i'Tec_Q11
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Using Dustmon to investigate the intrinsic qualities of dust behaviour measurements

This research follows up on the studies detailed in i'Tec_Q10, which led to the selection of 5 products with varying dust behaviours based on the two selected criteria: dust area and sedimentation rate. The purpose is to provide greater insight into the intrinsic qualities of this measurement (repeatability, reproducibility, number of measurements) and to study its relationship with the conventional method - Heubach measurement (i'Tec_Q5).

1. Objectives

This final phase aims to study the repeatability and reproducibility of this method, and to determine whether there is any relationship with the measurements taken using the Heubach method.

2. Method

The relevant premixers were asked to provide a new, and larger, supply of each of the 5 selected products.

Each product was tested in the Dustmon device according to the following method: 50 g x 4 days x 5 measurements / days.

The following physical and behavioural characteristics were also identified for each product:

- Bulk density (BD)
- Tap density (TD)
- Hausner Index (HI)
- Laser particle size grading (d50) (1 analysis)
- Particle density (PD) (1 analysis)
- Dust measurement using the Heubach method (3 analysis)

3. Results

3.1. Physical characteristics

The results were compared with the physical characteristics database for 30 additives used in the manufacture of animal feeds (i'Tec_Q2).

For each recorded characteristic, the products were grouped in quartiles based on the data in this Datasheet. (Table 1)

		A	B	C	D	E
BD (g/cm3)	reading	1.174	0.668	0.598	0.621	0.563
	quartile	75 - 100%	50 - 75%	25 - 50%	25 - 50%	25 - 50%
TD (g/cm^3)	reading	1.281	0.825	0.781	0.719	0.758
	quartile	50 - 75%	50 - 75%	50 - 75%	50 - 75%	50 - 75%
HI	reading	1.091	1.235	1.306	1.158	1.346
	quartile	25 - 50%	75 - 100%	75 - 100%	50 - 75%	> 100%
D50 (µm)	reading	539.0	57.6	50.5	660.5	46.8
	quartile	75 - 100%	25 - 50%	25 - 50%	75 - 100%	0 - 25%
PD (g/cm^3)	reading	2.018	2.464	1.361	1.273	1.359
	quartile	50 - 75%	50 - 75%	25 - 50%	0 - 25%	25 - 50%
Heubach (mg/kg)	reading	0.0	2920.0	2044.0	3330.7	5606.7
	quartile	0 - 25%	75 - 100%	75 - 100%	75 - 100%	75 - 100%

Table 1: Physical characteristics of the selected products

Products B, C, D and E have an intermediate **bulk density**. Product A has a higher bulk density.

The 5 products have a **tap density** slightly above the median. They are all grouped in the same quartile.

Products A and D have a **Hausner Index** close to the median. Products B, C and E have a higher Hausner Index suggesting greater compaction-dependence, with a potential for poor flow.

Products B and C have an intermediate **median diameter**. Products A and D have a coarser grain size while product E has the smallest grain size.

Products A, C, D and E have a **particle density** close to the median. Product B has the lowest particle density, suggesting that it is composed of lighter particles.

Lastly, the **Heubach measurement** method indicates that product A is dust free. Products B, C, D and E are highly pulverulent (Figure 1).

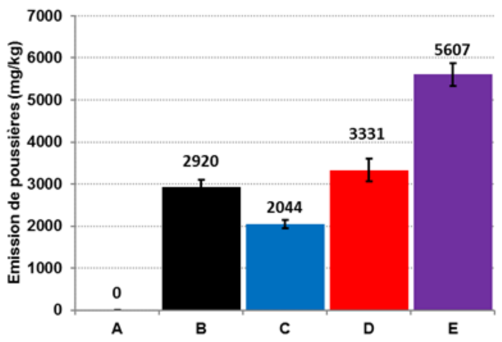

Figure 1: Measuring dust emissions using the Heubach method on a 50 g mass

3.2. Dustmon

The criteria selected for this study are **dust cloud size (dust area) and dust sedimentation rate**. The method used to identify these criteria is described in i'Tec_Q10.
This measurement campaign revealed that product A produces a negligible **dust cloud**. Product C generates an intermediate result. Products B, D and E generate large dust clouds (Figure 2).

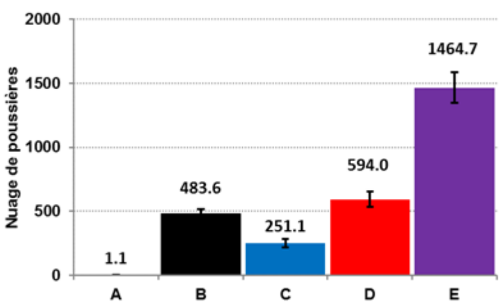

Figure 2: Dust clouds recorded for the 5 products

A variance analysis based on the measurements recorded over 4 non-consecutive days confirms that the 5 selected products are significantly different according to this criterion (Table 2).

Product	A	B	C	D	E
Dust cloud	1.0	483.6	251.1	594.0	1464.7
Group	e	c	d	b	a

Table 2: Dust cloud variance analysis

This same variance analysis demonstrates that this criterion is not subject to any "day" effect as shown in Figure 3. This measurement is therefore considered repeatable.

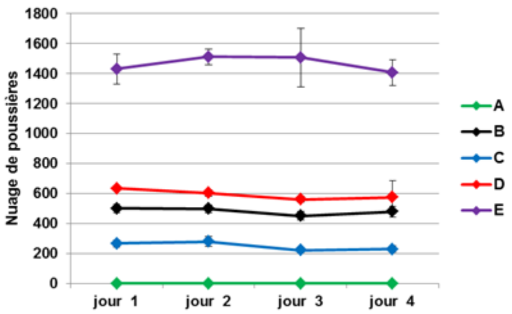

Figure 3: Day-related change in the dust cloud

Products C and E have a very high dust **sedimentation rate**. This rate is lower for products B and D and zero for product A (Figure 4).

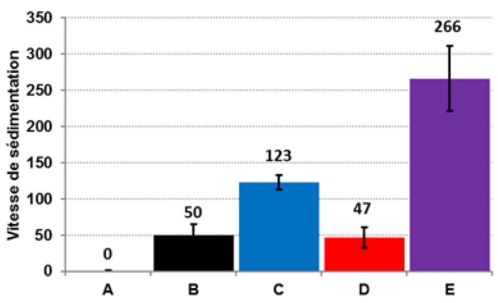

Figure 4: Sedimentation rate for the 5 products

The variance analysis performed on these results places products B and D in the same group and the 3 other products in 3 other, significantly different, groups (Table 3).

Product	A	B	C	D	E
Sedimentation rate	0.3	50.2	122.6	46.8	266.2
Group	d	c	b	c	a

Table 3: Sedimentation rate variance analysis

As with the dust cloud variance analysis, the sedimentation rate variance analysis does not reveal any effect relating to the day on which the measurements are taken (Figure 5). This measurement is therefore also considered repeatable.

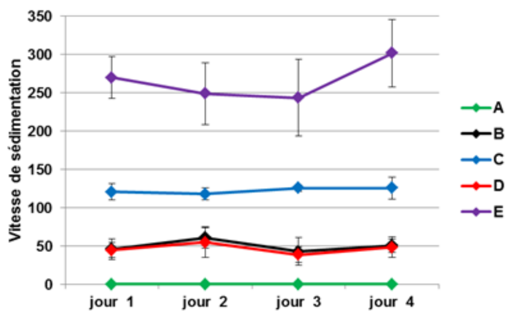

Figure 5: Change in sedimentation rate according to the days

As with the Heubach method, measurements may show some variability where the most pulverulent products are concerned, such as product E.

The results for the 5 products were compared to the results from the previous selection phase (Table 4).

Sample B, provided for this new phase, does not behave in the same way as its counterpart tested during the previous phase. During phase 1 of the study, product B was included in the group of low-dust products; the new sample, however, ranks alongside product E as one of the most pulverulent products in the sample collection. This demonstrates that this method can identify differences between several samples considered to come from the same product.

		A	B	C	D	E
Dust cloud	FT N° 101	0.6	120.3	353.5	654.4	1162.9
	FT N° 102	1.1	483.6	251.1	594.0	1464.7
Sedimentation rate	FT N° 101	0	9	152	40	256
	FT N° 102	0	50	123	47	266

Table 4: Comparison of means for each of the criteria and the 5 products

3.3. Comparison of characteristics

The 5 tested products were ranked in increasing order of physical and behavioural measurement results. (Table 5)

BD	TD	HI	PD	D50	Heubach	Dust cloud	Sedimentation rate
E	D	A	D	E	A	A	A
C	E	D	E	C	C	C	D
D	C	B	C	B	B	B	B
B	B	C	A	A	D	D	C
A	A	E	B	D	E	E	E

Table 5: Product ranking in increasing order of their physical and behavioural characteristics

Concerning the first similarity, it can be assumed that a high Hausner Index indicates a product with higher compaction-dependence and poor flow properties. The high sedimentation rate indicates that the dust particles fall rapidly. The formation of agglomerates may constitute a link between the 2 behaviours; the identical ranking of these 2 characteristics therefore appears to be consistent.

There is even greater consistency in the second similarity as both measurements are designed to rank products according to their dust emission capability. Statistical processing confirms this ranking (Table 6).

Product	A	B	C	D	E
Dust cloud Group	1.0 e	483.6 c	251.1 d	594.0 b	1464.7 a
Heubach Group	0.0 e	2920.0 c	2044.0 d	3330.7 b	5606.7 a

Table 6: Dust cloud variance analysis and the Heubach method

The hierarchical relationship between the 2 measurements is sufficiently meaningful to record behavioural differences in product dust emissions despite the natural variability in the measurements (Figure 6).

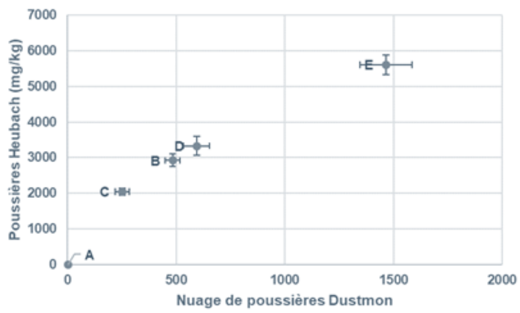

Figure 6: Relationship between dust measurement results using the Heubach and Dustmon methods for the 5 reference products

This graph reveals that the results of the Heubach method reach a limit while those obtained using the Dustmon method continue to increase. This fact demonstrates that the Dustmon method has a far higher discriminating power as it targets a much wider measuring range.

4. Pros and cons

4.1. Taking measurements using the Heubach method.

Note that this subject has already been discussed in an earlier study on the Heubach method i'Tec_Q5): *"Firstly, it should be noted that there is a defect in the measuring apparatus. The position of the flowmeter makes it impossible to detect a leak on the air intake circuit.*

Secondly, the necessity of cleaning the whole apparatus between measurements allied with the poor level of accuracy and the handling difficulties means that, even with improvements, this method would be unworkable for plant acceptance tests.

However, this conclusion does not prejudice the method being used to collect dust intended for measuring a product's active substance content. This method is also the only one that currently provides a means of measuring dust directly. At least three measurements are made in order to keep results costs low, which might not be sufficient to get truly reliable results."

4.2. Taking measurements using the Dustmon method

Dustmon measurement software is very simple to use and configure. However, while the software can display up to 10 curves simultaneously, it only has a 6-colour key which can make the graphs difficult to read. While the test configuration settings are the same, the actual measurement does not start at the same time for all samples.

The device is simple to use, and easy to clean between 2 measurements. This makes it possible to analyse many samples in a short period of time.

The various parameters recorded during the measurement give a more detailed and accurate characterisation of the tested products. The two criteria were chosen for their discriminatory power and non-correlation.
The Dust Area corresponding to the dust cloud is a good indicator of the level of dust emission and can be used for rapid differentiation of a variety of products.
The absolute value of the dust sedimentation rate corresponds to the difference between the values measured at 15 s and 5 s divided by 10 (number of seconds between these 2 values) and multiplied by 100 for easier data editing and interpretation. This calculation parameter was chosen for the study as it provides a more specific and accurate characterisation of the dust cloud. It demonstrates the extent of a product's ability to remain in suspension.
The usefulness of other parameters, such as the peak of the curve, may also be brought into play by increasing the number of repetitions. Use of this particular parameter was rejected, however, at the outset due to its variability during the tests. It could possibly be used to increase the discriminating power when computing the sedimentation rate.
In contrast to the Heubach method, the Dustmon method for direct measurement of dust levels may be used during plant acceptance tests. It should be noted though that this represents an ex. tax investment of around € 20,000.

5. Conclusion

The Dustmon device was tested during a dust measurement study. The results obtained with this device were consistent with those obtained using the Heubach method. Its simple use and easy cleaning are an added advantage.

In terms of characterising product dust emissions, this device appears perfectly suited for upstream identification of behavioural differences in delivered product batches or of handling issues for operators.

The only major difference between the two methods involves the collection of dust in order to dose its active ingredient content, which is only possible with the Heubach method.

This study demonstrated that the Dustmon device meets professional expectations for improved upstream identification of the level of dust generated by a given product batch.

5.1. Bibliography

i'Tec_Q2 : Physical properties of the additives used in animal feed: Operation of a database
i'Tec_Q5: Using the Heubach method to measure the emission of dust in animal feed additives