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Predict Beef Tenderness Using Image Texture Features

W. Ogdahl, A. Ward, E. Knutson, J. Liu, S. Wirt, E. Berg, and X. Sun*

Animal Sciences Department, North Dakota State University, Fargo, ND, USA

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Objectives

The aim of this study was to investigate the usefulness of image texture features extracted by computer image processing techniques to predict beef tenderness.

Materials and Methods

Fifty-eight strip loins from commercial Angus × Simmental steers were used to evaluate the effectiveness of image texture features on the predictability of beef tenderness. The average marbling score of these samples was 539.5, marbling score ranged from 360 to 820. The strip loins were vacuum packed and aged for 2 wk under 0°C. Upon aging, 2.5-cm 13th rib steaks were cut from the center section of each loin. After blooming 10 to 15 min, images were acquired using a laboratory-based color camera (NI 1776C, National Instruments, USA) with a controlled illumination system. Image background segmentation, lean/fat area separation was performed after the image acquisition (Fig. 1). Image texture features, which including 88 gray level co-occurrence, 81 fast Fourier transform, and 48 Gabor wavelet filter texture features were extracted from the fresh beef strip loin steak images. After cooking, steaks were placed on a metal tray to allow to cool to room temperature. Steaks were analyzed for tenderness by the Warner-Bratzler shear force (WBSF) method. First, steaks were cooked to a final temperature of 71°C with a clamshell-style grill and cooled to room temperature, six 1.3-cm cores were removed and sheared from each steak parallel to the muscle fiber orientation. Steak samples were segregated into tougher and tender classification groups based on WBSF values whereby a WBSF of 2.0 kg or less was considered tender. A STEPWISE regression model was established to test the prediction model. A total of 2017 image texture features were input as indicators for beef tenderness attributes. The subsequent textural feature selection method was analyzed by the STEPWISE method.

Figure 1. Image processing procedure for steak texture feature extraction.

Table 1. STEPWISE regression model summary for beef tenderness using image texture feature as predictors

Model	R	R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	Sig. F Change
1	.47	.22	.36	.22	15.80	.00
2	.55	.30	.35	.08	6.50	.01
3	.64	.41	.32	.11	10.01	.00
4	.69	.47	.31	.06	6.02	.02
5	.73	.54	.29	.06	7.13	.01
6	.76	.58	.28	.04	5.40	.02
7	.80	.63	.26	.05	7.32	.01
8	.82	.68	.25	.04	6.43	.01
9	.85	.72	.23	.05	7.93	.01
10	.88	.77	.21	.05	11.05	.00
11	.89	.80	.20	.02	5.45	.02
12	.91	.82	.20	.02	5.37	.03

Results

The STEPWISE model regression summary result of classified tenderness according to WBSF value was shown in Table 1. STEPWISE method generated 12 useful models to predict beef tenderness through image texture features. The best model's coefficient of determination value was 0.82, which means image texture features were able to explain 82% of the variation in strip steak tenderness as determined by WBSF value.

Conclusion

This study shows the potential of image texture analysis, in combination with image processing analysis, for prediction of fresh beef tenderness.