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Assessing the rapid measurement of moisture for compound feeds using hyper-frequencies

1. Context and aim of the study

In the animal feed industry, controlling the loss of water during the course of the production process (shrink) and the preservation of finished products during the course of storage requires real-time knowledge of the moisture of finished products.
To obtain this information, the industry needs to have quick and easy measurement methods. In theory, a number of techniques can be used, including near-infrared reflectance spectrophotometry, capacitive methods, low resolution nuclear magnetic resonance and hyper-frequency or microwave spectrometry.
Existing data reveals that:

- infrared and capacitive methods are unsuitable for mixed products as each composition involves the use of a specific calibration function (template),
- low resolution nuclear magnetic resonance is well suited to the rapid measurement of water content, however its implementation in an industrial setting is complex,
- the hyper-frequency or microwave method is used successfully for measuring moisture in the tobacco industry (Herrmann 1996), in fodder (Vijendra Das 1996) and in pet food (Van Vliet 1997).

The aim of the study undertaken by Tecaliman is to evaluate this last method.

2. Equipment and method

2.1. Collecting samples

Feed samples are taken from two plants making products with two different service companies. Collection takes place over a period of 2 months, in order to incorporate changes in the formula. It covers all pig, poultry and cattle feed sold in the form of pellets or crumbs.

2.2. Characterisation of samples

2.2.1. Reference method

Moisture measurement is carried out on a test specimen of 5g, with oven drying for 4 hours at 103°C. Samples of pellets and crumbs are ground in advance using a water-cooled grinder.

2.2.2. Hyper-frequency

Tests are carried out using a TEWS MW 2300 device. The temperature of samples is measured prior to their entry into the hyper-frequency measuring device. This measurement is undertaken using a probe connected to this device.
The sample is then placed, with no prior treatment, into the device's measurement chamber and the hyper-frequency value measured (HF).
All of this data is stored in the device's computer system with the sample reference.

2.3. Examining "oven/HF moisture" correlations

To form homogeneous groups or populations of samples, correlations between the "oven" moisture and the HF value are examined for all the data collected. This procedure enables the number of calibrations to be implemented in order to assess the moisture of feeds based on HF values to be reduced.

2.4. Creating calibration and validation ranges, calculating prediction models

In order to create a calibration range and a validation range, randomisation takes place within each of the populations formed during the course of the previous phase.
Processing the data for calibration ranges enables a prediction model to be established for each population of samples.

2.5. Assessing the hyper-frequency model

For the various validation ranges, the moisture values observed at the oven and calculated using the prediction model are statistically evaluated: calculation of the correlation coefficient, average difference between the values observed and predicted, standard deviation for prediction (standard deviation for differences between the two methods), paired comparison test of two samples.

3. Results

3.1. The entire data population

The origins and types of feed samples collected appear in Table 1.

Plant	Types of formulae	Types of feed	Number of formulae	Number of batches sampled
No. 1	Piglet, baconer, sow Complete and supplementary feeds	Pellets	17	38
	Piglet, baconer, sow Complete and supplementary feeds	Crumbs	19	31
	Dairy cattle supplements	Pellets	10	10
No. 2	Duck, broiler chicken, turkey, laying hen Reproduction, growth, finisher	Pellets	10	11

Table 1: Origin and type of feed studied

Figure 1 shows that there is no linear correlation between all the moisture levels measured at the oven and the hyper-frequency indices.
Nevertheless, three different populations of samples can be isolated: cattle pellets, pig crumbs, poultry and pig pellets. Each population is examined separately.

3.2. Pig and poultry pellets

The calibration and validation ranges are established from the 47 samples taken in the two plants. The calibration range includes 23 samples and the validation range includes 24 samples.
Multilinear regression with two variables (sample temperature and HF index) enables the calibration function to be established ($R^2 = 0.91$).
A study of the validation range reveals that there is a linear correlation between the values predicted by hyper-frequency and the values measured at the oven, for which the correlation coefficient R is 0.95 (Figure 2).
The average difference between the predicted and measured values is -0.02 with standard deviation of 0.24.
The differences between the two sets of data are not statistically significant at the threshold of 0.05 (t-test of paired populations). Pig crumbs
The quantity of data available is lower than for pig-poultry pellet feeds. The calibration and validation ranges include 15 and 16 samples respectively. The determination coefficient for the calibration function is 0.78 (R^2).
The linear regression performed on the predicted values (hyper-frequency) and measured values (oven) for the validation range has a correlation coefficient of 0.80 (R).
The average difference between the predicted and measured values is +0.15 with standard deviation of 0.40.
The differences between the two sets of data are not statistically significant at the threshold of 0.05 (t-test of paired populations).

3.3. Cattle pellets

The quantity of data (n=10) does not enable the hyper-frequency method to be tested. However, the few available results reveal that there is no correlation between the values measured at the oven and the hyper-frequency indices.

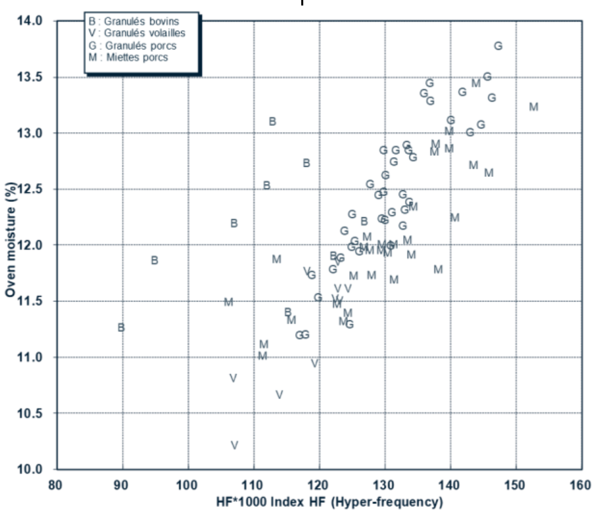

Figure 1: All samples of pig, poultry and cattle feeds. Oven moisture based on the hyper-frequency index

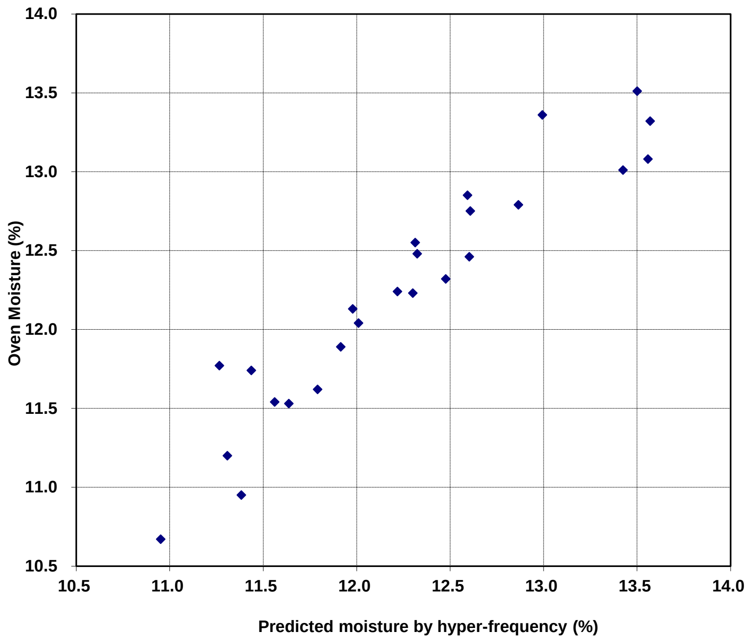

Figure 2: Pig and poultry pellet feeds. Oven moisture based on hyper-frequency moistures

4. Conclusion

The results obtained by TECALIMAN reveal that hyper-frequency may be envisaged for predicting the moisture of pellet feeds intended for monogastric animals, but that its widespread use for other types of feeds needs to be established.
Nevertheless, this method should be of interest to the animal feed industry because:

- it is only very slightly influenced by variations in the composition of feeds,
- there are existing on-line measuring devices.

5. Bibliography

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