Classification of nitrate/ nitrite levels in bacon using hyperspectral imaging

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Introduction: In the last year, bacon sales have contributed over £1 billion to the British pork industry (Randall, 2021). However, research indicates that nitrosamines formed during traditional curing with sodium nitrate and nitrite are carcinogenic and have been linked to human colorectal cancer (Bouvard et al., 2015; Santarelli et al. 2008). In light of these findings, a food processor in Northern Ireland has produced a "bacon" free from nitrates and nitrites. However, expensive and destructive testing is required to prove that this particular product is nitrate and nitrite free. Hyperspectral Imaging (HSI) is a novel technique that offers the potential to measure food quality non-destructively. The aim of this short project was to provide an indication whether HSI can discriminate nitrate/ nitrite free bacon from traditional bacons containing "medium" and "high" levels of nitrates and nitrites

Materials and Methods: Thirty samples of 5 brands of bacon (150 samples total); 2x nitrite free, 2x standard bacon and 1x dry aged were purchased from a large retail outlet over 7 dates. Bacon samples were then scanned using a hyperspectral imaging camera in both the VNIR (400-900nm) and SWIR (900-2400nm) spectral regions. Spectral profiles were extracted from each sample. Bacon samples were then extracted with water and extracts were tested for nitrate/ nitrite levels using commercial test strips (Water Works™ part number 480009). Results from test strips were used to create 3 classifications based on nitrate/ nitrite levels. Spectral data was then statistically analysed using Discriminant Analysis techniques.

Results: Analysis of aqueous bacon extracts using the nitrate and nitrite test strips identified three classifications, namely "Free", "Medium" and "High". Discriminant analyses, using these groupings, identified several models capable of differentiating the nitrate/ nitrite "free" bacon from other classifications with greater than >90% of samples correctly classified. The best performing model showed that 97% and 94% of samples were correctly classified in calibration and validation data sets respectively. Indeed, in total, only 6 of 150 bacon were incorrectly classified by this model. Selected wavelengths, important to model performance have also been identified.

Conclusions: Hyperspectral models have been developed that classify nitrate and nitrite levels in bacon with >90% samples correctly predicted. Wavelengths key to HSI model performance have been identified. Other models developed in this project indicate that it is possible to classify bacon by brand and by whether or not the bacon has been smoked. A wide range of samples will need to be tested to verify the model's widespread application.

Acknowledgements and Financial support statement: We acknowledge financial support from the Department of Agriculture, Environment and Rural Affairs (Northern Ireland) for funding this final year project by Andrew Pentland at the College of Agriculture, Food and Environment. Due to the COVID pandemic, the practical work was conducted by Trudi Scott and David Farrell.

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