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Application Note

Keywords

- Spices
- Chemical adulteration
- Flame spectrometer

Techniques

- Reflectance spectroscopy
- UV-Vis spectroscopy

Applications

- Adulterant detection
- Authentication
- Quality assessment

Adulteration of Spices

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Reflection Spectroscopy Can Identify Presence of Fillers and Dyes

High value ground powders like spices are frequently adulterated, as it is often difficult for consumers and importers to evaluate quality based on sensory input alone. Reflectance spectra collected using modular spectroscopy systems can reveal features signaling common spice adulterants, providing rapid on-site quality assessment without the need for chemical analysis.

The Spicy Truth About Adulteration

Spices are being used more than ever as consumers seek to reduce salt intake and expand their palates. In naturopathic medicine, spices are sometimes used for their antimicrobial or therapeutic effects. Spices ares high in value by weight, and are often sold in ground or powdered form, making them a prime target for substitution or alteration with low cost imitation products and fillers. In fact, the problem has become so prevalent that the EU has sponsored a special project called SPICED, which seeks "to reduce (industrial) chemical adulterations and to ensure authenticity of spices and herbs" and to address the issues surrounding spice fraud.

Spices like turmeric, paprika and ginger are often cut with fillers, from less expensive spices to flours, corn starch and even sawdust. Toxic or potentially carcinogenic dyes are added to hide aging of a product or the presence of fillers, as in the case of metanil yellow color and lead chromate found in turmeric originating from India. In 2005, over 600 finished food products in the EU and North America were recalled due to the presence of chili powder adulterated with Sudan 1, a red dye used to make the chili powder appear fresher. An industrial dye, Sudan 1 is a category 3 carcinogen not approved for human consumption. The consequences of spice adulteration extend far beyond quality to one of health and safety, underscoring the importance of developing convenient yet accurate testing techniques.

One Spectroscopic Solution

As the most expensive spice in the world, saffron is a very common target of spice fraud. Valued for the yellow color, delicate flavoring and scent it imparts to rice and other dishes, saffron threads are the dried styles and stigmas of the Crocus sativus flower, harvested by hand and carefully dried. To produce one kilogram of pure saffron requires 110,000–170,000 flowers and roughly 40 hours of labor. While evidence of saffron adulteration dates back to the Middle Ages, common fillers in current times include beets, pomegranate fibers, red-dyed silk fibers, or the tasteless, odorless yellow stamens of the same crocus flower.

UV-Vis absorption spectroscopy is already used to grade saffron via measurement of the compounds producing its unique color (crocin, ~440 nm), flavor (picocrocin, ~257 nm) and aroma (safranal, ~330 nm). The ISO 3632 method to do so, however, requires grinding of the saffron, filtering and extraction using solvents to produce a liquid solution.

Reflecting on Other Options

With this in mind, we couldn't help wondering if there might be a better way to test spices in their original form, so we tried reflection spectroscopy. Modular reflectance spectroscopy has proven to be a rapid, cost-effective alternative to chemical analysis in many other applications. It also has the benefit of allowing the ground powder to be measured directly.

As a test of feasibility, we looked at ginger, a spice sometimes cut with fillers to reduce its cost. The price of ginger began to skyrocket in 2013 due to a particularly cold winter in China, doubling in price by the end of that year to more than US $30 per pound. Ginger has been known to be adulterated with turmeric, corn starch, arrowroot, buckwheat, capsicum and allspice, and even powdered charcoal.

We chose allspice and turmeric as our trial adulterants, mixing each in turn with ginger in decreasing ratios to see how sensitive the technique potentially could be. Our reflectance measurement system consisted of an HL-2000-HP tungsten halogen lamp, Flame-S-VIS-NIR spectrometer, and a QR400-7-UV-VIS reflection probe mounted in an RPH-1 holder at 45°. We used a ring stand to hold the RPH-1 so the reflection probe assembly could be pointed upward. We then set a glass microscope slide on the RPH-1 and placed a pile of the spices on the microscope slide. The spices completely covered the opening in the RPH-1. A WS-1 diffuse reflectance standard was placed face down on the microscope slide when reference measurements needed to be taken.

While the reflection spectrum of pure ginger is quite smooth aside from a deep absorption band at ~400 nm, each adulterant betrayed its presence with a unique spectral feature. Allspice displayed a characteristic dip in its reflection spectrum at ~670 nm, visible even at levels as low as 10%. Turmeric had a broader absorption band from 400-500 nm, making its presence quite visible by eye down to 20%. Chemometric analysis could be used to improve the limit of detection, and for identification of the adulterant.

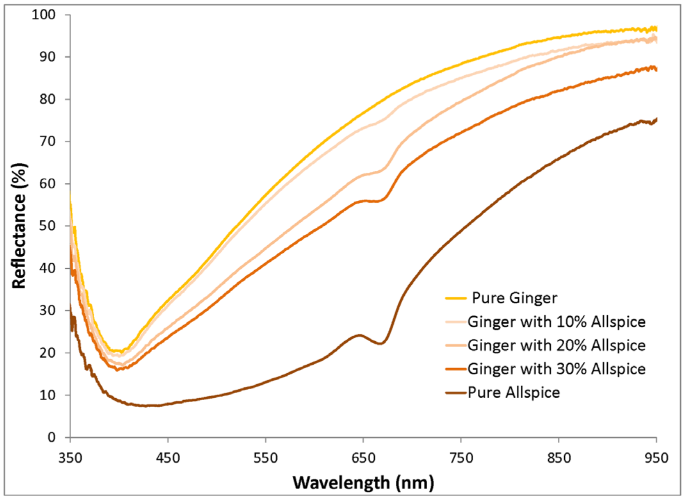


Figure 1: Reflectance spectra of ginger adulterated with allspice

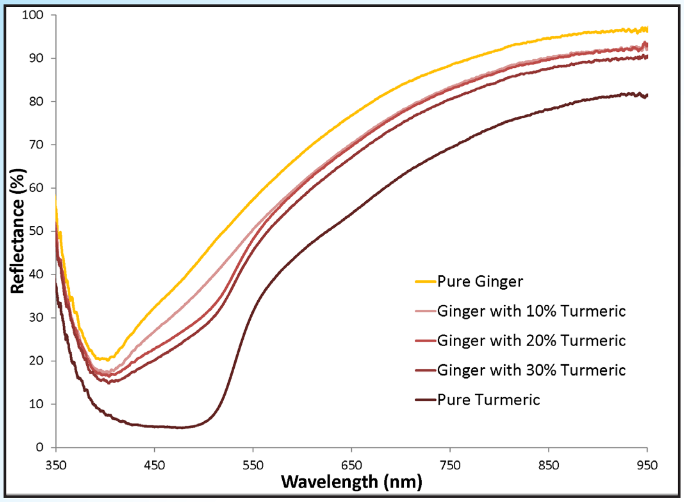
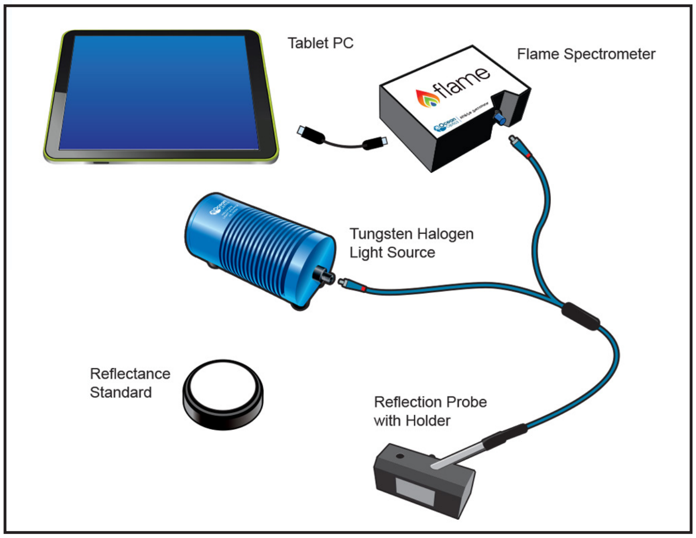


Figure 2: Reflectance spectra of ginger adulterated with turmeric

A Promising Solution

Modular spectroscopy enables the creation of compact, portable diagnostic systems that can be applied equally well in the field and in the lab. In demonstrating the ability of reflectance spectroscopy to discriminate dilution of ground ginger by some of its common adulterants down to 10% levels, we have shown the technique to be promising for use by importers, inspection agents and spice vendors alike.

Make Your Own Reflectance Measurements of Spice



Note: In the application described above, we added a ring stand to our setup to hold the reflection probe-with-holder assembly upside down (with probe pointing up toward sample). **This is not shown in the diagram.** We then placed a slide across the ring stand and spread our sample spice across the slide. Another option is to use a STAGE-RTL-T optical stage, which allows probes to be fixtured into multiple positions.

FLAME-S-VIS-NIR	Flame spectrometer, 350-1000 nm, 25 µm optical slit
HL-2000-HP	High-power tungsten halogen light source, 360-2400 nm, 1,000 hours bulb lifetime
QR400-7-UV-VIS	Premium-grade, general-purpose reflection probe, 400 µm diameter
WS-1	Diffuse reflectance standard, PTFE material, 250-2000 nm
RPH-1	Reflection probe holder for positioning probe at 45° and 90° to flat surfaces

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