PREDICTION OF FREEZING TEMPERATURES AND STORAGE PERIOD OF PORK LOIN USING VIS-NIR HYPERSPECTRAL IMAGE ANALYSIS

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I. INTRODUCTION

Freezing has been used for long-term storage of meat in spite of the quality deterioration of meat compared to fresh meat such as the thawing loss. The quality of frozen-thawed meat is different according to the freezing temperatures and storage periods as well [1]. However, it is difficult for consumers to distinguish the difference between frozen meat and fresh meat with the eyes
Hyperspectral imaging systems can provide both spectral and spatial information on the differences in the physicochemical properties of meat. This method is non-destructive, the measurement time is short and quality classification is possible continuously. Therefore, we hypothesize that a hyperspectral imaging system can classify frozen-thawed pork loin according to the freezing temperatures and storage periods.

II. MATERIALS AND METHODS

The 30 loins were purchased from a local market. Each loin was sliced (5 cm thickness) and a total of 360 pork loin slices were obtained. Loins were classified into three freezing temperatures (-20, -50, and -70 °C) and three frozen storage periods (30, 60, and 90 days). The 30 loins were assigned to each treatment group and the 90 loins were used as fresh meat. Frozen loins were thawed in the refrigerator at 2±2 °C for 48 h. The thawing loss (TL) was calculated as a difference between the weight before freezing and the weight after freezing-thawing. Statistical analysis of TL using the mixed model was calculated by SAS (version 9.4, SAS Institue Inc., Cary, NC, USA)
The hyperspectral image of the frozen-thawed loin was measured by the hyperspectral camera (Ultris X20 plus, Cubert GmbH, Germany). The spectral images were obtained in the reflectance mode, and the wavelength range of 350-1002 nm, in other words, using a total of 164 bands. The region of interest of pork loin was selected using perClass software (perClass Mira, Nederlands) to obtain the mean reflectance spectral value. 70% data in each treatment were used for calibration, and the other was used for prediction. Several pre-processing methods such as standard normal variate (SNV), first or second-derivate (1DER, 2DER), Savitzky-Golay (SG), and offset were used. To classify pork loin according to temperature and the storage period, partial least squares discriminate analysis (PLS-DA) and SIMCA analysis were conducted with the SIMCA program (Sartorius, Germany).

III. RESULTS AND DISCUSSION

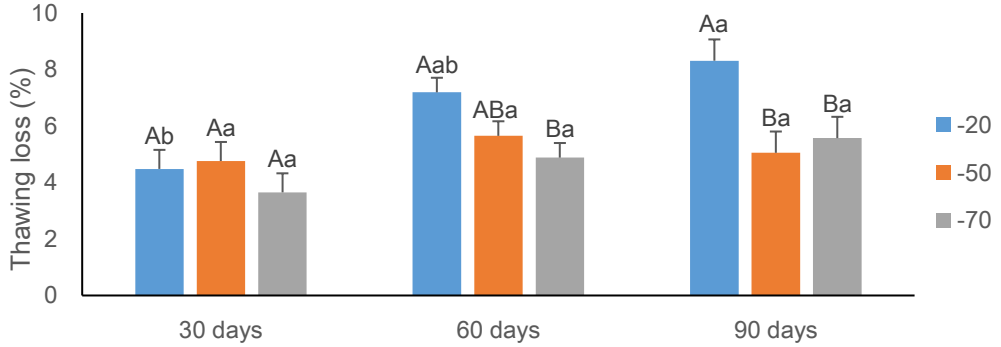

Figure 1. The thawing loss (%) of frozen-thawed pork loin with the different freezing temperatures and frozen storage periods

[A-B] Different capital letters and [a-b] different lowercase indicate significant differences between means in the same storage day and the same frozen temperature, respectively ($P<0.05$)

The TL of pork loins was not different between freezing temperatures at -50 °C and -70 °C for all frozen storage days (Figure 1). However, the pork loin frozen at -20 °C had the highest TL in 60 and 90 days of frozen storage. When the freezing rate is slow and the frozen storage period is extended, the larger ice crystals generated in extracellular space could damage the cell structure, resulting in increasing the release of exudates [2].

Table 1. Performance of PLS-DA and SIMCA analysis for classification of frozen-thawed pork *longissimus* different freezing temperatures and storage period

	Pre-processing method	Calibration (n=252)		Prediction (n=108)
		Number of components*	%CC	%CC
PLS-DA	x	17	84.32	78.99
	SNV, 1DER	15	80.51	73.95
	Offset, 1DER	15	83.9	69.75
	SG, SNV, 2DER	13	67.23	67.23
SIMCA	x	8-7-9-8-8-9-8-6-1-5	73.31	51.26
	SNV, 1DER	15-3-9-9-9-9-9-9-9-8	88.56	56.3
	Offset, 1DER	15-3-9-9-8-4-9-9-9-4	82.63	53.78
	SG, SNV, 2DER	15-9-9-8-6-9-7-9-6-9	88.14	59.66

* (Fresh, -20 ℃, -50 ℃, and -70 ℃ at each 30 days, 60 days, and 90 days) in order.

The correct classification (%CC) of each treatment classified by PLS-DA and SIMCA analysis was shown in Table 1. In calibration by PLS-DA, pre-processing methods had no effect on %CC, and the highest %CC was 84.32%. However, the highest %CC was 88.56% in the calibration by SIMCA analysis with SNV and 1DER. The highest %CC in prediction was 78.99% with the PLS-DA without pre-processing although the %CC in calibration was higher in SIMCA than in PLS-DA

IV. CONCLUSION

The 78.99% of pork loins were effectively classified into frozen temperature and frozen storage period. If the classification of pork loin is conducted based on the TL, the %CC may be increased. Therefore, further research is needed for the development of an effective and correct model to classify the quality groups of frozen-thawed pork loin.

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