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POSTER

Evaluation of near-infrared spectroscopy (NIRS) for the quality control of packaged cured ham-sliced from Iberian pigs

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Additional keywords
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SUMMARY

In the last years, the consumption of packaging cured ham-sliced has significantly increased. But the self-life of this products is lower than full ham, so it is required carry out a high number of physic-chemical analysis. This requires a large investment of time, material and financial resources and destruction of the sample. So, the main aim of this work was the potential used of Near Infrared Reflectance Spectroscopy (NIRS) as an alternative to conventional methods for to on line predict the content of most important quality parameters because is a non-destructive technique, fast and versatile. The predictive equations were developed by multivariate regression method by partial least square (PLS), and the evaluation of the effects of different spectral pre-treatments (1st y 2nd derivate, EMSC, SNV and their combinations). The results showed a predictive ability in NaCl (SNV, R^2=0.96; SEc=0.12; 1-VR=0.85; SEVC=0.23 and RPD=2.6), C16:0 (1,11,15+EMSC, R^2=0.87; SEc=0.93; 1-VR=0.81; SEVC=1.14 and RPD=2.12) and C18:1 (1,11,15+SNV, R2=0.80; SEc=1.70; 1-VR=0.83; SEVC=1.47 and RPD=2.28). Nevertheless, the results are not as good as expected for α-tocopherol, γ-tocopherol, C18:0, C18:2, C18:3 and lipid oxidation although can be used for internal control, and may be improved the number of samples or the range of each parameter.

Evaluación de la tecnología NIRS para el control de calidad de productos curados loncheados y envasados del cerdo Ibérico

Palabras clave adicionales
Vida útil.
Productos cárnicos.
Tecnologías predictivas.
Refrigeración.

RESUMEN

En los últimos años, el consumo de jamón Ibérico loncheado y envasado ha aumentado significativamente. Pero la vida útil de estos productos es menor que la de la pieza entera, lo que requiere que se lleven a cabo un gran número de análisis físico-químicos para el control y evolución de la calidad de los mismos. Esto requiere una gran inversión de tiempo, dinero así como la destrucción de la muestra. Por lo tanto, el objetivo principal de este trabajo fue evaluar el potencial de la Espectroscopia de Reflectancia de Cercano Infrarrojo (NIRS) como una alternativa a los métodos convencionales para la predicción a tiempo real del contenido de los principales parámetros de calidad, ya que se trata de una técnica no destructiva, rápida y versátil. Las ecuaciones predictivas se desarrollaron mediante el método de regresión multivariante por mínimos cuadrados parciales (PLS) y se evaluó el efecto de diferentes pretratamientos espectrales (1ª y 2ª derivada, EMSC, SNV y sus combinaciones). Los resultados mostraron una buena habilidad predictiva para el contenido en NaCl (SNV, R^2 = 0,96, SEc = 0,12, 1-VR = 0,85, SEVC = 0,23 y RPD = 2,6), C16: 0 (1,11,15 + EMSC, R^2 = 0,87; SEc = 0,93; 1-VR = 0,81; SEVC = 1,14 y RPD = 2,12) y C18: 1 (1,11,15 + SNV, R2 = 0,80; SEc = 1,70; 1-VR = 0,83; SEVC = 1,47 y RPD = 2,28). Sin embargo, los resultados para α-tocoferol, γ-tocoferol, C18: 0, C18: 2, C18: 3 y oxidación de lípidos, no fueron tan buenos, aunque podrían usarse para control interno y se podrían mejorar aumentando el número de muestras o el rango de cada parámetro.

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INTRODUCTION

Dry-cured ham is a traditional meat product typically consumed in the Mediterranean area and the vacuum packed dry-cured ham slices are one commercial presentations on the rise in the last years, but their self-life is inferior to that of the whole ham. Quality control of packaging cured ham-slices from Iberian pig must be done by meat industry, through analysis in laboratory and consequently sample destruction, additional expense and loss of time, creating a significant problem in the meat industry.

Near-infrared spectroscopy has been successfully used as a substitute for chemical analysis, due to its recognized advantages as a rapid, non-destructive and

Table I. Descriptive statistics of the parameters determined by conventional methods of sample set (Estadísticos descriptivos de los parámetros analizados por los métodos convencionales del conjunto de muestras).

	N	NaCl (g/100g)	α-Tocopherol (ng/g)	Lipid Ox. (mg MDA/kg)	Oleic Ac. (g/100g FAMEs)
Mean	124	4.01	2.33	5.52	52.79
Max	124	5.37	6.06	10.27	60.12
Min	124	1.88	0.32	0.51	40.71
SD	124	0.64	1.14	2.27	3.75

accurate tool to predict the parameters of chemical composition of meat (Alomar et al. 2003).

NIRS has been widely applied to predict meat composition from different species (pig: Hoving-Bolink et al. 2012; lamb: Guy et al. 2011 or guinea fowl: Tejerina et al. 2009). This technology has also been on the prediction of the quality parameters and has developed models of predicted meat pH (Monin, 1998), water loss (Geesink et al. 2003), color (Leroy et al. 2004; Rødbotten et al. 2000), fatty acids content on beef (Prieto et al. 2012) and on Iberian pig carcasses directly on the process line. Salt content and lipid oxidation have also been studied on cured ham (Collell et al. 2011; Pérez-Marín et al. 2009). Recently, Prieto et al. (2015) with Lacombe, Duroc and Iberian pig loins showed the potential of this technology for on-line application in processing plants to discriminate the quality of pork. However, in order to determine composition in the main nutrients (moisture, fat, proteins, etc.), a number of studies have been conducted on sausage (Fernández-Cabanás et al. 2011; Gaitán-Jurado et al. 2008) but non-evolution of the oxidative state and other sensory attributes.

The objective of this study was to evaluate the viability of near infrared reflectance spectroscopy (NIRS) for the quality of control, oxidative stability and salt content in packaged dry-cured ham sliced from Iberian pigs without needing to open the package, as it is a non-destructive, fast and versatile technique.

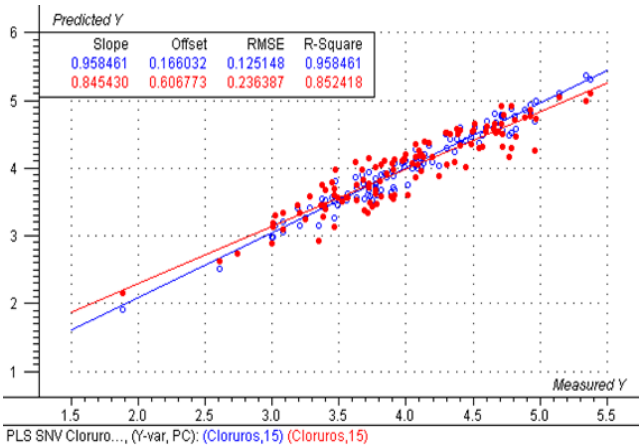

Figure 1. Values predicted versus real measured NaCl values (expressed as g/100g) using PLS analysis (Valores predichos vs. valores reales para el contenido en NaCl (expresado como g/100g) en análisis PLS).

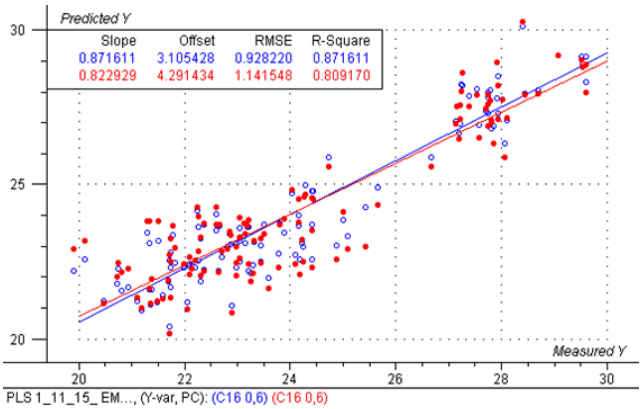

Figure 2. Values predicted versus real measured Palmitic acid values (expressed as g/100g FAMEs) using PLS analysis (Valores predichos vs. valores reales para el contenido en ácido palmítico (expresado como g/100g de ésteres metílicos de los ácidos grasos) en análisis PLS).

MATERIAL AND METHODS

Experimental design

124 samples of vacuum packaged dry-cured ham sliced from Iberian pigs reared under different production system: *extensive* (diet based on commercial concentrate and grass), *intensive* (diet based on commercial concentrate) and *Montanera* system (according to Norma de Calidad (RD 14/2014), were randomly selected.

Spectra acquisition and meat sampling

Spectral data were taken with turn-table probe coupled to LabSpec 2500 ASD Inc.® instrument by continuous measures from 1000 to 2500 nm, which were processed with the software IndicoPro®. The predictive equations were developed by software Unscrambler by CAMO® by multivariate regression method by partial least square (PLS) and the evaluation of the effects of different spectral pre-treatments (1st y 2nd derivate, EMSC, SNV and their combinations).

Chemical determinations

Parallely the determination of content of NaCl, α-tocopherol, γ-tocopherol, fatty acids profile and lipid oxidation were performed by conventional methods (AOAC, 1979; Liu et al., 1996 and Tejerina et al., 2012, respectively).

RESULTS AND DISCUSSION

Descriptive Statistic by Conventional analysis

Table I show the descriptive statistic of mean parameters of quality in vacuum packaged dry-cured ham. So, it observed a wide range in NaCl (5.37-1.88 g/100g), α-tocopherol (6.06-0.32 ng/g), lipid oxidation (TBARS index) (10.27-0.51 mg MDA/kg) and oleic acid (60.12-40.71 g/100g FAMEs). This is a good behaviour to obtain a good ability predict by NIRS technology.

NIRS Predictive Statistic

Figures 1, **2** y **3** represent the best prediction model. The results showed a good predictive ability in salt content (**SNV**, R^2=0.96; SEc= 0.12; 1-VR=0.85; SE_{VC}= 0.23 y RPD=2.6), C16:0 (**1,11,15+EMSC**, R^2=0.87; SEc= 0.93; 1-VR=0.81; SE_{VC}= 1.14 y RPD=2.12) y C18:1 (**1,11,15+SNV**, R^2=0.90; SEc= 1.14; 1-VR=0.83; SE_{VC}= 1.47 y RPD=2.28) for vacuum packaged dry-cured ham sliced from Iberian pigs.

Table II shows the predictive statistic in each mathematical treatment used for to quality parameters determinate in our study. Predictive model for α-tocopherol (**1,11,15**, R^2=0.82; SEc= 0.40; 1-VR=0.65; SE_{VC}= 0.57 y RPD=1.50), γ-tocopherol (**ABS**, R^2=0.85; SEc= 0.09; 1-VR=0.71; SE_{VC}= 0.14 y RPD=1.64), C18:0 (**1,11,15**, R^2=0.87; SEc= 0.56; 1-VR=0.71; SE_{VC}= 0.85 y RPD=1.68), C18:2 (**ABS**, R^2=0.59; SEc= 0.63; 1-VR=0.51; SE_{VC}= 0.69 y RPD=1.08), C18:3 (**2,10,15+SNV**, R^2=0.76; SEc= 0.06; 1-VR=0.59; SE_{VC}= 0.08 y RPD=1.38) and lipid oxidation (**1,11,15+EMSC**, R^2=0.76; SEc= 1.10; 1-VR=0.64; SE_{VC}= 1.38 y RPD=1.43) were not as robust although they could be used at the internal control level, and be improved by increasing the number of samples or the range of each parameter.

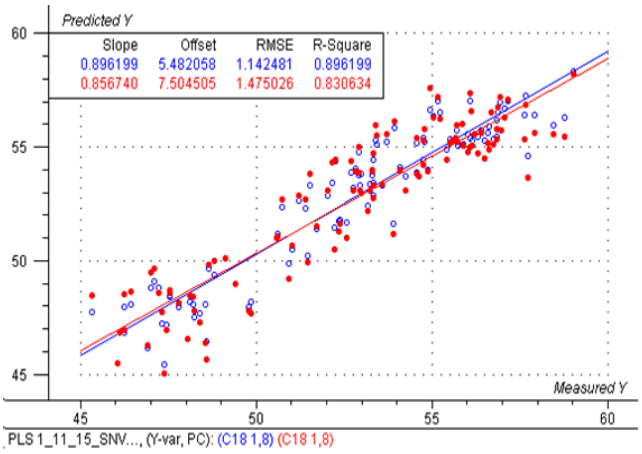

Figure 3. Values predicted versus real measured Oleic acid values (expressed as g/100g FAMEs) using PLS analysis (Valores predichos vs. valores reales para el contenido en ácido oleico (expresado como g/100g de ésteres metílicos de los ácidos grasos) en análisis PLS).

Table II. Statistics of predictive models for α-tocopherol, γ-tocopherol, C18:0, C18:2, C18:3 and lipid oxidation (Modelos predictivos para el α-tocoferol, γ-tocoferol, C18:0, C18:2, C18:3 y oxidación lipídica).

Analysis	PLS	N	PC	Calibration		Cross-validation		
	Treatment			R^2	SEC	1-VR	SEP	SD
α-Tocopherol	1,11,15	100	10	0.82	0.4	0.65	0.57	0.85
γ-Tocopherol	Abs	101	11	0.85	0.09	0.71	0.14	0.23
C18:0	1,11,15	109	11	0.87	0.56	0.71	0.85	1.43
C18:2	Abs	114	5	0.59	0.63	0.51	0.69	0.75
C18:3	2,10,15+SNV	119	9	0.76	0.06	0.59	0.08	0.11
Lipid Ox	1,11,15+EMSC	112	7	0.76	1.1	0.64	1.38	1.97

CONCLUSIONS

NIRS technology could be used to determine some quality parameters (salt content, palmitic and oleic acids) in packaged cured ham-sliced without to need to open the package, as an alternative to conventional methods of analysis.

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