Ocean Optics

Application Note

Keywords

- Anti-counterfeiting
- Edible oils
- Adulteration

Techniques

- Solid-state optical sensing
- Color analysis

Applications

- Product authentication
- Quality control

In Search of Counterfeit Olive Oil Using the Spark Spectral Sensor

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The Spark spectral sensor makes a great choice for many emerging applications of spectroscopy including anti-counterfeiting of high value food ingredients such as olive oil. With the new Spark spectral sensing technology – a form of solid-state optical sensing comparable to a detector chip that functions as a spectrometer – Ocean Optics has developed a lightweight, compact spectral sensor that can be used as a stand-alone instrument, or integrated into an OEM device.

Spark has the sensing power to get rapid, meaningful results at incomparable value. With its small size, great speed and favorable pricing, the Spark is accessible to a wider range of research, process and OEM applications than similar devices. In this application note we use the Spark to measure counterfeit extra virgin olive oil, demonstrating Spark's utility for detecting both dilution and adulteration of olive oil samples.

Background

The olive oil industry is thought to be worth around $11 billion annually (1). High quality extra virgin olive oil commands premium prices, making counterfeit oil products a real threat to the industry. This has been exacerbated in recent times as the industry's largest producers, Spain and Italy, have had crops hit by drought and disease, resulting in diminished production.

Confidence in product authenticity is important for consumers and businesses alike as adulterants and dilutions can affect quality and may even be harmful. Spectral analysis can be a surefire way discriminate true extra virgin olive oil from counterfeit products, which may otherwise look and even taste identical. In this application note, we use the Spark visible spectral sensor to explore the power of spectroscopy in distinguishing a number of oils and oil blends. We will show how the Spark can be used to identify different oils and to detect diluted extra virgin olive oil and cheap, low-grade oil made to look like extra virgin olive oil through the addition of chlorophyll -- a known counterfeiting technique (2), (3).

Determining the Authenticity of Olive Oil

Color is a great visual indicator of oil type, but it's not always possible to tell oils apart just by looking at them. Color can be subjective and change under different lighting. Also, the color of oil can be artificially adjusted to replicate different qualities of oil. Plant pigments such as chlorophyll and beta-Carotene are known to be added to oils to imitate the characteristic darker color of extra virgin olive oil (2), (3). Taste testing is sometimes used, but this also lacks accuracy and can be costly.

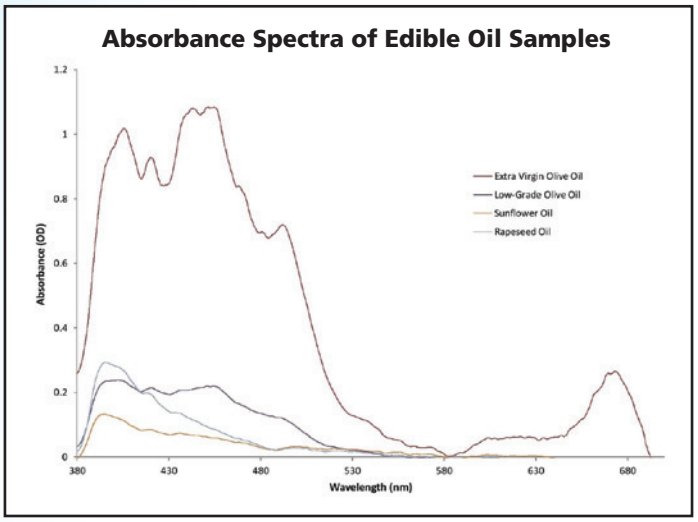

Figure 1 - Four different types of oil are displayed here to demonstrate general distinctions among them as measured by the Spark spectral sensor. Each type of oil has a unique spectral shape determined by the organic compounds present in the oil.

With spectral analysis using a device like Spark, more subtle differences among olive oil types can be discerned. Spectral analysis brings more accuracy to color measurements than the commonly used RGB sensor measurement technique. This is due to the extended range of wavelengths that are measured, giving more precise detail than a more limited number of wavelengths can achieve.

Spectral differences among various olive oil samples are shown in Figure 1. Spectral sensing techniques reveal more sample detail and are more accurate than other measurement methods, and highlight distinctive differences even when sample color is very similar.

The variation in the characteristic spectrum of each oil sample is clear, with the extra virgin olive oil having the strongest absorbance. The regular olive oil has a much lower level of absorbance but maintains the general spectral shape of the extra virgin olive oil. The sunflower and rapeseed oils show different spectral shapes altogether, noticeably in the region from 430-530 nm.

With spectral information like the absorbance features detected in Figure 1, Spark users have another tool for identifying and authenticating unknown oil samples. While the Spark has lower resolution than traditional, array-based spectrometers (5.0-9.0 nm FWHM), the primary olive oil absorbance features of interest are easily distinguished.

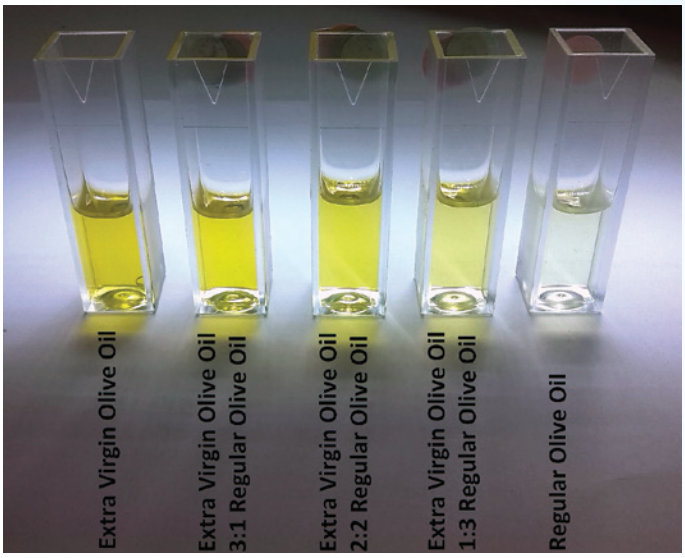

Figure 2 - Samples of extra virgin olive oil, diluted with increasing amounts of regular olive oil.

Monitoring Dilutions of High Quality Olive Oils

Dilution is one of the most common ways to counterfeit expensive extra virgin olive oil. In Figure 2 a sample of extra virgin olive oil was diluted with a series of increasing amounts of inexpensive, lower quality olive oil. The dark color of the extra virgin olive oil persists in dilutions up to 50%, making it difficult to distinguish among the oil samples by eye.

Figure 3 shows the results from our dilution test. In examining the spectra, it is easy to see the absorbance changes taking place with each dilution of the extra virgin olive oil. This is especially noticeable with the absorbance peak at 680 nm, which becomes very low or non-existent at the lower concentrations of extra virgin olive oil. Spectral features across the range from 380-500 nm also reveal the effects of dilution on absorbance.

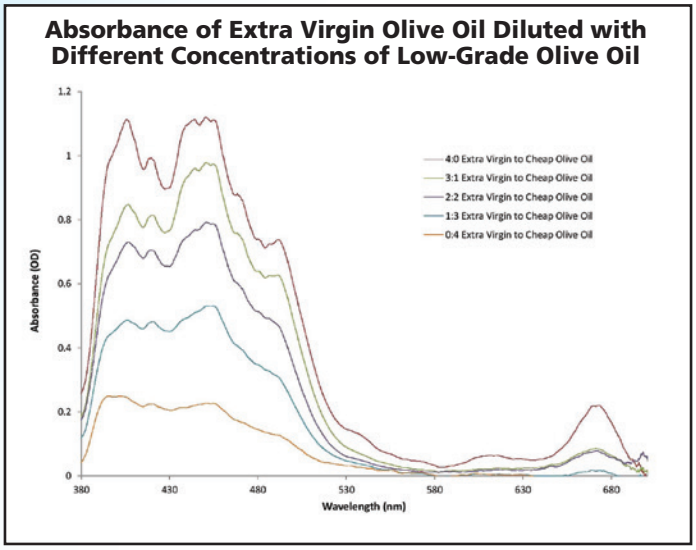

Figure 3 - Each different ratio of extra virgin and regular olive oil was tested for absorbance using the Spark spectral sensor. The results show a significant change with each dilution.

The spectral changes observed in Figure 3 show clearly how it is possible to authenticate extra virgin olive oil against a reference sample. Fast, in situ tests can be done using a comparison to a known sample in order to verify the sample within specified tolerances. Even minor spectral differences are noticeable, making spectral sensing techniques powerful in identifying dilution in cheaper olive oils.

Identifying Adulterated Oils

Low-grade oils can be made to look like extra virgin olive oil through the addition of chlorophyll. Beta-Carotene is also known to be added for flavor. For our testing, samples of sunflower and rapeseed oils were prepared with the addition of natural chlorophyll, extracted from spinach, to look like real olive oil.

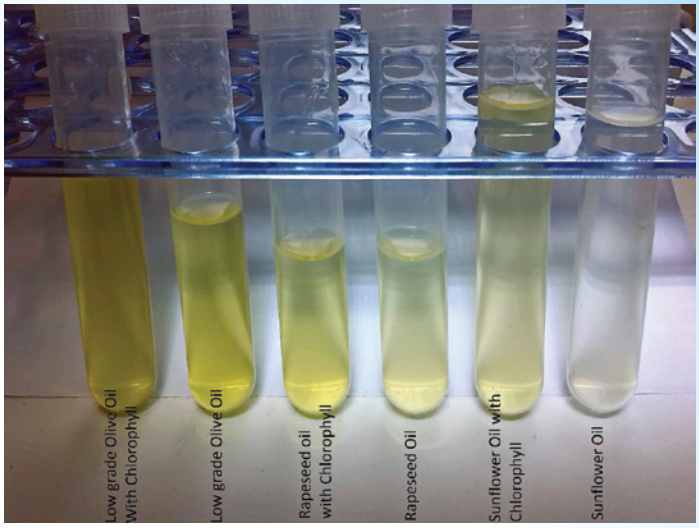

Figure 4 – A sampling of edible oils includes some containing added chlorophyll, which darkens the color.

It was impossible to distinguish by eye between the sunflower oil with chlorophyll and the darker rapeseed oil without added chlorophyll. Similarly, no distinction could be made between the rapeseed oil with added chlorophyll and the darker regular olive oil without added chlorophyll. This is shown in Figure 4.

With simple measurements using the Spark, we can easily distinguish each of these oils.

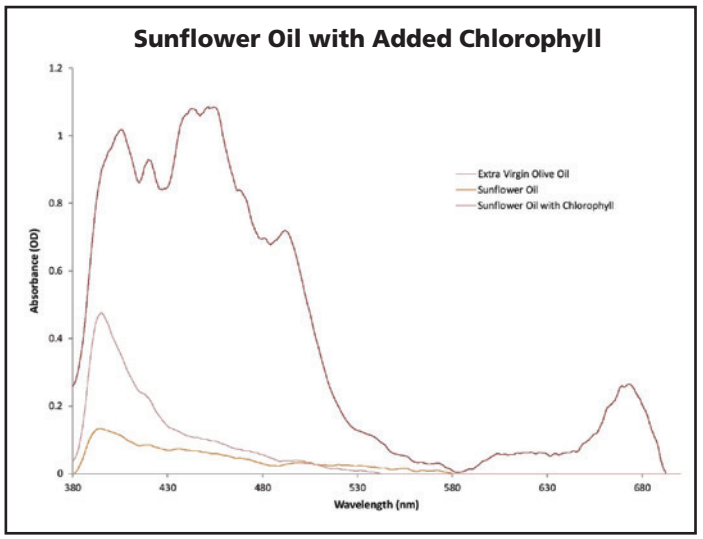

Figure 5 – Adulterants such as chlorophyll may be added to lesser-grade edible oils and passed off as premium-grade extra virgin olive oil. Spectral analysis helps to identify the adulterated samples.

The addition of chlorophyll significantly changes the absorbance spectrum of these oils, which is especially notable at 390 nm (Figures 5-7). When the chlorophyll is added, the oil color is darker and "greener" than the original light yellow color. The rapeseed oil with added chlorophyll (Figure 7) looks very similar in color to the cheap olive oil (Figure 6), but you can still see a clear difference between these two spectra. Spectral absorbance measurements offer a way to reliably and repeatedly tell these oils apart even when our own eyes are not able to.

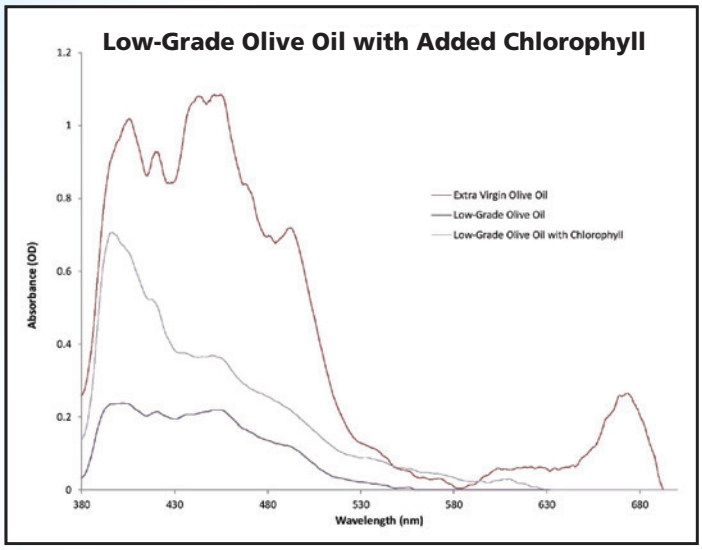

Figure 6 – To the naked eye, the addition of chlorophyll to a lesser-grade olive oil provides a darker appearance associated with extra virgin olive oil. However, spectral analysis reveals differences among the samples.

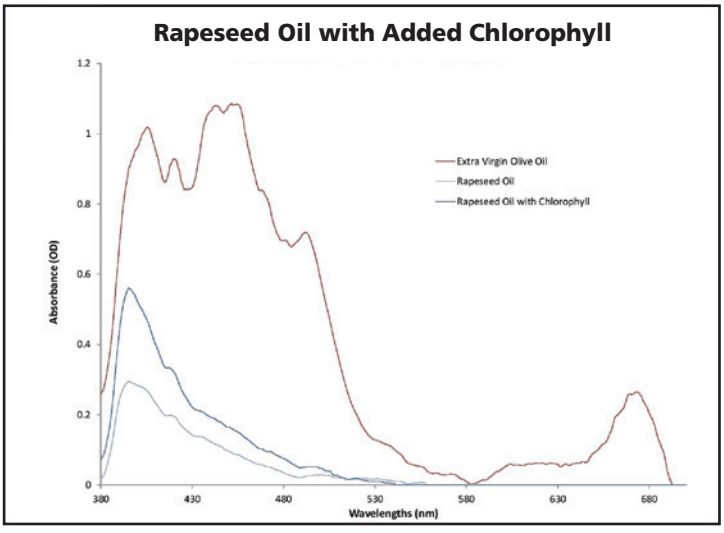

Figure 7 – Counterfeiters often use rapeseed oil to represent high-grade olive oil. Spectral analysis of rapeseed and extra virgin olive oil demonstrates significant differences between the two.

Conclusion

This study has demonstrated that with a compact, low-cost spectral sensor like Spark we can monitor olive oil to authenticate product quality and to detect counterfeit products. This was demonstrated for dilutions of extra virgin olive oil with cheaper oils, and for the addition of chlorophyll to cheaper oils to replicate the characteristic dark golden color of olive oil. Similar measurement methods could be scaled for laboratory analysis, integrated onto process lines or embedded into other instrumentation for quality control.

The Spark is ultra-compact, fast and has great value. It is a great choice for developing OEM solutions including compact handheld measuring systems. Spark can be used in situ throughout the entire food supply chain to ensure quality and authenticity of food oils being produced and sold.

Works Cited

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