Near infrared hyperspectral imaging for spices adulteration: a feasibility study

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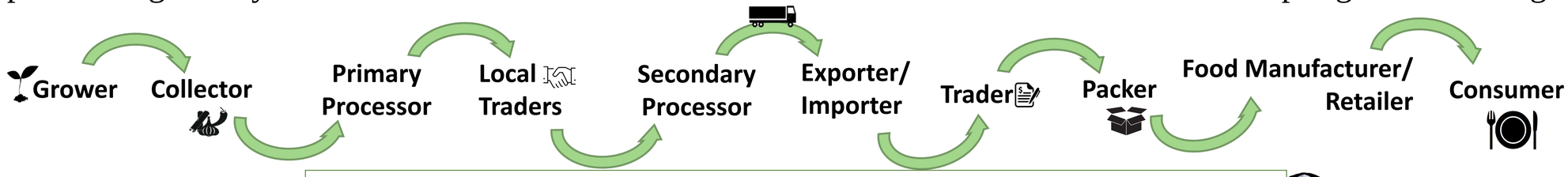
Introduction

The world market for herbs and spices is valued at US $4 billion, and is expected to grow in the near future. In this sector, supply chains tend to be long, complex and can pass through many countries. One of the most common adulterations is the addition of cheaper ground bulking agents, such as cistus, myrtle and olive leaves [1].



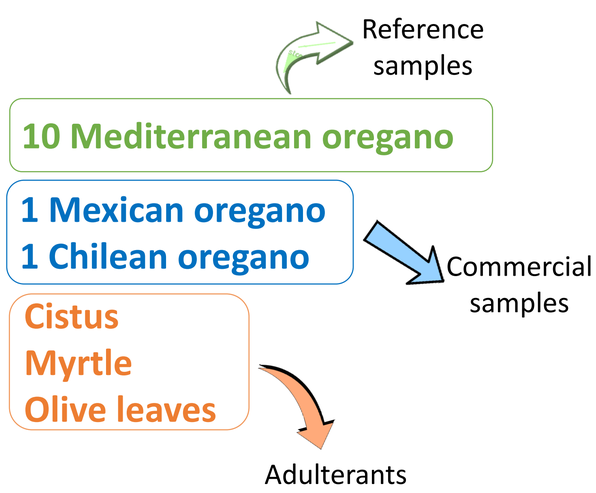
Fraud opportunities can occur at any stage of this supply chain

Hyperspectral Imaging

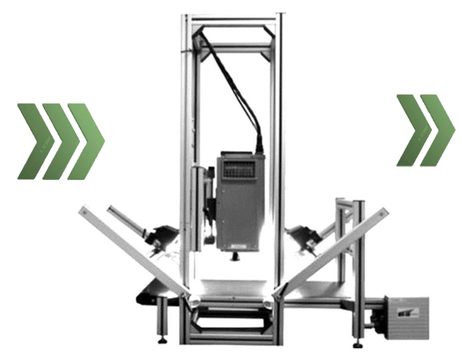
Apart from light microscopy, different vibrational spectroscopic techniques are the major analytical approach used to determine adulteration of herbs and spices in high concentrations [2].

Hyperspectral imaging is an emerging method which incorporates spectroscopy and imaging to produce both spatial and spectral data from a sample.

This technique enables a large quantity of material to be analysed, avoiding problems associated with representative sampling.

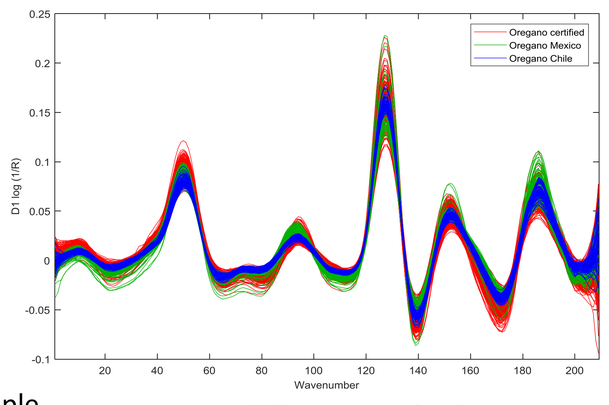


SWIR XEVA CL 2.5 320 TE4 coupled with ImSpector N25E



320-pixel images acquired for every sample
Reflectance spectrum (1100-2400 nm) for each pixel

1st Derivative Spectra



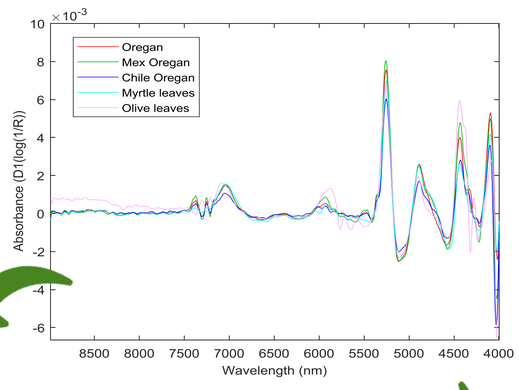
NIR spectra of reference and commercial oregano

Each pixel was used as data-point in the chemometric computations

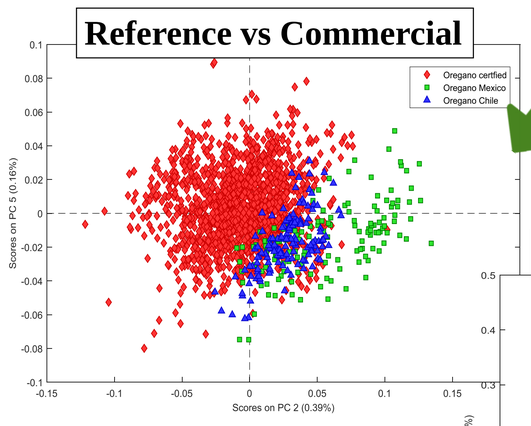
Chemometric Analysis

Principal Component Analysis

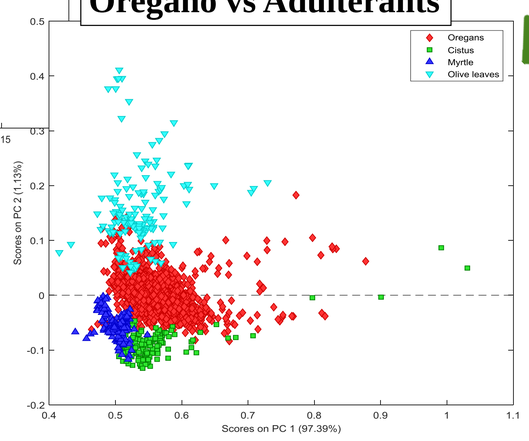
Mean-spectra of contaminants, reference and commercial oregano are reported. As can be observed in the spectra, several characteristic bands are present, particularly for the contaminants.



Reference vs Commercial



Oregano vs Adulterants

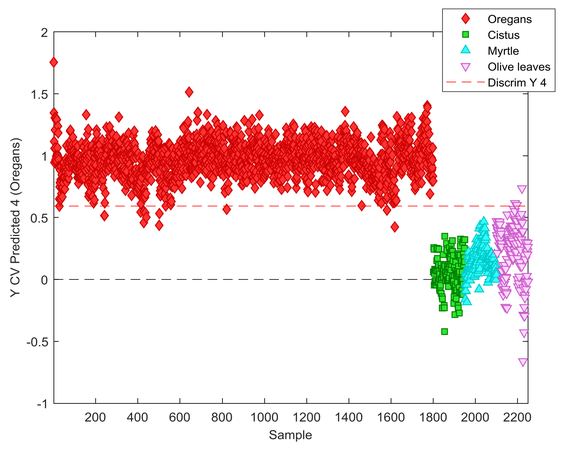


In both cases, distinct clustering was observed

PLS – Discriminant Analysis

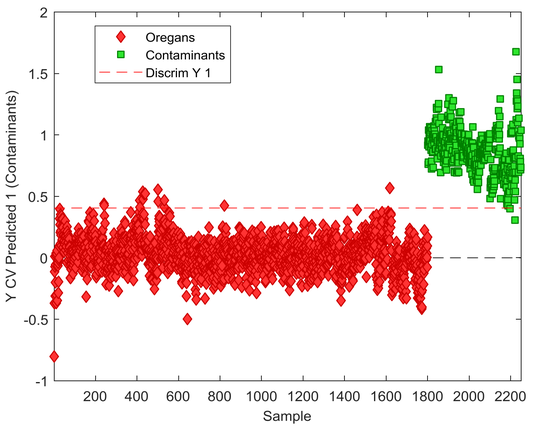
PLS-DA was selected as chemometric tool to develop classification models.

Confusion matrix (Cross-Validation)		
	Sensitivity [%]	**Specificity [%]**
Oregano	99	100
Cistus	100	99
Myrtle	98	99
Olive Leaves	96	99



The table gives the percentage of pixels detected as oregano or adulterants.

A high correct classification rate was obtained. This proves the spectral differences for adulterants, reference and commercial oregano.



Conclusions

Herbs and spices are highly vulnerable commodities to adulteration. This study shows the potential of NIR hyperspectral imaging combined with chemometrics as rapid and non-destructive method for herbs fraud detection. This method has been already tested in similar problematics and allows detecting adulteration and quantification at the ppm level. Overall, this techniques provide a good first point of control in the fight against adulteration. However the use of other confirmatory techniques such as mass spectrometry may be required in some circumstances.

References

[1] Galvin-King et al. (2018), Herb and spice fraud; the drivers, challenges and detection, *Food Control* 85-97;
[2] Reinholds et al., (2015), Analytical techniques combined with chemometrics for authentication and determination of contaminants in condiments: A review, *Journal of Food Composition and Analysis* 56-72.