Detection of Adulteration in Saffron using NIR-HSI

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Background

Saffron (Crocus Sativus L.), is a time-honored spice with a rich history of medicinal and therapeutic applications in various nations globally. Despite its high market value and growing demand, the cultivation of Saffron is restricted due to its specific agro-climatic growth requirements. This limitation often leads to deceptive practices by merchants to satisfy market needs and gain substantial financial profits. That is why, in the current global trade environment, verifying its quality and its possible adulteration is crucial [1-3]. Near Infrared Hyperspectral Imaging (NIR-HSI), a non-destructive and rapid method, joined with multivariate data analysis strategies, has shown promising results in visualizing the spatial distribution of chemical components, thereby enabling the identification of adulterants [4].

Motivation/goals

In this study, the combined use of NIR-HIS multivariate data analysis techniques and has demonstrated a powerful ability to detect and visualize adulteration in Saffron, paving the way for more effective quality control measures in the spice industry [5]. For this purpose, this study explores the efficiency of NIR-HSI coupled with chemometric techniques such as MCR-ALS for detecting and visualizing adulteration in Saffron.

Experimental

Sample Preparation

Saffron was milled in a coffee grinder

Saffron/Paprika and Saffron/Turmeric samples were prepared by weight

the range of saffron purity goes from 100-70%

The samples are mixed to assess the homogeneity

NIR-HIS camera

Headwall Photonics NIR hyperspectral camera (Model 1002A-00371, Fitchburg, MA, USA). Spectral Range 1000-1700nm. Spectral resolution of 4.85 nm and 142 bands. Spatial resolution, 20 µm.

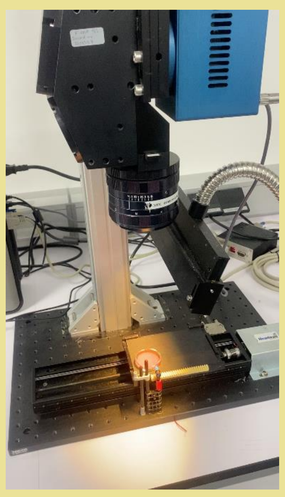


Figure 1. NIR-HIS sample registration

Saffron mass determination by weight

Table 1. Sample composition

Sample	Saffron	Paprika	Saffron purity (%)
P0	0.4015	0	100.00
P1	0.4014	0.0042	98.96
P2	0.4003	0.0080	98.04
P3	0.4005	0.0119	97.11
P4	0.4001	0.0161	96.13
P5	0.4007	0.0211	95.00
P6	0.4003	0.0441	90.08
P7	0.4002	0.1001	79.98
P8	0.4002	0.1700	70.19
P9	0	0.4004	0.00
T0	0.4007	0	100.00
T1	0.4005	0.0040	99.01
T2	0.4007	0.0083	99.97
T3	0.4012	0.0120	97.10
T4	0.4011	0.0162	96.12
T5	0.4008	0.0210	95.02
T6	0.4009	0.0440	90.11
T7	0.4005	0.1004	79.96
T8	0.4005	0.1703	70.16
T9	0	0.400	0.00

Data Structure

NIR HYPERSPECTRAL IMAGES

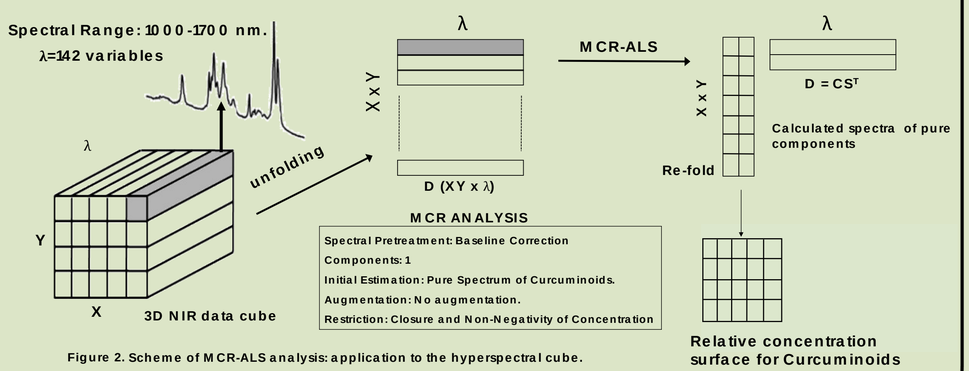
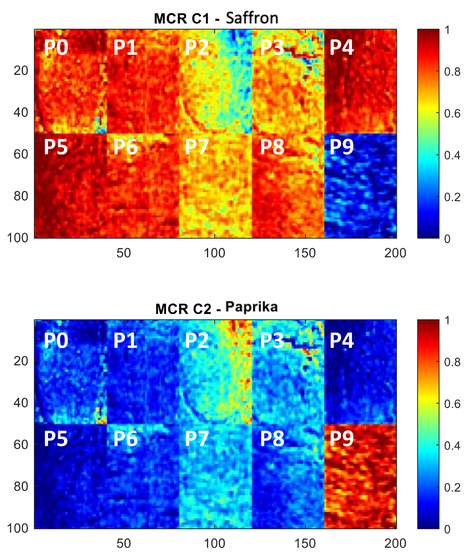


Figure 2. Scheme of MCR-ALS analysis: application to the hyperspectral cube.

Results and discussion

Paprika



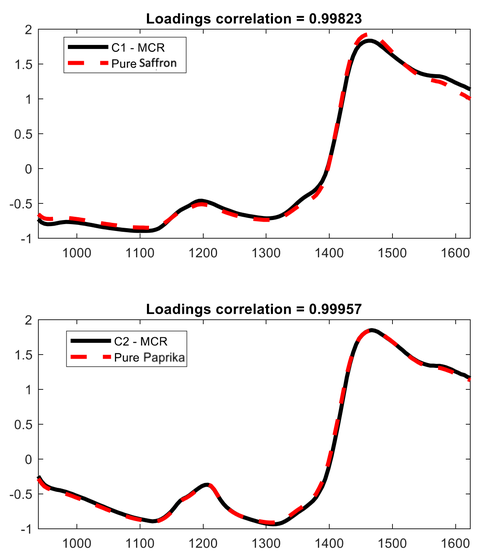
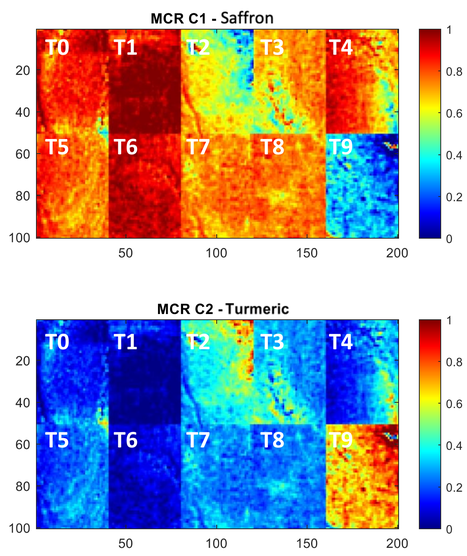


Figure 2. Saffron and Paprika concentration maps

Figure 3. Saffron and Paprika pure spectra vs. MCR concentration profile

Turmeric



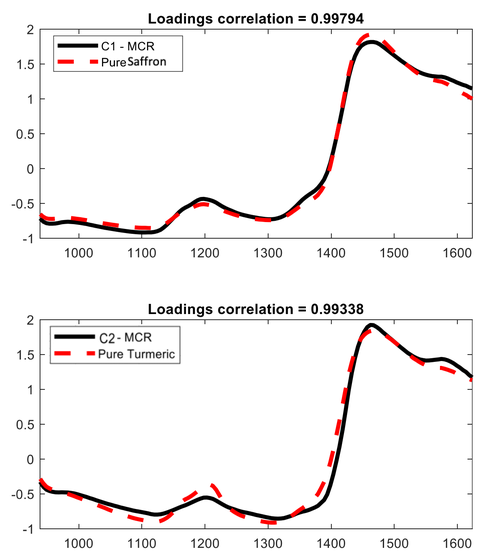


Figure 4. Saffron and Turmeric concentration maps

Figure 5. Saffron and Turmeric pure spectra vs. MCR concentration profile

1. **Although the samples have been mixed, the samples show evident segregation problems.**
2. **Also, samples with low amounts of adulterant are difficult to be distinguished by using NIR-HSI.**
3. **Samples with an adulterant content bigger than a 10% show acceptable results**

Conclusions and Future Prospects

This study has revealed significant challenges in detecting adulteration in mixed samples, mainly when the adulterant content is below 10%. Despite mixing samples, apparent segregation issues were observed, complicating the identification of samples with low adulterant content using Near-Infrared Hyperspectral Imaging (NIR-HSI). However, the study found that the results were considerably more reliable when the adulterant content exceeded 10%.

The results of this study highlight the potential of NIR-HSI coupled with chemometric techniques such as MCR-ALS as valuable tools in the fight against food fraud, ensuring the authenticity and quality of high-value products like Saffron.

As for prospects, upcoming research will focus on refining these techniques specifically for detecting saffron adulteration. Furthermore, the potential applicability of these techniques to other food products will also be explored.

Acknowledgments

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