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Vibrational Spectroscopy Facility

APPLICATION NOTE 03 by Dr Janine Colling

Food Fraud: using hyperspectral imaging to distinguish between pepper and papaya

Spices add flavor, aroma and assist with preservation when added to foods and beverages. Several spices and herbs are sold dried or milled. This creates an avenue for food adulteration and food fraud. Spices which are commonly adulterated include garlic powder, black pepper, cinnamon, nutmeg, saffron and oregano amongst several others. Products used for adulteration range from plant husks, ground shells, saw dust, millet, buckwheat, chalk powder and cornstarch (Galvin-King et al., 2018). None of these are items that a consumer would want to consume.

What is food fraud and what is the motivation behind this?

Food fraud is described as 'the deliberate and intentional substitution, addition, tampering or miss-presentation of food, food ingredients or food packaging or false or misleading statements made about a product for economic gain' (Spink and Moyer, 2011). The adverse effects can be immediate toxicity or lethality, whereas long term exposure may result in chronic side effects (Spink and Moyer, 2011). The misrepresentation of food contents can also result in serious allergic reactions. In this application note, we investigated the ability of NIR hyperspectral imaging to detect the adulteration of black pepper.

Pepper or papaya?

Black pepper is collected from the dried mature fruit of the climbing vine (*Piper nigrum*), which is native to Southern India and Sri Lanka (Vadivel et al., 2018). Pepper contains the chemical compound piperine, which usually occurs in the range 3 - 8 g/100g (Schulz et al., 2005). This alkoloid gives pepper the characteristic taste (McGoverin et al., 2012). The aroma of pepper is derived from the essential oils, which are extracted by steam distillation (Schulz et al., 2005). Examples of the adulteration of pepper includes addition of buckwheat or millet, pearl millet and even papaya seeds (McGoverin et al., 2012; Vadivel et al., 2018). Addition of seeds from other species can be dangerous. When dried, the pepper and papaya seeds look similar, making it difficult to distinguish between them (Fig 1).

Figure 1: Dried seeds from papaya and pepper have a similar appearance

Seeds from (A) a fresh papaya may be collected from the fruit. Upon drying the seeds from papaya (B) and pepper (C) look similar especially when mixed.

Can HSI distinguish between the true spice and the adulterant ?

Whole black pepper and papaya seeds were imaged using the SWIR hyperspectral camera, which collects the absorption spectra in the 950 – 2500 nm range. The average raw spectra for each sample type appeared similar (Fig 2A), and requires the use of multivariate data analysis to discriminate between the two products. Principal component analysis can be used to explore the data (Fig 2B). The pixels were coloured according to their class (papaya or pepper). Two clusters corresponding to each product type can be recognized in the scatter plot. The difference in the chemical profiles of the samples can be investigated using a loading plot (Fig 2C). Key NIR bands or wavenumbers for example a band at 2174 nm responsible for the separation between the two product types, can be identified. The distribution of a compound with amide bonds (2174 nm) can be studied visually by using chemical maps (Fig 2D).

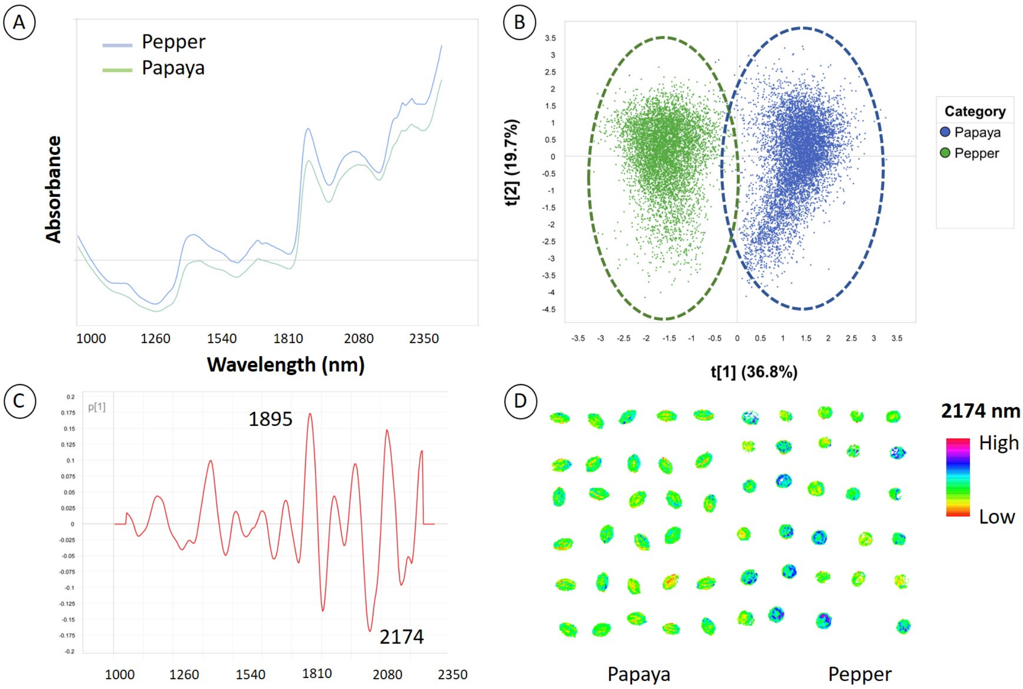

Figure 2: *Multivariate data analysis can be used to distinguish between products based on their chemical differences.* (A) The average spectral plot displaying the absorbance of each product over the NIR spectral range. (B) Scatter plot displaying two clusters for pixels belonging to papaya (blue) and pepper (green). (C) Loading plot for PC[1] indicating important spectral bands related to clustering. (D) Chemical maps indicate that the spatial distribution of a compound with amide bonds is higher in black pepper.

How can NIR spectroscopy be used for industrial applications?

The spectra of authentic and known adulterants can be collected and used to construct a calibration model. Application of the model would facilitate identification of products and adulterants in unknown samples. NIR spectroscopy can also be used to evaluate other properties of spices such as the moisture content and for quantification of the chemical contents for example the capsaicinoid levels in chilli peppers (Jiang et al., 2018).

References for further reading

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Interested in the use of hyperspectral imaging?

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