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Results of a durability ring test

In 2011, 73 French companies funded a durability ring test that grouped a total of 74 durability testers, making it possible to compare the results from each appliance against the results obtained by Tecaliman appliances, and against those of similar appliances surveyed in this study. The repeatabilities and discriminating power of each appliance were calculated by comparing the measurements obtained from a panel of 5 pellet samples with known durabilities, fully controlled by Tecaliman. This data sheet describes the operating procedure, together with the findings and insights gleaned from this ring test.

1. Focus

The aim was to test the variability of the results obtained from the same durability tester models, assuming that use conditions may vary from one company to next depending on their operating methods.

2. Principle

Five pellet samples were simultaneously shipped to each company in order to test each appliance according to its own specific protocol.
Tecaliman selected 2 feed pellet samples sold commercially, and produced 3 other pellet samples with differing durabilities using its pilot pelleting line.
Companies participating in the ring test were asked to repeat the measurements 3 times on each sample in order to test for repeatability, and to do this within 15 days of receiving the pellets.
In addition to taking the measurements, the companies were asked to complete a questionnaire indicating the conditions in which these measurements were taken.
The data was then processed to give an overall summary, one for each company/group and another for each individual site. The summaries of this data processing illustrated:

- Repeatability
- Discriminating power
- Relationship to the Tecaliman appliance
- Interpretation of any observed deviation

3. Equipment and apparatus

3.1. Feedstuffs

Two commercially sold feedstuffs were used, one for rabbits and the other for laying hens. Tecaliman's pelleted feedstuff was a growing broiler feed.

3.2. Pilot pelleting press line

Tecaliman produced 3 batches of pellets with differing durabilities using a Kahl flat die pilot press on its pilot pelleting line.

3.3. Tecaliman durability testers

Two durability testers were used:

- Tumbling box durability tester (PDI method in the USA)
- Eurotest durability tester

3.4. Company durability testers

The study covered three main types of durability tester, corresponding to 3 pellet stressing methods:

- Eurotest and Quicktest (German version) that stresses pellets by "cracking".
- Tumbling box tester, which stresses pellets by having them constantly spill one over the another.
- Holmen and Lignotester, which uses forced air to stress the pellets.

Most companies (Table 1) use the Eurotest appliance (73% of the group under study).

Method	Hardness devices	Nbr of devices	% population
Cracking	**Eurotest/ Quicktest**	54	73.0
Spilling	**Tumbling boxes**	7	9.5
Forced air	**Holmen/Ligno**	13	17.5

Table 1: Durability tester population

4. Method

4.1. Producing the pellets

The companies were sent a range of 5 pellet samples of differing durabilities to test.
The pellets all had diameter 4-mm and length approx. 10 mm.
The chosen range covers Eurotest durability values of between 70 and 100% for a corresponding range of Tumbling Box durabilities of between 90 and 100%.
2 commercially sold pellet batches and 3 pellet batches custom-produced by Tecaliman were used for simple acquisition of the 5 durabilities.
The tested batches were:

- Pellets A: broiler feed - Eurotest durability 70.0%
- Pellets B: broiler feed - Eurotest durability 80.2%
- Pellets C: broiler feed - Eurotest durability 87.9%
- Pellets D: laying hen feed - Eurotest durability 88.9%
- Pellets E: rabbit feed - Eurotest durability 96%

4.2. Sample production, preparation and shipping

The 2 batches of commercially sold pellets were selected based on preliminary durability measurements.
The durability range was completed with the other 3 batches, based on a manufacturing protocol for pilot line production of growing broiler pellets.
This involved 3 set-point temperatures at the press conditioner output and 2 die compression thicknesses.
5 initial 200-kg pellet batches were split in cascade, providing a sufficient number of sibling sub-samples of pellets weighing approx. 2 kg, with identical grades.
These sub-samples were packed in hermetically sealed trays and coded A to E.
All the samples for the 74 durability testers were sent the same day.

4.3. Operating procedures used to calculate Tecaliman reference durabilities

Before each passage through the durability testers, pellets must be free of any fragments with grain size less than 80% of their diameter.
This involves systematically "cleaning" the pellets by sieving them through a vibrating apparatus fitted with a woven wire screen.
The screen's wire mesh is spaced at 3.2 mm to ensure compliance with the 80% rule when measuring 4-mm diameter pellets.

4.3.1. EUROTEST durability tester

The tested appliance was a 2011 model with a rotor speed of 542 rpm, i.e. 181 revs per 20 seconds of rotation.
The test was performed on 500 g of fragment-free pellets, stressed for 20 seconds.
The weakened pellets were then sieved using the same operating procedure as that used to separate out the fragments.
The durability % was obtained by weighing the fragment-free pellet quantity.
This measurement was made three times on each sample.

4.3.2. TUMBLING BOX durability tester

The test used a BUHLER brand tumbling box durability tester, which allows simultaneous measurements on a maximum of 6 tumbling boxes. This appliance is fitted with a tachometer.
The boxes rotate at 50 rpm, with the total number of rotations set at 500, i.e. a 10-minute stressing time.
The operating procedure and box dimensions are based on a standard currently in force the United States (ASAE Standard S269.4).
The test was performed on 500 g of fragment-free pellets, stressed in each tumbling box for a period of 10 minutes.
The pellets recovered at the box outfeed were then sieved using the same operating procedure as that used for the EUROTEST appliance.
The durability % was obtained by weighing the fragment-free pellet quantity.
This measurement was made three times on each sample.

4.3.3. Holmen or Lignotester durability testers

Due to a malfunction on the first appliance and to not having received the second, Tecaliman did not perform any measurements on these two durability testers.

4.4. Questionnaire and table of results

The companies were sent a form containing a table in which to record durability measurement results and a questionnaire, along with the samples to be tested.
They were asked to take the measurements within 15 days, and to return the completed table of results and questionnaire to Tecaliman.

4.5. Processing the results

By repeating the measurements 3 times on the 5 samples, the durability tester's repeatability limit "R" can be calculated as:

R = 2.83 Mean standard deviation

and its discriminating power as the number of feedstuffs differentiated by the plant out of the 5 delivered samples that were found by Tecaliman to be significantly different based on the Eurotest results.

Comparative tests were also run on the slopes of the regression lines in order to investigate the sources of the deviations.

5. Results

5.1. Comparison of measurement results against the reference measurements

Generally speaking, the durability values recorded by the companies approached the reference values (Table 2).

Hardness testers	Methods	Feedstuff durabilities (%)				
		A	B	C	D	E
Eurotest (%)	Tecaliman	70.0 e	80.2 c	87.9 b	77.5 d	97.2 a
	Companies (54)	69.2	78.7	86.8	77.9	96.5
	Variances	- 0.8	- 1.5	- 1.1	+ 0.4	- 0.7
Tumbling box:	Tecaliman	91.0 d	94.4 c	96.4 b	94.5 c	99.3 a
	Companies (7)	91.8	94.7	96.6	94.2	99.3
	Variances	+ 0.8	+ 0.3	+ 0.2	- 0.3	0.0

Table 2: Durability measurement results

The values recorded by the companies involved a test population of 54 Eurotest appliances and 7 tumbling box appliances. The mean measurement obtained on 4 feedstuffs with the Eurotest appliance was below that of the Tecaliman value and, surprisingly, the companies recorded higher mean "Tumbling box" values for 3 of these feedstuffs.

5.2. Comparison of the measurement results obtained by each company for a given appliance

The Eurotest durability tester demonstrated a higher feedstuff discriminating power (Table 3) with 57.4% of companies being able to discriminate between the 5 feedstuffs, as opposed to 28.6% for tumbling boxes and 15.4% for the Holmen and Lignotester methods.
If a discriminating power of 4/5 is deemed acceptable, the Eurotest durability tester comes out top with 98.1%, followed by Holmen with 92.3%. Note, however, that some Holmen and Tumbling Box durability testers demonstrated absolutely no ability to differentiate the 5 feedstuffs.

	Significant differentiations of 5 feedstuffs					
% population	5/5	4/5	3/5	2/5	1/5	0/5
Eurotest	57.4	40.7	1.9	0	0	0
Tumbling box	28.6	28.6	14.3	14.3	0	14.3
Holm/Ligno	15.4	76.9	0	0	0	7.7

Table 3: Discriminating power (percentage of industrial sites able to discriminate between feedstuffs)

5.3. Operating procedures

An additional questionnaire revealed differences in the implementation of operating procedures.
A non-exhaustive and non-hierarchical list provides insight into these differences, largely explaining the variations in durability measurements:

- Samples not always sieved (pre-measurement extraction of fragments) prior to being put through the durability tester.
- Variations in the quantity of pellets tested.
- Shorter appliance throughput times.
- Screen mesh sizes below 80% of pellet diameter.
- Manual sieving (operator effect)
- Measurements taken after the specified deadline
- Incorrect storage of pellet samples.
- Used appliances or worn rotors.

For the Eurotest appliance, only 27.8% (i.e.15/54) of companies duplicated the operating procedure used at Tecaliman.
Of these 15 companies, only 5 obtained durability results that approached those recorded by Tecaliman with a differentiation of 5/5.
The following example (Figure 1) shows a comparison of the durabilities obtained by a company using the same operating procedure as Tecaliman:

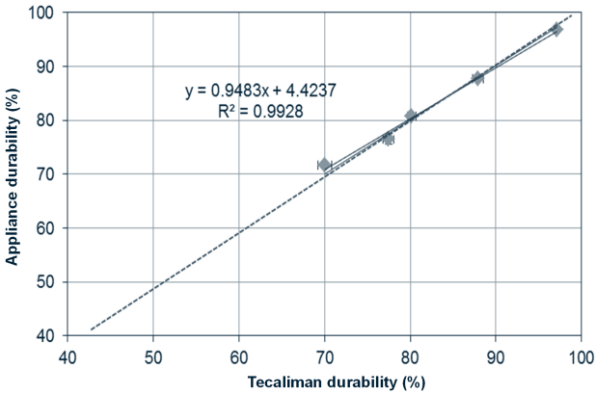

Figure 1: Durabilities similar to those recorded by TECALIMAN

Several of these 15 appliances were legacy models in use for over 15 years, where rotor wear and tear could explain the differences in the results (lower durabilities). For some of these appliances, the measurements were taken too late (taken after the 15-day deadline).
Figure 1 therefore illustrates the results obtained by companies that used the same operating procedure as Tecaliman but with used appliances and taking too long to perform the measurements after receiving the pellets.

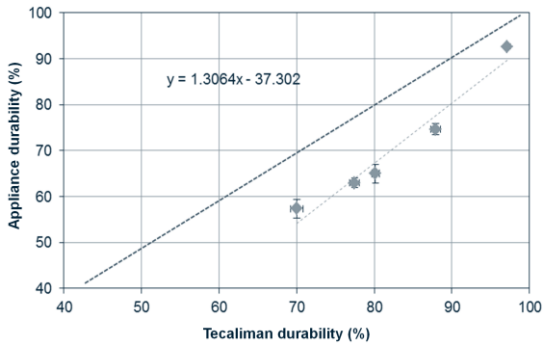

Figure 2: Example of lower durability results due to rotor wear and/or overlong measurement delays.

Other deviations from the recommended protocol involved the duration of the test, i.e. comparing durabilities at a company that stressed pellets for 12.5 seconds instead of the recommended 20 seconds (Figure 1).

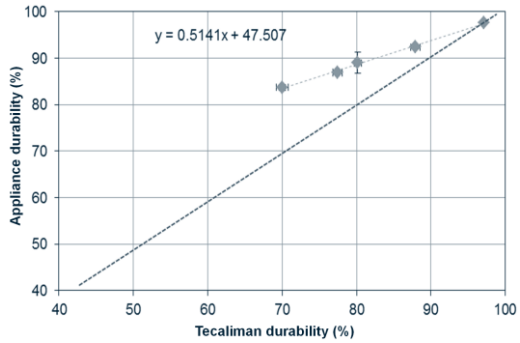

Figure 3: Example of higher durability results due to the implementation of a 12.5-second pellet stressing period.

Deviations were also recorded within a given company. A company using an alternative pellet stressing period and an inappropriate sieve (smaller mesh size) would obtain higher durability results than other sites in the same group. In addition to this, and as a likely consequence, this same plant would not be able to discriminate two out of the five feedstuffs (Figure 4).

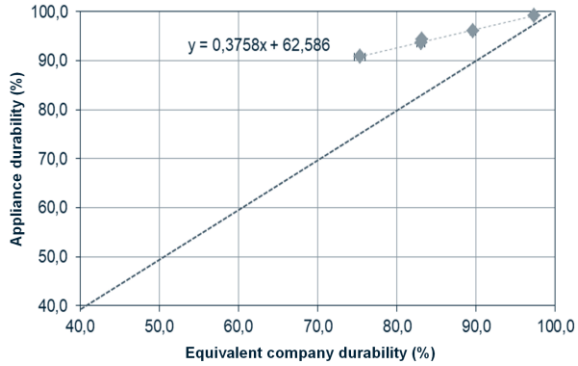

Figure 4: Example of the results obtained using a Eurotest appliance compared against the mean results of other plants in the same group

Regarding the tumbling box method, only 2/7 companies (28.6%) used TECALIMAN's recommended operating procedure, and of these, only one took the measurements within the specified deadline (< 15 days).
The results recorded by the only company to follow the same operating procedure and comply with the measurement deadlines were actually similar to those obtained by Tecaliman (Figure 5).

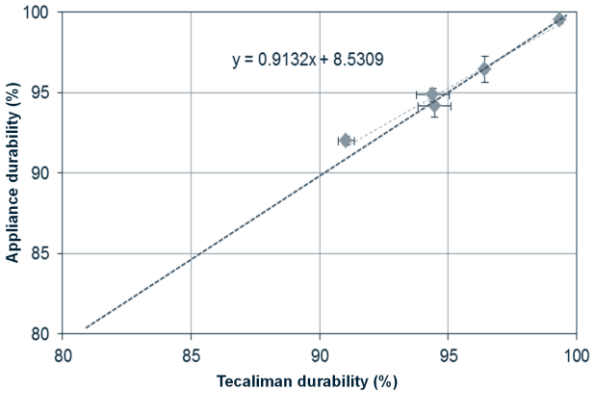

Figure 5: Example of the results obtained using a tumbling box durability tester in compliance with Tecaliman's recommended operating procedure and measurement deadlines

6. Conclusion

If the Holmen and Lignotester durability testers are discounted, only 16 plants out of the remaining 61 applied the operating procedure recommended by Tecaliman for many years.
Despite its recommendation, Tecaliman has never forced companies to implement this operating procedure. However, it has to be acknowledged that the differences recorded between plants, and even between sites of a given group, stress the importance of standardising these procedures across the whole profession.
For foreign companies using the PDI procedure (tumbling box), these results spotlight yet again the inferior discriminating power of this method.

This ring test has revealed differences in operational practice that lead to industrial divergence. These differences can now be used during press operation training in order to identify the factors that drive variations in results. The test has also highlighted the potential impact of rotor wear and tear, which may reduce a durability tester's discriminating power and measurement range over time.

Lastly, the ring test has also focused attention on the need to consider the establishment of a standard, particularly in term of quality certifications.