Discrimination of fresh *vs.* frozen-then-thawed pig meat by percent reflectance values using SIMCA (Soft Independent Modeling of Class Analogy).

Martín, María Jesús[2], Sanabria, Carmela[2] , Gutierrez, J.I. [1] & Andrés, A.I[1]

1 Department of Food Technology, University of Extremadur.a Ctra. Cáceres s/n. 06071 Badajoz. Spain

2Department of Meat products. Institute of Technology of Extremadura (INTAEX), Ctra.San Vicente, s/n, 06071, Badajoz

Abstract

***Serratus ventralis* muscle (¨presa¨) from Iberian pigs were stored under freezing conditions for 365 and 547 days. Percent reflectance spectral data from muscle cut surface were analyzed using Soft Independent Modeling of Class Analogy (SIMCA). As a result, SIMCA models from percent reflectance values could correctly classify the groups of non-frozen meat and frozen-stored for 365 days-then-thawed meat and frozen-stored for 547 days-then-thawed meat, within 95% confidence limits.**

Keywords- freezing, reflectance, SIMCA.

I. INTRODUCTION

The *Serratus ventralis* muscle (¨presa¨) is highly appreciated by consumers in Spain and can be easily found as fresh meat at commercial stores. However, in the latest years consumer demand of meat from Iberian pig has experienced a marked increase, so that freezing is beginning to be used at industries of this sector.

During freezing and thawing of meat, ice crystal growth causes biochemical and physical changes that can affect some of the physical-chemical and sensory characteristics such as meat color [1]. Color is one of the most important meat characteristics that consumers consider before making a decision to buy, so that it is of utmost importance that technological process does not affect color. In this sense, as far as we are concerned, no specific studies have been developed in order to study the effect of freezing on color of such a peculiar meat as ¨presa¨ from Iberian pig.

A non-destructive and non-time consuming technique is always preferred for analysis of meat color. In this sense, spectrocolorimetry and chemometrics can be useful techniques for a fast analysis of the effect of storage on color of meat. The multivariate techniques of chemometrics, as Soft Independent Modelling of Class Analogy (SIMCA), have been shown as a suitable technique for detection of adulterants in meat [2], classification of commercial wines [3] or for the study of the effect of high pressure treatments in ham [4].

Thus, the aim of the present work was to determine if raw and frozen-then-thawed meat (365 and 547 days) could be distinguished using percent color reflectance values and Soft Independent Modeling of Class Analogy (SIMCA).

II. MATERIAL AND METHODS

Serratus ventralis muscles were obtained from a local industry, Montesano, S.A., frozen in an air blast freezer (-40ºC) and subsequently placed at -18ºC for 365 and 547 days. Non-frozen samples were also taken (day 0) for analysis. After storage, frozen samples were subsequently thawed under refrigeration (5±1ºC for 48 hours). Samples were cut into steaks 1cm thick and reflectance values (n=3) from 360 nm to 740 nm were taken using a spectrocolorimeter (Konica Minolta CM-3500d).

Reflectance data were analyzed with SIMCA (Soft Independent Modeling of Class Analogy) using Unscrambler Software (CAMO, ASA, Oslo, Norway). The SIMCA method establishes a principal component model for each class or category and the corresponding models (so-called disjointed class models or SIMCA boxes) are developed individually. In the present work, three classes were defined: a) raw meat b) frozen-stored for 365 days-then-thawed meat and b)frozen-stored for 547 days-then-thawed meat. This technique allows the evaluation of the capacity of the constructed models to recognize the objects of their own class of category (sensitivity) and the capacity to reject those which do not belong to their category (specificity).

III. RESULTS AND DISCUSSION

Color reflectance data have been used in a number of publications for the study of color changes in meat and meat products [4,5]. In the present study, percent reflectance values at wavelengths from 360 nm to 700 nm from raw and frozen-then-thawed pig meat were used to carry out a ¨Soft Independent Modeling of Class Analogy¨ (SIMCA).

Figure 1 (a and b) represents Coomans diagram [6] corresponding to raw meat model and frozen for 365 days and 547 days meat models, respectively. Coomans diagram shows distances of samples to two models (or categories) selected at the same time. In case a sample belongs to a model or category it should be plotted within the limits of the model, this is at the upper left area or at the lower right area of the graphic. Samples which are for example, near to the origin of the axis, should be classified as belonging to both of the models. If any sample is located outside the limits, for example, at the upper right area, the sample does not belong to any of the models.

In the present study, raw meat samples are located at the upper left area in figure 1a and thus, they were correctly classified. Moreover, non-frozen meat (0) can be discriminated from frozen for 365 days samples and from frozen for 547 days samples (1 and 2 respectively), since these samples are located at the right area of the axis. A certain number of frozen for 547 days samples (2) were incorrectly classified and included in the group of 365 days (1). Frozen during 365 days samples and 547 days samples are not so fine discriminated, since as can be observed, many of these samples (1 and 2 respectively), are located in the same rectangle.

An important advantage of SIMCA is the ability, not only to determine whether a sample belongs to any of the predefined categories, but also to determine if it does not belong to any class. In this sense, the sensitivity of a model is the proportion of samples of a category, which the model correctly recognizes, whereas the specificity is the proportion of samples outside the category correctly rejected by the model. Table 1 shows the results of the classification of SIMCA based on sensitivity and specificity of the developed SIMCA model.

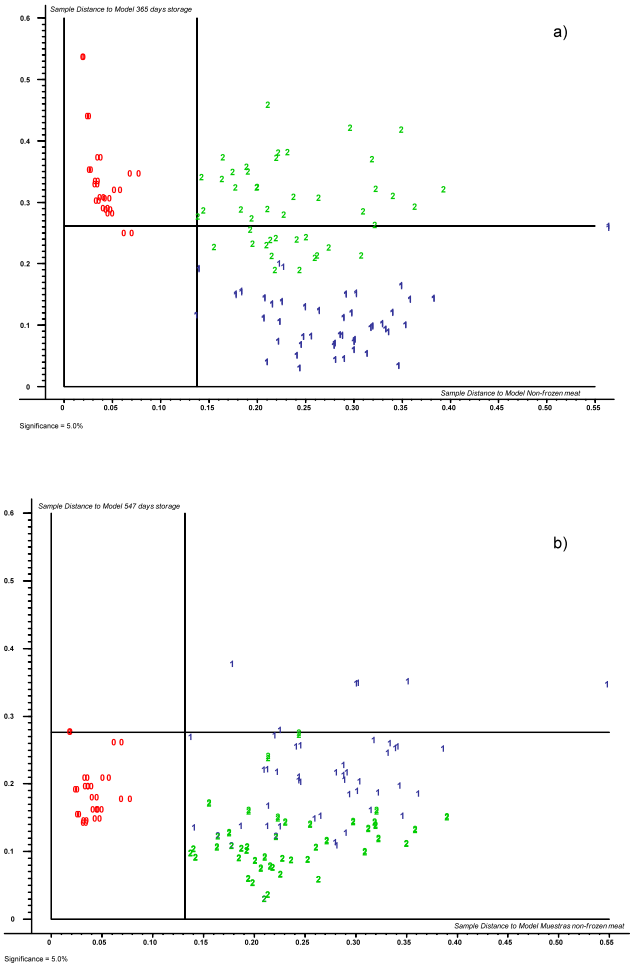

Figure 1(a and b).- Coomans diagram for SIMCA models constructed with percent reflectance values at wavelenghts from 360 and 700 nm for a) non-frozen raw meat (symbol=0) and b) frozen- stored for 365 days-and then thawed meat (symbol=1) and (c) frozen- stored for 547 days-and then thawed meat (symbol=2).

Table 1.- Sensitivity and specificity from SIMCA modeling for non-frozen meat (0), frozen- stored for 365 days-and then thawed meat (365) and frozen- stored for 547 days-and then thawed meat (547).

Class	Sensitivity(%)[a]	Specificity (%)[b]
0	15/15(100.0%)	88/90(97.7%)
365	43/45(95.5%)	60/60(100.0%)
547	43/45(95.5%)	47/60(78.3%)

[a] The highest sensitivity for an optimal model is 100% [b] The highest specificity for an optimal model is 100%

A high percentage of samples were correctly classified, as shown by the high sensitivity of 0, 365

and 547 models (95-100%). Specificity was also high with the exception of samples stored for 547 days (547), for which 13 out of 60 samples were incorrectly rejected (78.3% specificity).

Discriminant power and modeling power for each of the spectral variables were also calculated (data not shown). None of the individual variables (percent reflectance at a single wavelength) contributed to Models SIMCA in a significant way.

SIMCA models allow the calculation of interclass distances; the higher the distance between groups, the better the discrimination. Interclass distances between groups in this study are presented in table 2.

Table 2.- Interclass distances for non-frozen meat (0) frozen- stored for 365 days-and then thawed meat (365) and frozen- stored for 547 days-and then thawed meat (547).

Class	PC[a]	0 [b]	365
0	4	1	14.516
365	4	14.516	1
547	4	6.288	5.448

[a] Number of principal components in optimal model.[b] Interclass distances equal or higher than 3, indicate a fine class separation.

As a rule of thumb, a distance higher than 3, indicates that samples are well distinguished and hence different [7]. A distance to model close to 1, suggests that the two models are virtually the same (with respect to the analyzed data). Distance of a model to the same model is of course equal to 1. A distance between 1 and 3 indicates that models are to some extent superimposed [8]. In the present study, interclass distances were higher than 3, indicating that the calculated SIMCA models can discriminate reflectance of raw and frozen-then thawed meat. Specifically, samples which were best classified by SIMCA models were non-frozen samples and frozen-stored for 365 days-then-thawed meat, with 95% confidence limits, followed by non-frozen samples and frozen-stored for 547 days-then-thawed meat. Frozen-stored for 365 days-then-thawed samples and frozen-stored for 547 days-then-thawed samples were not so well discriminated by SIMCA models.

IV. CONCLUSIONS

SIMCA models from percent reflectance values can correctly discriminate among raw, non-frozen ¨presa¨ meat and ¨presa¨ meat which has been frozen, stored for 365 and 547 days and then thawed.

Acknowledgments

Authors are grateful to the ¨Junta de Extremadura¨ for the economical support through project reference PDT08B006. ¨Junta de Extremadura¨ is also acknowledged for making the attendance at the ICOMST possible.

V. REFERENCES

1. Akamittath, J.,G., Grekke, C.J. and Schanus, E.G. (1990). Lipid oxidation and color stability in restructured meat systems during frozen storage. J. Food Sci., 55, 1513-1517.

2. Meza-Márquez, O.G., Gallardo-Velázquez, T.,Osorio-Revilla, G. (2010). Meat Science, 86, 511-519.

3. Frías, S., Conde, J.E., Rodríguez-Bencomo, J.J., Carcía-Montelongo, F., Pérez-Trujillo, J.P. (2003). Classification of commercial wines from the Canary Islands (Spain) by chemometric techniques using metallic contents. Talanta, 59, 335-344.

4. Andrés, A.I., Adamsen, C., Møller, J., Skisbted, L. (2004). High pressure treatment of dry-cured Iberian ham. Effect on radical formation an dcolour. Food Res. Technol. 219(3), 205-210

5. Møller, J. K. S., Adamsen, C. E., & Skibsted, L. H. (2003). Spectral characterisation of red pigment in Italian-type dry-cured ham. Increasing lipophilicity during processing an maturation. European Food Research and Technology, 216, 290–296. Oxford Dictionary & Thesaurus III (2001). Oxford.

6. Coomans D (1982) Pharm Theses, Vrije Universiteit, Brussels.

7. He, H., Rodriguez-Soana, L.E. & Giusti, M.M. (2007). Midinfrared spectroscopy for juice authentication-rapid differentiation of commercial juices. Journal of Agricultural Science of Food and Agriculture, 76, 263-269.

8. Esbesen, H (2002). Multivariate Data Analysis-in practice. Aalborg University, Camo Process AS, Esbjerg.