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Quality Assessment of New Zealand Mānuka Honeys Using Hyperspectral Imaging Combined with Deep 1D-Convolutional Neural Networks

Authors : Hien Thi Dieu Truong, Mahmoud Al-Sarayreh, Pullanagari Reddy, Marlon M. Reis, Richard Archer

Abstract : New Zealand mānuka honey is a honeybee product derived mainly from Leptospermum scoparium nectar. The potent antibacterial activity of mānuka honey derives principally from methylglyoxal (MGO), in addition to the hydrogen peroxide and other lesser activities present in all honey. MGO is formed from dihydroxyacetone (DHA) unique to L. scoparium nectar. Mānuka honey also has an idiosyncratic phenolic profile that is useful as a chemical maker. Authentic mānuka honey is highly valuable, but almost all honey is formed from natural mixtures of nectars harvested by a hive over a time period. Once diluted by other nectars, mānuka honey irrevocably loses value. We aimed to apply hyperspectral imaging to honey frames before bulk extraction to minimise the dilution of genuine mānuka by other honey and ensure authenticity at the source. This technology is non-destructive and suitable for an industrial setting. Chemometrics using linear Partial Least Squares (PLS) and Support Vector Machine (SVM) showed limited efficacy in interpreting chemical footprints due to large non-linear relationships between predictor and predictand in a large sample set, likely due to honey quality variability across geographic regions. Therefore, an advanced modelling approach, one-dimensional convolutional neural networks (1D-CNN), was investigated for analysing hyperspectral data for extraction of biochemical information from honey. The 1D-CNN model showed superior prediction of honey quality (R^2 = 0.73, RMSE = 2.346, RPD= 2.56) to PLS (R^2 = 0.66, RMSE = 2.607, RPD= 1.91) and SVM (R^2 = 0.67, RMSE = 2.559, RPD=1.98). Classification of mono-floral manuka honey from multi-floral and non-manuka honey exceeded 90% accuracy for all models tried. Overall, this study reveals the potential of HSI and deep learning modelling for automating the evaluation of honey quality in frames.

Keywords : mānuka honey, quality, purity, potency, deep learning, 1D-CNN, chemometrics
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