Prediction of pork belly quality during refrigerated storage using hyperspectral imaging

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Objectives: Pork is the most consumed red meat in the world and, in some countries, belly is considered the most valuable cut. The fat content of pork bellies can affect some technological qualitative traits (Hoa et al., 2021). Although conventional techniques are traditionally utilised to determine the essential quality traits, different non-destructive techniques based on NIR spectroscopy and hyperspectral imaging (HSI) have also been successfully implemented, and they have gained increased interest over recent years (Gowen et al., 2007). The main aim of this study was to investigate the feasibility of the HSI technology to predict some important quality parameters of pork bellies having different fat content through different refrigerated storage periods.

Methods: Deboned pork bellies from different breeds (n=24) were selected from a local cutting plant to obtain 3 types of bellies with different fat content: low fat (LF) from 20 to 30%, medium fat (MF) from 40 to 50%, and high fat (HF) from 60 to 70%. Bellies were sliced at 1 cm in thickness and packed in a modified atmosphere (MAP) with 70% O_2 / 30% CO_2. The samples were stored in refrigerated display cabinets and exposed to 12 h lightness cycles for 20 days. Total Viable Count (TVC), pH, oxidation index (TBARS) and L*, a*, b* colour coordinates of the lean were measured. The hyperspectral imaging system composed of a CCD camera, a spectrograph, a conveying platform and a computer supported with an image acquisition software (Spectronon, Resonon Inc., Bozemari, MT, USA). Spectral images were acquired line by line in a wavelength range from 386 to 1015 nm with 300 wave- bands at 2 nm intervals in the spectral domain. Spectral data were analysed with MATLAB software (2022a version). PLS models were developed using around 400 combinations of two different pre-processing techniques, band selection using the ensemble Monte Carlo Variable Selection (EMCVS) method and an internal validation was applied. To select the best model, R^2, RMSE and RPD were estimated. Prediction models developed for complex matrices can be classified as excellent (RPD > 4.1), very good (RPD 3.5-4.0), good (RPD 3.0-3.4), fair (RPD 2.5-2.9) and poor (RPD 2.0-2.4) (Williams, 2014).

Results: In all studied samples, we obtained a range of TVC from 0.95 to 8.23 log CFU/g, pH from 5.43 to 7.03 and TBARS from 0.02 to 1.79 MDA/kg meat. The minimum and the maximum values for L*, a* and b* measured were 54.41-77.45, 2.78-14.92, 5.47-13.83 respectively. The best prediction equations for pork belly quality parameters throughout refrigerated storage had a R^2 of 0.85, 0.66, 0.91, 0.56, 0.95, 0.66, a $RMSE_p$ of 0.47, 0.20, 0.15, 2.86, 0.66, 0.98% and a RPD_p of 2.46, 1.67, 3.49, 1.56, 4.77, 1.76 for TVC, pH, TBARS and L*, a*, b* coordinate respectively.

Conclusion: The use of advanced chemometrics techniques permitted to obtain robust models to predict TVC, pH, TBARS and L*a*b* colour coordinates as quality indicators of bellies slices with different fat content throughout refrigerated storage with the hyperspectral imaging in the studied conditions.

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