i'Tec_G9
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Crumb durability
Using Eurotest to develop a measurement method

Crumbs are a type of feedstuff made from pellets.
They are produced by reducing the size of the pellets by passing them between fluted rollers with controlled speed and spacing.
Crumbs are then sifted to select their particle size, with fines and large particles (large crumbs) being recycled through the pelleting press in real time.
Lower pellet grades result in a higher proportion of crumbs being recycled, which is why crumb production requires the use of pellets with a high durability rating.
Crumb manufacture results in lower production yields and higher energy costs due to recycling.
For many years now, pellet durability has been measured using a range of devices that are recognised and referenced according to tried and tested methods (see i'tec_G7).
There are few methods currently available for assessing crumb grade, and the ones that do exist tend to measure the particle size of the marketed crumbs rather than their fundamental durabilities.
It should be possible to assess industrial crumb grades in the same way as their source pellets.

1. Test principle

Looking at the pellet durability measurement method, it became apparent that the EUROTEST device could be used to stimulate crumbs in the same way using abrasion and fragmentation.
A crumb particle size profile can be established by passing the products through a sieve tower at the durability tester output.
Crumb durability tests were performed on 5 sample batches of poultry feed produced on Tecaliman's pilot line.
The pellets were produced with a diameter of 4 mm.
The poultry feed formulation was treated at 5 different temperatures (40, 45, 55, 70 and 99°C) at the conditioner output in order to obtain 5 pellet samples of increasing durability; all other production parameters remained the same.

2. Method

2.1. Crumb manufacture

The pellets were crumbed using a grinder with two Socam brand fluted rollers.
To obtain crumbs with a standard particle size, it was decided to space the rollers at 2.5-mm for all 5 pellet samples.

2.2. Running the samples through the Eurotest durability tester

A 500-g sample of crumbs was placed in the device for a 20-second throughput time.
The 500-g samples were then collected and split into four 125-g sub-samples.

2.3. Sieving the crumbs

A 9-level sieve tower was set up on a laboratory sifter (Retsch AS200) according to pellet diameter (4mm).
The sifters were chosen to have screen sizes close to the 10, 20, 30, 50, 60, 70, 80, and 90% thresholds for initial pellet diameter (Table 1).

Sifter size (µm)	% of the 4-mm pellet diameter
3550	88.75
3150	78.75
2800	70
2500	62.5
2000	50
1600	40
1250	31.25
800	20
400	10
Sifter base	0

Table 1 : Sieve tower composition

Three of the four 125-g sub-samples, taken from each batch of crumbs, was sieved for 10 minutes at an amplitude of 1.22 mm so as to obtain an average particle size spectra calculated on 3 repetitions. Sifter sizes were expressed as a percentage of initial pellet diameter, which was 4 mm in these tests.

3. Results

The resulting particle size distributions (Figure 1) indicate batch-dependent variations in weight distribution.
Crumbs tend to disintegrate less and their weights cluster more on sifters with larger screen apertures

when operating at higher batch conditioning temperatures and greater pellet durabilities.
This result clearly demonstrates that, after mechanical stressing, a relationship can be seen between crumb particle size distribution and initial pellet texture.

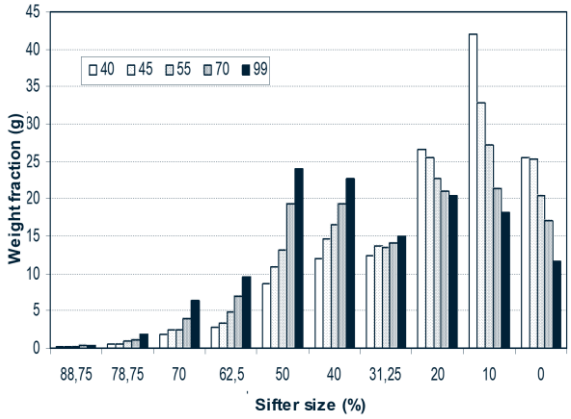

Figure 1: Particle size distribution by crumb category

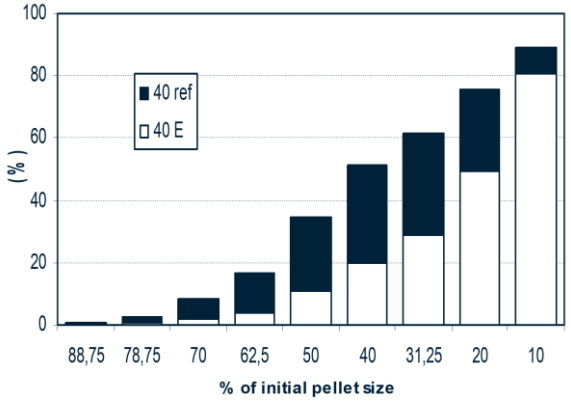

Figure 2: Cumulated particle size distributions before and after being run through the durability tester - Crumbs produced from low grade pellets (40°C)

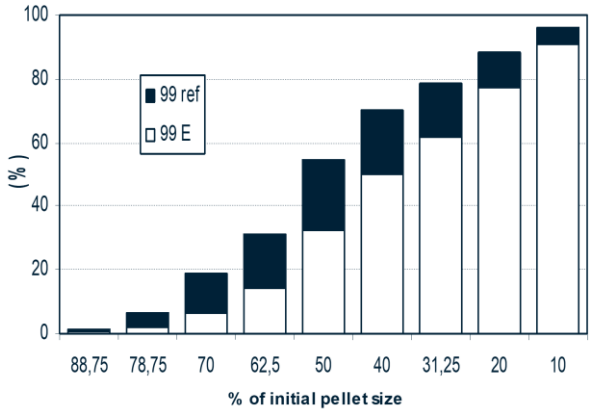

Figure 3: Cumulated particle size distributions before and after being run through the durability tester - Crumbs produced from high grade pellets (99°C)

Figure 2 and Figure 3 illustrate the particle size distributions of outlier crumbs (40°C and 99°C) before (Black) and after (White) being run through the durability tester.

Particle size distributions, deriving from low grade crumbs (Figure 2) and high grade crumbs (Figure 3), show that the proportion of crumbs remaining on each sifter category is affected by impacts sustained in the durability tester, irrespective of the grade of the resulting crumbs. However, this deterioration was markedly greater with one sifter in particular.

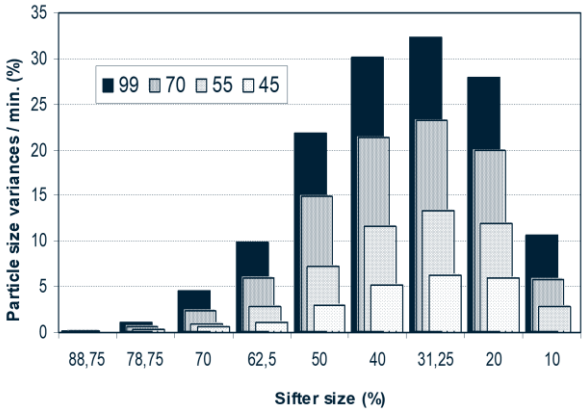

Figure 4: Variances in particle size distributions with respect to the resulting minimum particle size spectra (40°C)

For each sifter, Figure 4 shows the particle size variances obtained in relation to the crumb batch produced at 40°C.

This bar chart illustrates that, during these tests, batch differentiation improved when using the sifter at 31.25% of pellet size (diameter).
This is the sifter most likely to record the largest variance between crumb populations produced from pellets of differing textures.

It should be noted though that these results characterise crumbs produced on the pilot grinder with a spacing of 2.5 mm.
Even though the sifter used was not the most discriminating, these results revealed a link between crumb attrition and the pellets' initial attrition resistance value.

This suggests that an alternative grinder spacing or crumbler would give different measurements.

However, these results tend to show that for each crumb calibration, there would be one particular sifter likely to discriminate between the various crumb qualities better than the others.

4. Expressing "crumb durability"

The pellet durability equation can also be used to calculate a crumb durability index (see equation below) by expressing for each sifter class used the percentage of crumbs remaining on the same sifter screen after being run through the durability tester (Table 2).

$$\text{Crumb durability (\%)} = \frac{Mt}{Mi} * 100$$

Durability expressed as a %

Mt = Weight of the crumbs remaining on the sifter screen

Mi = Initial weight of the crumbs (500 g)

Crumbs	% Sifter	88,8	78.8	70.0	62.5	50.0	40.0	31.3	20.0	10.0
Grade at 40°C	Crumb durability (%)	28.9	28.0	24.1	25.1	30.8	38.7	47.2	64.8	90.9
Grade at 45°C		20.1	28.9	28.6	28.3	35.1	44.7	53.4	69.4	88.4
Grade at 55°C		41.2	37.1	32.9	36.8	43.5	53.1	61.0	74.4	90.0
Grade at 70°C		50.8	37.5	40.7	45.8	58.1	68.0	74.6	84.1	92.9
Grade at 99°C		27.3	28.1	34.9	44.7	59.9	71.5	78.2	87.1	94.9

Table 2: Using the sifter % method to identify crumb durabilities

Figure 5 identifies an optimum discriminatory zone between the 31.25% and 40% sifters, which gives the most accurate grading of the crumbs tested in these studies.

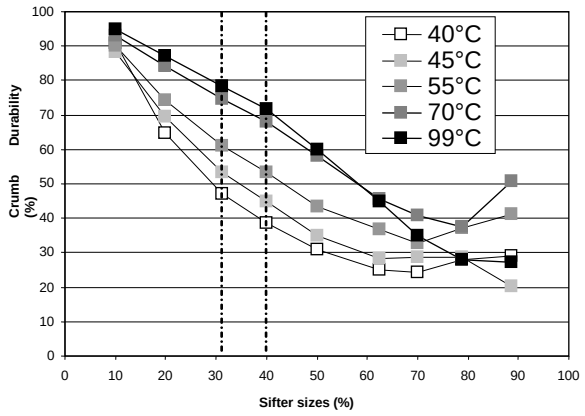

Figure 5: Illustrations of crumb durability according to sifter size

Figure 6 confirms the correlation between crumb texture (crumb durability) and pellet texture (pellet durability), from which it derives.

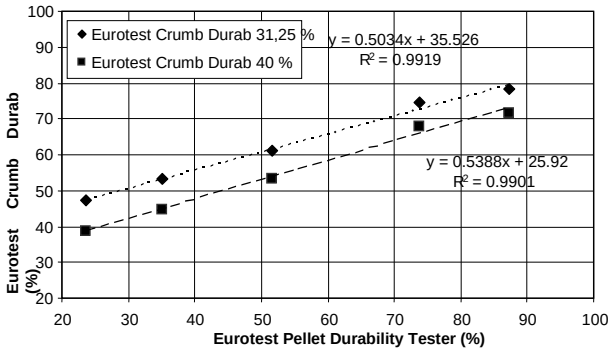

Figure 6: Correlations between crumb durability (31.25 and 40% sifters) and pellet durabilities (80% sifter)

5. Recommended method

These tests demonstrated that crumb durability can be assessed using the EUROTEST durability tester, which up till now had only been used for pellets.
Naturally, the results concern crumbling, with a roller spacing of 2.5 mm selected by TECALIMAN, and may well differ for other settings and other feedstuffs.
Sifting the crumbs before and after running them through the durability tester makes it possible to calculate a percentage crumb durability by using a reference sifter.
When calculating the crumb durability %, Tecaliman recommends using a sifter with a mesh size that is 30% to 40% of the pellet diameter to provide a reference grade.

To recap, the method is given as follows:

- Take a 1-kg sample of crumbs
- Divide into two portions of 500 g
- Pass one portion through a sifter (e.g. sifter size approx. 30% of the initial pellet diameter) to collect a quantity of crumbs on the sifter screen (Mi)
- Run the other 500-g portion of crumbs through the Eurotest durability tester.
- Sift this portion through the same sifter to collect a quantity of residual crumbs on the sifter screen (Mt)
- Calculate crumb durability according to the equation

6. Bibliography

Tecaliman Report No. 457, 2007 Étude de la texture des granulés dans le secteur de l'alimentation animale

Tecaliman Report No. 458, 2007 Étude de nouvelles méthodes caractérisant la texture des granulés et des miettes dans le secteur de l'alimentation animale.