DETECTION OF PASTINESS IN DRY-CURED HAM USING DIELECTRIC TIME DOMAIN REFLECTOMETRY

M. Rubio[1*], E. Fulladosa[1], A. Claret[1], M.D. Guàrdia[1], and N. Garcia-Gil[1]

[1]IRTA. XaRTA. Food technology. Finca Camps i Armet, E- 17121 Monells, Girona, Spain

Abstract – Pastiness is one of the major texture defects in dry-cured ham. It is commonly evaluated by sensory analysis and instrumental methods, but these methods are laborious and time-consuming. The development of screening methods which could be related to sensory texture attributes would be a great asset to the meat industry. Time Domain Reflectometry (TDR) has shown to be a rapid and effective tool for meat quality assessment. In this study, the feasibility of TDR for classification of pastiness levels in different dry-cured ham slices was evaluated. For this purpose, an induced pasty reference scale was developed. TDR measurements were then carried out on the surface of dry-cured ham slices and a discriminant analysis was performed with the data obtained. Results clearly showed the formation of three clusters belonging to three pastiness groups: absence of pastiness, moderate pastiness and intense pastiness. Therefore, TDR could be useful for the classification of dry-cured ham slices according to their pastiness level.

Key Words – Meat products, Defective texture, Non-destructive technology

I. INTRODUCTION

Texture is one of the main factors influencing consumer acceptability of dry-cured ham [1]. One of the major texture defects is pastiness, which is more prone to occurring in the *Biceps femoris* muscle [1]. Pastiness is described as the feeling of paste detected in hams with a high proteolitic index during the chewing process [2]. Furthermore, pastiness is a problem for the industry because pasty textures decrease the slicing yield.

Pastiness is commonly evaluated in dry-cured ham by sensory analysis and/or instrumental methods [3]. However, there is no entirely satisfactory pastiness standard reference scale and the above methods are tedious and time-consuming. Therefore it would be useful to resort to faster methods that could be related either to sensory attributes or to instrumental texture parameters. Online and non-destructive monitoring of dry-cured ham quality is possible using technologies based on the use of electromagnetic radiation at different wavelengths [4]. Artificial vision has been used to determine textural features of bovine meat [5]. Near Infrared Spectroscopy (NIR) has been found to be feasible in differentiating dry-cured hams with pastiness from those with normal texture [6]. Microwave spectroscopy has been also found to be a rapid and effective tool for meat quality assessment. Clerjon *et al*. [7] monitored structural changes during bovine meat ageing. Other measurement systems based on microwave spectroscopy such as Time Domain Reflectometry (TDR) appear to be more suitable for food control because there is a faster response, and the equipment is portable and easy to manage [8]. A TDR device was successfully calibrated to accurately estimate water and salt contents in dry-cured hams [9]. Nevertheless, the ability of TDR to estimate texture defects in meat or dry-cured ham was not found in literature.

The main objective of this work was to assess the feasibility of TDR to classify dry-cured ham slices according to the pastiness level.

II. MATERIALS AND METHODS

1. Development of a pastiness reference scale

5 commercial vacuum-packed packages of sliced Serrano dry-cured ham (9 months ripening) showing absence of pastiness were obtained from the same ham producer. 10 slices 1.5 mm thick from each package were spread on each face with 250 µl of a 50% solution of a protease (Delvolase®, DSM Food Specialties, France). The slices were then vacuum packed individually and kept at 20±2ºC for 0.5, 1, 4, 8 and 24 hours. The pastiness of the slices resulting of the protease action was assessed by

2 expert panellists. The sensory analysis was focused on *Biceps femoris* muscle and was carried out in 5 independent sessions. In each session panellists evaluated the 5 samples corresponding to each action time of the protease. The samples were presented in a monadic way. The pastiness of the samples was scored by means of a non-structured scoring scale ranging from 0 (absence) to 10 (very high intensity).

2. TDR equipment

The RFQ Scan 3.0 device (Sequid GmbH, Bremen, Germany) was used to obtain TDR curves from the samples. A TDR-curve is the response resulting from the interaction of an electromagnetic pulse containing a wide range of frequencies (up to $5x10^9$ Hz) with the sample.

3. Preparation of samples for TDR measurements

20 vacuum-packed commercial packages of sliced Serrano dry-cured ham (9 months ripening) showing absence of pastiness were obtained from the same ham producer as the one used for sensory analysis. 2 consecutive slices from each package were compiled in order to be thick enough for the TDR measurements. Protease solution was spread on the compiled slices following the protocol described above in order to induce a full pastiness scale. Three TDR measurements were carried out on the BF muscle from each sample. During measurements, the samples had a temperature of between 15 and 20 °C.

4. Data treatment and statistical analysis

The TDR device acquires the time domain curve at an interval from 0 ns to 2.56 ns, yielding 256 points with spacing of 10 ps. An interval from 0.6 ns to 1.2 ns was chosen for evaluation. This part of the curve includes the slope and part of the *plateau* of the TDR-curve and therefore contains the most information [9]. A discriminant analysis was used to determine whether the TDR device was able to classify dry-cured ham samples according to different pastiness levels, and a partial least square regression (PLSR) analysis was used to develop models to predict pastiness intensity. Both analyses were performed using XLSTAT statistical package v.7.5.2 (Addinsoft, Paris, France).

5. Determination of composition

Salt and water contents of the dry-cured ham slices were estimated using the RFQ-Scan 3.0 device and the commercial modules developed by Sequid GmbH (Bremen, Germany) using data obtained by Fulladosa *et al*. [9]. The standard error was 0.37% for salt content and 1.89% for water content.

III. RESULTS AND DISCUSSION

Table 1 shows the sensory analysis results of the dry-cured ham slices subjected to the action of protease for different lengths of time. Pastiness intensity increased over time, but the increase was not lineal. 24 hours were needed to achieve maximum pastiness intensity. From these results three pastiness groups were established: a pastiness intensity of 0.09±0.17 was considered as *absence of pastiness;* intensities of 2.70±0.54 and 3.71±0.86 were considered as *moderate pastiness*; and intensities of 5.61±0.70 and 8.00±0.53 were considered as *intense pastiness*. The pastiness intensity of 9.30±0.29 (belonging to 24h-action time samples) was discarded because the extremely high destructuration of the slices did not allow a proper performance of TDR measurements.

Table 1. Sensory analysis results for pastiness intensity after protease application.

Action time of protease	Average intensity	Standard deviation
Control (0h)	0.09	0.17
0.5h	2.70	0.54
1h	3.71	0.86
4h	5.61	0.70
8h	8.00	0.53
24h	9.30	0.29

No clear effect of protease action was observed in any part –slope or *plateau*- of the obtained TDR curves. The estimation of pastiness intensity from the obtained TDR curves was not possible using PLSR. However, the formation of three different clusters corresponding to the three different groups of pastiness intensity (absence, moderate and intense) can be clearly observed when performing discriminant analysis (Figure 1). Overall, samples could be correctly classified into the different groups of pastiness with a probability of 93% (Table 2). It is known that food composition –salt and water contents- may affect TDR-curves [9]. For this reason, the effect of salt and water content on the analysis was evaluated by using only the samples with a similar composition (4-5% salt content and 50-60% water content). Nevertheless, no improvement was observed, and obtained a similar overall accuracy of classification (96%). Therefore, the composition of samples does not significantly affect the classification of the different groups of pastiness. Further studies are needed in order to elucidate this point.

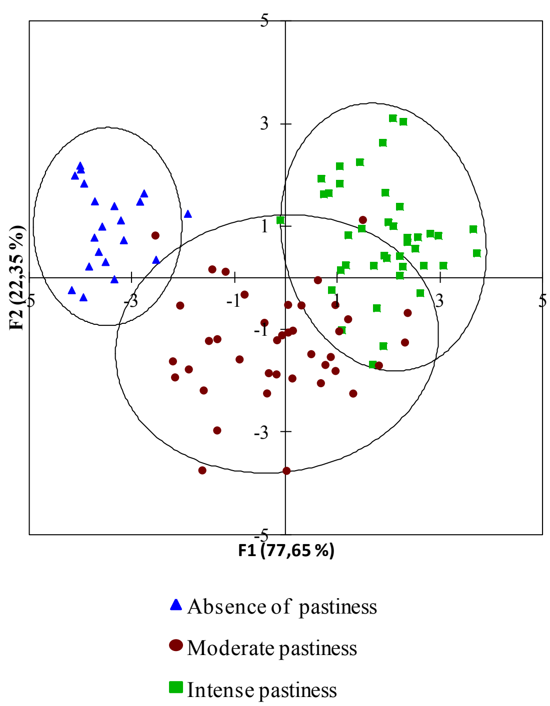

Figure 1. Graphical distribution of dry-cured ham samples according to three pastiness levels using discriminant analysis. Factor (%), percentage of discrimination between samples. Ellipses show a range of confidence of 95%.

Table 2. Results of the classification according to the three levels of pastiness (absence, moderate and intense) provided by discriminant analysis.

	Level of pastiness	Real: Absence	Moderate	Intense	Total
Predicted	Absence	20	1	0	21
Predicted	Moderate	0	36	3	39
Predicted	Intense	0	3	37	40
	Total	20	40	40	100
	% of correct classification	100	90	92.5	93

IV. CONCLUSION

TDR is useful for the classification of dry-cured ham slices in the three different levels of pastiness established but not for estimating the pastiness intensity.

ACKNOWLEDGEMENTS

This work was partially financed by the project RTA2010-00029-CO4-01 of the Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA) of Spain.

REFERENCES

1. Arnau, J. (1991). Aportaciones a la calidad tecnológica del jamón curado elaborado por procesos acelerados. Thesis. Barcelona, Spain: Universitat Autònoma de Barcelona, Facultat de Veterinària.
2. Arnau, J., Guerrero, L. & Gou, P. (1997). Effects of temperature during the last month of ageing and of salting time on dry-cured ham aged for six months. Journal of the Science of Food and Agriculture 74: 193–198.
3. Morales, R., Arnau, J., Serra, X., Guerrero, L. & Gou, P. (2008). Texture changes in dry-cured ham pieces by mild thermal treatments at the end of the drying process. Meat Science 80: 231–238
4. Valous N. A., Mendoza F. & Sun, D.-W (2010). Emerging Non-contact Imaging, Spectroscopic and Colorimetric Technologies for Quality Evaluation and Control of Hams: A Review. Trends in food science & technology 21 (1): 26-43.
5. Basset, O., Buquet, B., Abouelkaram, S., Delachartre, P. & Culioli, J (2000). Application of texture image analysis for the classification of bovine meat. Food Chemistry 69: 437-445

6. Garcia-Rey, R.M., García-Olmo, J., De-Pedro, E., Quiles-Zafra, R. & Luque de Castro, M.D (2005). Prediction of texture and color of dry-cured ham by visible and NIR spectroscopy using a fiber optic probe. Meat Science 70: 357-363.
7. Clerjon, S. & Damez, J-L. (2009). Microwave sensing for an objective evaluation of meat ageing. Journal of Food Engineering 94: 379–389.
8. Miura, N., Yagihara, S. & Mashimo, S. (2003). Microwave Dielectric Properties of Solid and Liquid Foods Investigated by Time-domain Reflectometry. Journal of Food Science 68(4), 1396–1403.
9. Fulladosa, E., Duran-Montgé, P., Serra, X., Picouet, P., Schimmer, O. & Gou, P. (2013). Estimation of dry-cured ham composition using dielectric time domain reflectometry. Meat Science 93(4): 873–879.