i’Tec_T3
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An investigation into how the physical properties of additives influence the behaviour of carry-over in animal feeds

The amount of carry-over measured in a system may derive from three main sources:

- system geometry.
- system operating procedure.
- physical properties of the carry-over products.

This datasheet sets out some of the results collected either during pilot trials, or at a premix production plant, with the aim of studying the third-listed source.

1. Pilot trial

1.1. Method

The aim was to test how collector products influence measured carry-over rates. Figure 1 shows a diagram of the pilot system used in the trial.

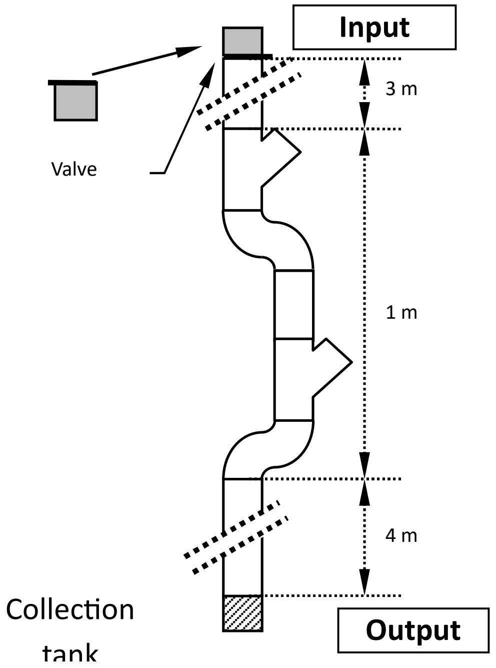

Figure 1: Diagram of the pilot system

The pilot system consisted in a PVC tube with diameter 80 mm and height eight metres. The system also contained a bend designed to create turbulence and dead spots in which dust could be collected.

Six collector products were tested. The tracer used was a 90-µm, blue metal microtracer. 500 g of carbonate containing 25 g of microtracer was used to contaminate the circuit.

Once the tracer batch had been run through, the same volume (330 ml without compacting) of collector product was run through the circuit. Given the differing densities of these collector products, the quantities used were of different mass (Table 1).

Collector product	Mass introduced (g)	Quantity of tracer recovered (g)	Carry-over (% of 25 g)
Carbonate	500.0	0.697	2.79
Wheat flour	233.8	0.533	2.13
Corn cob	142.3	0.438	1.75
Corn flour	241.2	0.703	2.81
Bran	89.6	0.482	1.93
Glass beads	502.8	0.564	2.26

Table 1: Quantities of product used and results

1.2. Results

Each collector product recovered different quantities of microtracer (Table 1). This means that any assessment of carry-over rates may vary depending on which collector product was used. The most effective products in terms of overall recovery were carbonate and corn flour. However, for the homogeneity assessment tests, the laboratory analysed aliquot portions sampled in grams in order to express a result as the ratio between mass of tracer and mass of mix. When the results were expressed as concentrations (Table 2), the best performance was obtained with bran, due to its light weight, followed by corn cob and corn flour.

Collector product	Concentration in tracer (g/kg)
Carbonate	1.39
Wheat flour	2.28
Corn cob	3.08
Corn flour	2.91
Bran	5.38
Glass beads	1.12

Table 2: Tracer concentration in each collector product

2. Industrial trials

2.1. Method

Four additives (A, B, C and E) were tested at a premix plant. A mix containing 80% carbonate/20% additive was used as the tracer batch. Three batches of middlings were used to assess the resulting carry-over.

The test media (carbonate and middlings) were dosed automatically. The additives were weighed manually, and then incorporated using a bag emptying station.

The circuit consisted of:

- One pneumatic conveyor belt
- One hopper on the mixer
- One horizontal plough-share mixer
- One hopper under the mixer
- One sieve shaker
- One cell
- The bagging system

One rinsing batch of a ton of carbonate was introduced into the circuit prior to the test.

For each additive, one ton of tracer batch was produced followed by three collector batches of 760 kg of middlings, 200 kg of which were introduced via the bag emptying system (Figure 2). The tracer batch was bagged in forty 25-kg bags, while the collector batches were bagged in thirty-eight 20-kg bags.

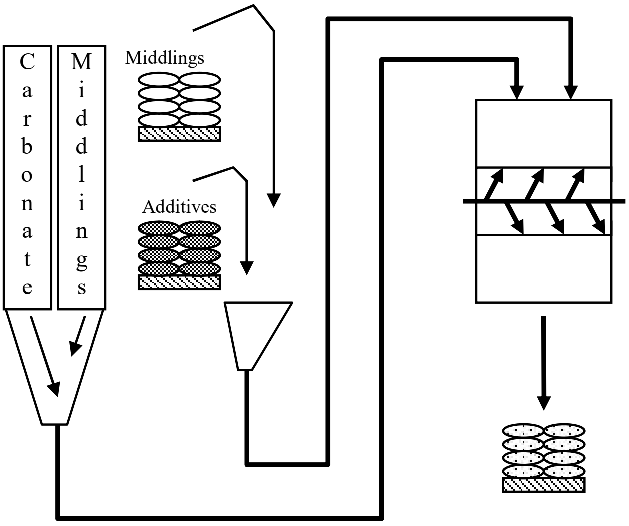

Figure 2: Diagram of the circuit

These batches were produced without any added liquid. The quantities of each batch ensured that the mixer was filled to 50%.

Each bag for all tracer and collector batches was sampled using a corkscrew sampling probe. Each sample was then blended separately. Each sample was divided into two; one part was stored and a fixed portion of the other sample was added to an aggregate group corresponding to each batch. Once mixed this aggregate group was used for the analyses.

The ratio between the mean of the tracer mixing concentration at circuit output and the mean of the collector mixing concentrations measured at the same location was calculated for each tracer. Expressed as a percentage, this ratio indicated the carry-over rate for each additive.

2.2. Results

The four additives generated fairly low carry-over rates for the first rinsing batch, which were all reasonably similar (Table 3).

Product	Batch 1	Batch 2	Batch 3
A	6.25	1.06	0.80
B	4.56	0.37	0.23
C	3.85	0.23	0.08
E	5.92	0.53	0.26

Table 3: Percentage carry-over according to product concentration in the tracer batch

In accordance with current findings, the carry-over rate was seen to decrease over successive collector batches. The additive ranking remained the same for all three collector batches, from the most to the least persistent:

A > E > B > C

The consistency of the results validated the protocol. Conversely, the homogeneity of inter-batch product ranking casts doubt over the usefulness of searching for products over three collector batches. Reducing the number of collector batches would appear to be feasible and would provide for cutting the industrial site's intervention costs.

While several of the additives' physical properties appeared to have an effect, it quickly became evident that carry-over in the first collector batch could not be explained by the same properties as carry-over in collector batches 2 and 3.

2.2.1. Carry-over to the first collector batch

Initially, carry-over levels appeared to be slightly influenced by additive tap density (Figure 3). The heavier the product, the greater its impact on carry-over rates in the first batch. However, this observation was not confirmed by the relationships between bulk density and particulate matter density. The positions of plot points A and E also undermine this relationship, particularly as this involves products with the smallest particle size. This would suggest that this parameter is not one of the elements contributing to persistence in the feed circuits.

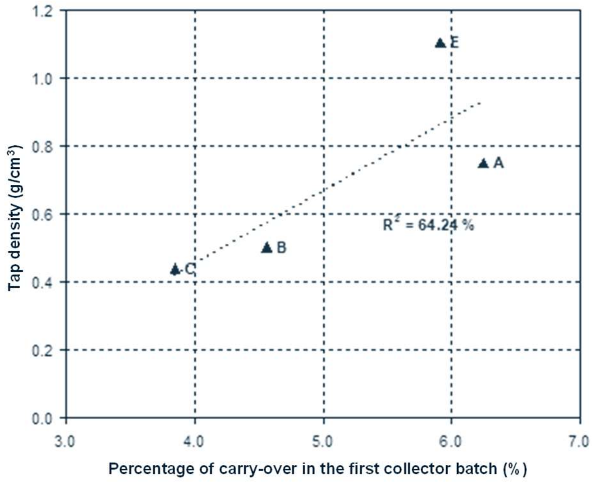

Figure 3: Influence of tap density on the percentage of carry-over in the first collector batch

The carry-over level in batch 1 also appeared to be influenced by powder particle size. This conclusion could only be arrived at via image analysis measurement. The median diameter property established by this type of analysis is one of the properties linked to carry-over rates in batch 1 (Figure 4). This relationship would appear quite logical, i.e. the smaller a product's particle size, the longer it persists in the feed circuit. This change appeared after an apparent breach of the limit value at approx. 100 to 200 µm.

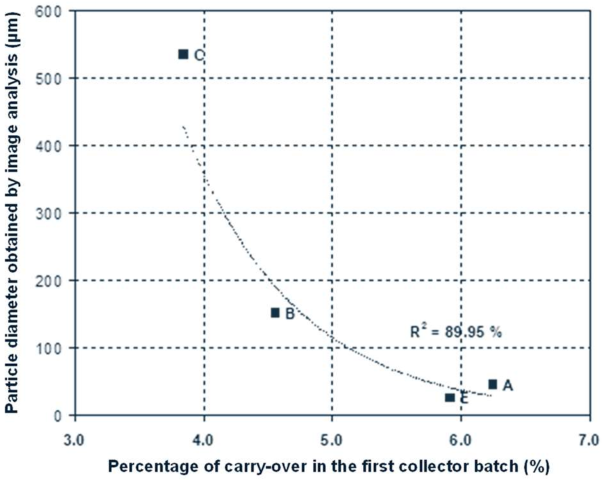

Figure 4: Influence of additive median diameter on the percentage of carry-over in the first collector batch

This particle size effect was confirmed by the results of a comparison with the dust concentration measurement (Figure 5). This suggested that there is a close link between the carry-over level in the first collector batch and the additives' capacity to generate dust. The performance of this result was surprising given the inaccuracy of the Heubach method for measuring dust concentrations (see i'Tec_Q5). It should be noted, though, that this criterion had already been identified as a possible option by animal feed businesses, although by measuring rather the concentration of active agent in dust. It would appear that measuring dust rates could provide an alternative method with no need for chemical analysis.

However, while the relationship works well for the first collector batch, it becomes less relevant with succeeding batches.

This measurement cannot be used to predict carry-over in collector batches 2 and 3.

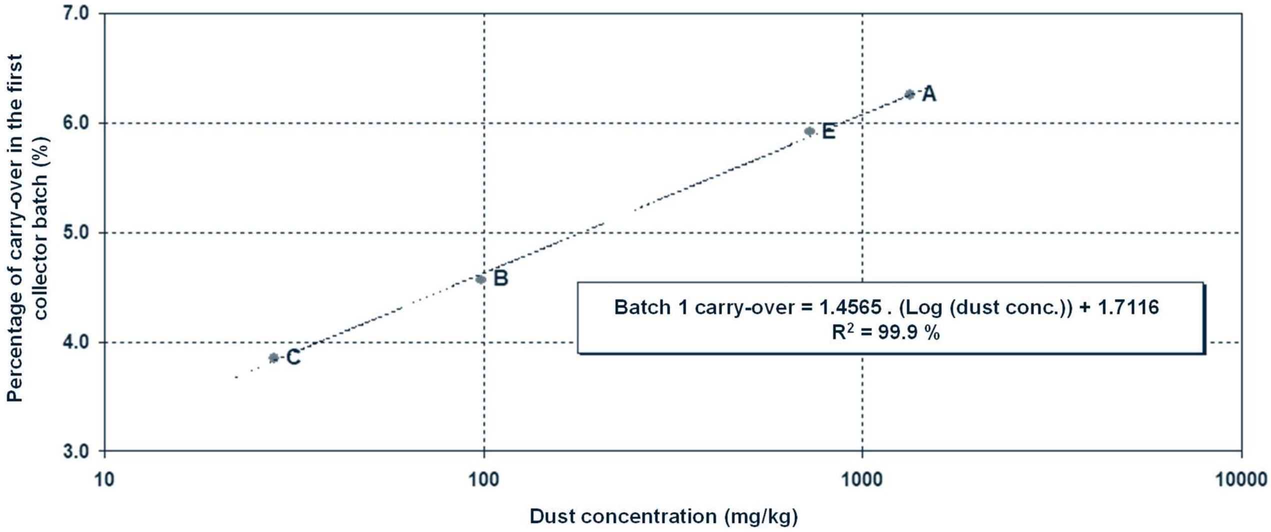

Figure 5: Influence of additive dust concentration on the percentage of carry-over in the first collector batch

2.2.2. Carry-over to other batches

Carry-over levels measured in the following collector batches did not appear to relate to the criteria that drove carry-over in the first batch. Another property appeared to have a significant influence: porosity (Figure 6).

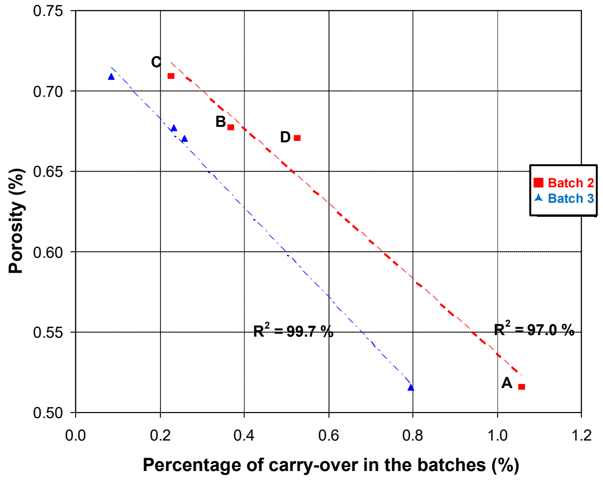

Figure 6: Influence of porosity on carry-over rates in collector batches 2 and 3

However, this raises several comments:

- This relationship only appeared in collector batches 2 and 3 and was completely absent in batch 1.
- Product A contributed mainly to formation of the straight line.
- Researchers have not been able to identify any physical explanation.

3. Conclusion

The main criterion that appears to influence carry-over in successive collector batches would therefore appear to be the amount of dust that the additives are capable of generating, whether measured using the direct method or via particle size analysis. It is likely that the small size of the test population might explain why this effect could not be revealed directly through laser diffraction particle size analysis. Additional tests will obviously be needed in order to confirm this assumption. It should also be noted that the nature of the collector product impacts on the result of the carry-over measurement. These results should therefore be considered within the context of the measurement made.

4. Bibliography

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