixer output (10 above and 10 below); each sample was analysed twice.

The **second series** of tests involved 50-kg mixes of poultry feed using a non-optimal mix with an insufficient mixing time (15 s.), based on the assumption that any effect induced by the level of premix dilution would be easier to identify in a non-optimal mix. The other test conditions were similar.

3.2.4. Processing the results

Conducting dual-analyses on the 20 samples collected for each mix made it possible to run a randomised model variance analysis (see i'Tec_H3).

3.3. Results

3.3.1. First series

The first series of tests involved dairy cow feed mixes given 2 minutes (Table 4) or 30 seconds of mixing time (Table 5).

	Pure	50% premix	12.5% premix	5% premix
Recovery rate (%)	82.0	104.2	100.4	92.4
Calculated F	6.1	2.5	4.2	1.4
Significance	s	s	s	ns
CV_{total}	11.6	5.2	5.7	5.8
CV_{residual}	6.2	3.9	3.5	5.3
CV_{homogeneity}	9.2	3.4	4.5	2.8

Table 4: Results of the 2-minute tests on dairy cow feed

When running the tests with a 2-minute mixing time, it appeared that the method used to clean the mixer was inappropriate, as all the dust was recovered in the tray under the mixer, which had an adverse effect on the sampling performed in the top section (higher concentrations). This raised the possibility that the results were skewed. Recovery rates were variable but lay within the range of acceptability.

The high CV_{residual} values indicated that certain analysis errors had been made (incorrect microtracer recovery, incorrect solvent sampling, etc.). All these instances of incorrect handling were corrected in the other tests.

Despite these errors, the results gave a preliminary assessment but should, however, be treated with caution. The tests with premixes at 50% and 12.5% gave acceptable results (low CV_{residual}). Based on the CV_{homogeneity} values, these results can be considered comparable.

	Pure	50% premix	12.5% premix	5% premix
Recovery rate (%)	96.2	93.1	104.1	95.7
Calculated F	1.18	1.15	1.41	4.72
Significance	ns	ns	ns	s
CV_{total}	6.7	4.3	3.5	5.0
CV_{residual}	6.2	4.2	3.2	3.0
CV_{homogeneity}	2.4	1.1	1.4	4.0

Table 5: Results of the 30-second tests on dairy cow feed

The results of the 30-second tests recorded very acceptable recovery rates. In three out of 4 tests, the inter-sample variance was not significant, which confirmed that the fairly satisfactory CV_{homogeneity} values (from 1.1 to 4.0) were generally comparable. It is surprising to note that the CV_{residual} values appeared to decrease as the premix's dilution rate increased.

This suggests that, despite the effects of analytical error, both tests point to the absence of any effect of the premix's dilution rate on final mix homogeneity. The second test series was carried out with a shorter mixing time in order to check this conclusion.

3.3.2. Second series

These tests were performed on broiler chicken feed

using a shorter test time. Its higher fat content make this feed more cohesive, which should limit its additive dispersion capability.

These 15-second tests gave similar results overall (Table 6). Recovery rates were excellent and close to 100%. The low CV_{residual} values (between 2 and 3%) meant that all inter-sample variances were significant.

	Pure	50% premix	12.5% premix	5% premix
Recovery rate (%)	102.8	101.5	105.0	100.0
Calculated F	38.1	18.3	29.4	30.4
Significance	s	s	s	s
CV_{total}	10.3	8.5	9.4	8.6
CV_{residual}	2.3	2.7	2.4	2.2
CV_{homogeneity}	10.0	8.1	9.1	8.3

Table 6: Results of the 15-second tests on broiler chicken feed

These tests gave similar CV_{homogeneity} values of between 8.1 and 10.0%, which demonstrates that the percentage of tracer dilution has little impact on the tracer's final dispersion pattern. The results of incorporating pure tracers (at 15 seconds and 2 minutes) were the only ones that might suggest a slight disadvantage in this method of incorporation, although this conclusion was not confirmed by the results of the 30-second test.

4. Conclusion

The findings of these tests therefore agree with those of McElhiney and Tangprasertchai (1983) and the observation made by Heidenreich and Strauch (2000). They effectively contradict all the findings published by other authors.

This would suggest that implementing a premix phase, whether internal (premixer) or external (premix) at animal feed plants does not improve additive dispersion, even where non-optimal mixes are concerned.

Note, however, that this observation does not invalidate the use of premixes, which have many other advantages, among which we can cite:

- Reduction in product inventories and their related management: the animal feed plant does not have to inventory multiple premix products and their use-by dates.
- Purchase prices: The premixer can negotiate better price deals than the feed manufacturer, as they buy larger quantities of products that are ultimately incorporated in small quantities.
- Dosage accuracy: animal feed plants are not always equipped with high-precision dosing facilities for multi-microcomponents, which would be required if using a premix.
- Time-saving at the animal feed plant: the multi-dosing of several microcomponents would be very time-intensive in the plant's time diagram.

- Reduction in carry-over: a residue of diluted active product will always be less contaminating than the same quantity of concentrated residual product.

Note also that lower carry-over rates are often recorded at animal feed plants that have removed the premixer, as any residual premix found at this location could lead to significant carry-over in the next batch.

5. Bibliography

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