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NON-DESTRUCTIVE PREDICTION FOR COOKING LOSS OF PORK BELLY SLICES BY SEMISPINALIS CAPITIS MUSCLE USING HYPERSPECTRAL IMAGING ANALYSIS

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I. INTRODUCTION

The pork belly is an internal cut of pork carcass with excellent juiciness, flavor, and texture because it contains a high-fat content. However, measuring the meat quality of pork belly is time-consuming and destructive. In South Korea, carcass properties such as hot carcass weight and backfat thickness have been used as fatness indicators of pork carcasses, an indirect quality parameter. The cooking loss (CL) is a more direct quality parameter of pork belly, which reflects juiciness of sensory quality, water-holding capacity, and meat composition [1]. Conventional analysis of CL is destructive and time-consuming. A hyperspectral imaging system (HSI) is a non-destructive and rapid method that provides spatial and spectral information [2]. The *semispinalis capitis* (SC) muscle in the pork shoulder butt is the exposed muscle to the outside of the half-pork carcass. Also, our previous research discovered that the physicochemical properties of SC muscle in pork shoulder butt are related to the cooking loss of pork belly [3]. Therefore, this study aims to predict the CL of pork belly by capturing the SC muscle using HSI.

II. MATERIALS AND METHODS

The pork shoulder butt and whole bellies were obtained from 70 pork half-right carcasses (Landrace x Yorkshire x Duroc) after 24 h postmortem. The SC muscle was removed from the pork shoulder butt after the acquisition of hyperspectral imaging. Pork belly slices (7 mm thickness) were removed from the 6th and 11th thoracic vertebrae (TV) and 4th lumber vertebrae (LV). The CL of pork belly slices and SC muscle was measured. Pearson correlation between the CL of pork belly slices and SC muscle was investigated using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA). The pork shoulder butt was captured (350-1002 nm, 164 bands) in a reflectance mode using a hyperspectral camera (Ultris X20 plus, Cubert GmbH, Germany) and CUVIS software (Cubert GmbH, Germany). The SC muscle was set as a region of interest to extract the mean spectrum. The partial least square regression (PLSR) was used to establish prediction models for CL of pork belly. 70 samples were used to establish the calibration model, and 30 samples were extracted from the calibration models to establish the validation models. The pre-processing methods, standard normalized variate (SNV), and the first derivative (1st der) were employed to enhance the model performance. The optimal number of latent variables (LVs) was selected based on the K cross-validation (K=7). The determination correlation of calibration and validation sets (R^2_c and R^2_v, respectively) and the root mean squared error of calibration and validation sets (RMSEC and RMSEV, respectively) were calculated to determine the accuracy of the models. The chemical maps of SC muscle were provided for the CL level of pork belly based on models with the highest accuracy using MATLAB R2022a (The MathWorks, Inc., Natick, MA, USA).

III. RESULTS AND DISCUSSION

Determining a relationship between the CL of pork belly and SC muscle could help understand whether it is possible to predict the CL of pork belly through spectral data of SC muscle using HSI. The CL of SC muscles had a weak correlation with the CL of whole pork belly slices (r_p=0.37~0.38, Table 1). These results showed that SC muscle's quality property is related to pork belly slices. Thus, indirect monitoring of CL of pork belly slices using SC muscle might be possible.

Table 2 shows the model's performance in predicting the CL of pork belly slices from different anatomical locations using PLSR. The prediction accuracy of models without pre-processing showed 0.60 of R^2_v for the 6th TV and 0.74 of R^2_v for the 11th TV. Also, the model of the 4th LV without pre-processing showed an accuracy of 0.61 of R^2_V. The 1st der of pre-processing improved the model accuracy for predicting the CL of pork belly slices from all different anatomical locations. After the 1st der of pre-processing, the highest model accuracy of validation sets for CL of all pork belly locations was observed, which was over 0.7 of R^2_v. The 1st der of pre-processing could remove the noise and emphasize different spectra between the samples [2]. Figure 1 shows the chemical maps of SC muscles. Because the SC muscle is an exposed muscle, if the chemical maps of the SC muscle represent the CL level of pork belly slices, the chemical maps could easily provide the CL level of pork belly, an internal primal cut of pork carcass.

Table 1 – Pearson correlation coefficient between cooking loss (%) of pork

	SC muscle	6th TV	11th TV	4th LV
SC muscle	1	-	-	-
6th TV	0.37**	1	-	-
11th TV	0.38**	0.82***	1	-
4th LV	0.37**	0.68***	0.68***	1

Table 2 – Prediction results of cooking loss (%) from pork belly using PLSR

6th thoracic vertebrae					
Pre-process	LVs	R^2c	RMSEC	R^2v	RMSEV
-	16	0.65	1.35	0.60	1.28
SNV	14	0.62	1.37	0.48	1.36
1st derivative	13	0.74	1.25	0.73	1.15
11th thoracic vertebrae					
Pre-process	LVs	R^2c	RMSEC	R^2v	RMSEV
-	16	0.62	1.41	0.74	1.23
SNV	12	0.51	1.50	0.66	1.32
1st derivative	13	0.71	1.32	0.80	1.15
The 4th Lumbar vertebrae					
Pre-process	LVs	R^2c	RMSEC	R^2v	RMSEV
-	12	0.54	1.37	0.61	1.28
SNV	11	0.52	1.38	0.58	1.31
1st derivative	12	0.70	1.23	0.73	1.17

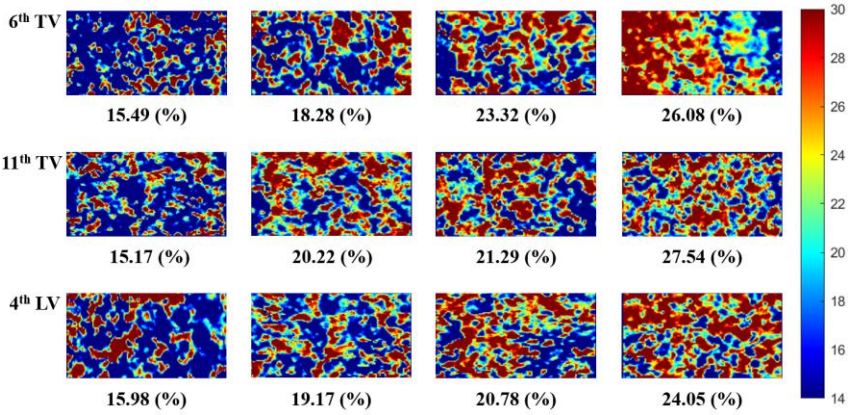


Figure 1. The prediction maps in the semispinalis capitis muscle for the pork belly cooking loss from different anatomical locations

IV. CONCLUSION

This study was investigated to predict the CL of pork belly slices from different anatomical locations by capturing the SC muscle using hyperspectral imaging analysis. The accuracy of models was improved by the 1st der of the pre-processing method in all anatomical locations (R^2_v > 0.7). This study showed the potential of non-destructively predicting the CL of the pork belly using the SC muscle spectra by HSI.

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