Fast, effective evaluation of edible bird nests using the handheld Agilent 4100 ExoScan FTIR

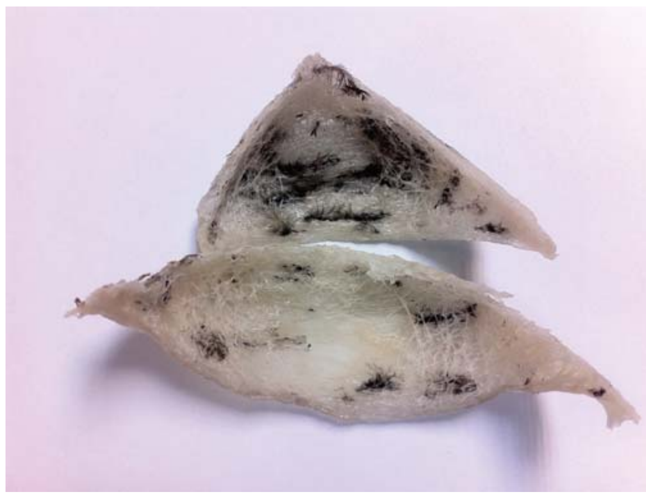
Application note

Food testing

Author

Joe Set

Agilent Technologies
Petaling Jaya, Malaysia



Introduction

The popularity of birds nest soup in Chinese cuisine stretches back over 1000 years. The literal translation of the Chinese name for the dish, yàn wō (燕窝), is “swallow’s nest”. In fact, edible bird nests are produced by swiftlets (Collocalia fuciphaga), which belong to the same family as the common swallow, but which are smaller in size. Although there are 90 varieties of Southeast Asian swiftlet, the nests of only four types of bird, namely cave swifts, are deemed worthy of human consumption. During the breeding season, the male birds regurgitate a sticky salivary secretion to form the nest. As a rich source of amino acids, carbohydrates and mineral salts, bird nests have also been used for hundreds of years as an important health supplement in Traditional Chinese Medicines (TCM). Examples of its use include as a treatment for malnutrition, a boost to the immune system, and to enhance the body’s metabolism. More recently bird nests have also been used in cosmetic products.

The high demand for edible bird nests, especially from China, Hong Kong and Taiwan, and limited supply has led to a lucrative market building up around the product. This in turn has led to the upsurge of fake and adulterated edible bird nest products. Unethical suppliers blend the original bird nest with additives in order to boost its weight and market value. Common substances used to imitate bird nests include edible plants, fish skin, mushroom or algae [1]. The more expensive 'Red Blood' bird nest can be adulterated from the less expensive white nest by adding a natural colorant such as karayagum, red seaweed or tremella fungus or by exposing it to sodium nitrate.

The method that is required to identify genuine, unadulterated bird nests also needs to be applied to the food safety arising from the production and preparation of nests for consumption. Edible bird nests undergo treatment with hydrogen peroxide to 'whiten' the nests. Many processes involve the addition of preservatives such as boric acid, potassium sulfite or sulfur dioxide (according to country regulations). Sugar, salt, and monosodium glutamate (MSG) are added to improve the taste. Gluten, white fungus, jelly, animal skin or synthetic rubber is often used to improve the shape and appearance of the nests.

This application note provides a simple method for the authentication of edible bird nests, the identification of adulterants and food safety using handheld Fourier transform infrared (FTIR) spectroscopy. IR spectroscopy measures the covalent chemical bonds, creating a molecular 'fingerprint' of the chemicals present. This fingerprint can be used to identify and quantify chemicals present in a sample. FTIR spectroscopy is commonly used for the identification and contamination of food products. An example of edible bird nest analysis by conventional FTIR is shown in Figure 1. In this example, major bands can be observed resulting from protein at 1640 and 1550 cm^{-1} , carbohydrate near 1030 cm^{-1}, and lipids near 2930 cm^{-1}. Clear differences can be seen between the clean and adulterated samples. Recent advancements have reduced the size and weight of FTIR spectrometers, resulting in easy to use handheld systems. This new technology now allows for non-destructive analysis, which is particularly useful for expensive food products such as edible bird nests.

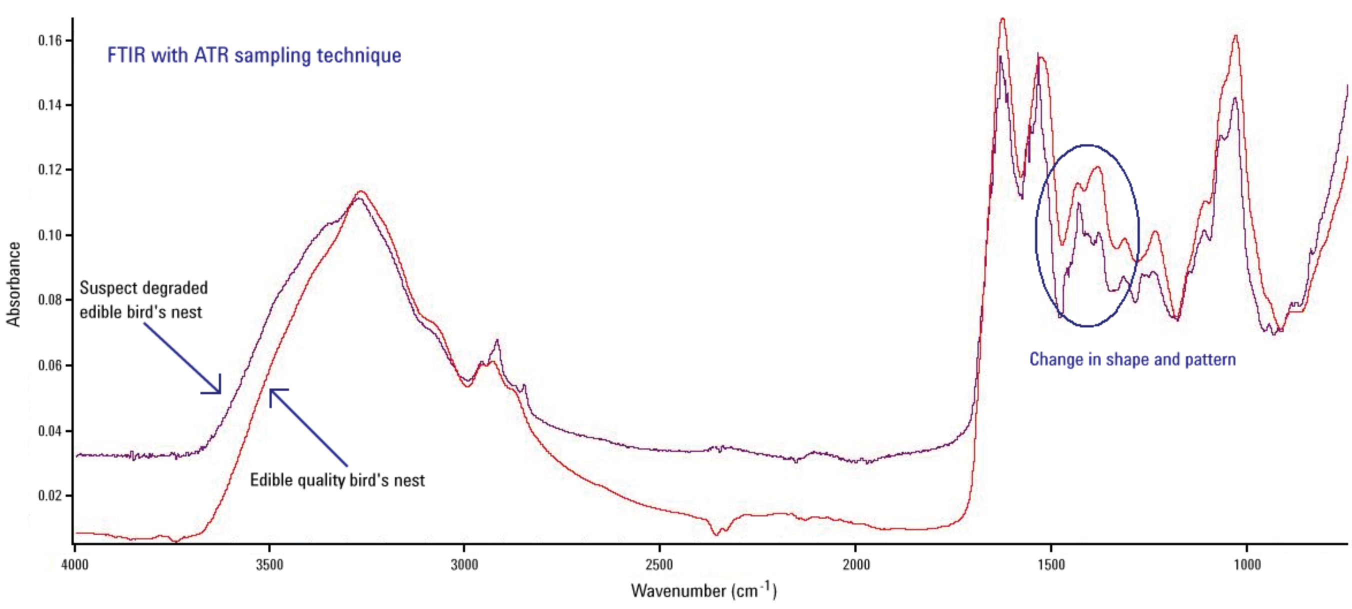


Figure 1. Infrared spectra of a pure edible bird nest and an adulterated edible bird nest acquired using a bench FTIR spectrometer with attenuated total reflectance (ATR)

Instrumentation

An Agilent 4100 ExoScan FTIR (Figure 2) was used for this study. It is a versatile, robust handheld mid-IR system that can be equipped with a wide range of interchangeable sampling interfaces. In this study, the diffuse reflectance interface was used. The 4100 ExoScan FTIR is powered by rechargeable and interchangeable lithium ion batteries that can be operated continuously for 4 hours. It can also be docked in the lab and operated like a benchtop FTIR, with performance equal to conventional laboratory FTIR spectrometers.

Used with the diffuse reflectance sample interface, the 4100 ExoScan FTIR provides non-destructive testing. This is in contrast to the a more conventional lab benchtop FTIR using an attenuated total reflectance (ATR) sampling method that would destroy the physical structure of a bird nest. Additionally, the diffuse reflectance sample interface measures a greater sample volume, yielding a more sensitive measurement than ATR. In addition to providing non-destructive testing, the compact design of the 4100 ExoScan means that sample analysis can take place where it is most convenient, whether in a lab, mobile facility or in the field.

Diffuse reflectance mid-IR spectroscopy of edible bird nests

Diffuse reflectance IR spectra of neat samples have a different band shape compared to classical absorbance spectra as shown in Figure 3. Highly absorbing samples produce negative bands when plotted on an absorbance scale. These negative bands are due to changes in the refractive index of the material coincident with the absorbance band. The bands are, however, at the same frequency as positive absorbance bands measured with ATR and can be used to identify and quantify materials in a similar manner. Although the band shape is different, the information content is the same between measurements made with diffuse reflectance and ATR sample interfaces.

As was stated above, edible bird nests can be contaminated or adulterated with a number of common additives including carbonates, sugars, salt, MSG and feathers. Examples of adulterated bird nests were measured with the 4100 ExoScan FTIR. Spectra obtained from these adulterated samples are shown in Figures 4 to 7, demonstrating the ease of detection. Furthermore, a method was created to give a pass/fail answer, and identify the adulterant as detailed in the following section.

Figure 2. The Agilent 4100 ExoScan FTIR (left) and in use (right), testing an edible bird nest

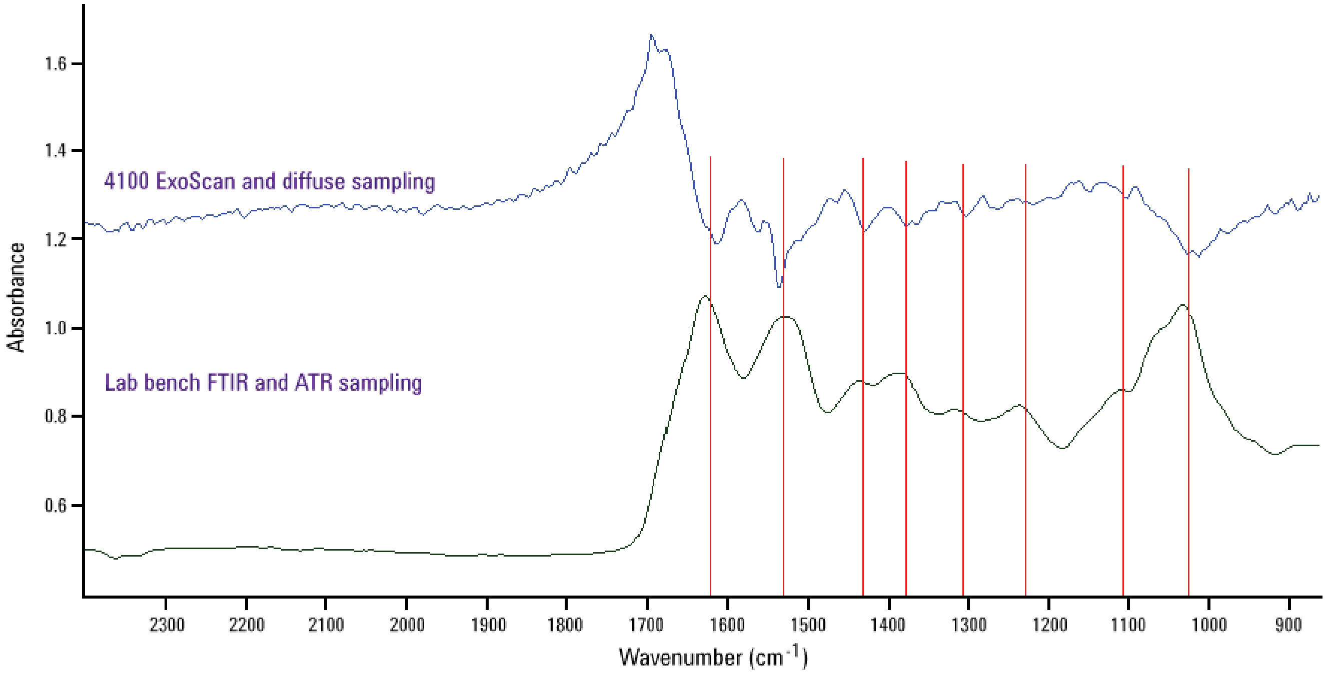


Figure 3. Lab bench FTIR with ATR sampling compared to 4100 ExoScan with diffuse sampling. The identical sample has been measured by both sampling techniques.

Figure 4 shows a comparison of a spectrum obtained from a pure edible bird nest sample, and one that has been contaminated with calcium carbonate, most likely arising from the nest's original location on limestone rocks or cave. The pure nest is characterized by spectral bands due to the protein (amide I, II and III) as well as bands due to cellulose. In addition to those bands, the nest contaminated with calcium carbonate contains two additional bands at 1410 cm^{-1} and 873 cm^{-1} due to the carbonate functional group. As can be seen from the spectra in Figure 4, the 4100 ExoScan FTIR can easily distinguish a pure edible bird nest sample from one that has been contaminated with calcium carbonate.

Salt (sodium chloride) is often added to an edible bird nest to enhance its flavor and to increase its weight and value. Sodium chloride is an inorganic compound; therefore, it is not visible by IR. However, adulteration of edible bird nests by salt is still detectable with the 4100 ExoScan FTIR. Salt effectively 'dilutes' the sample, causing the spectrum to exhibit positive bands where a spectrum of pure bird nest has negative bands. This can be seen in Figure 5.

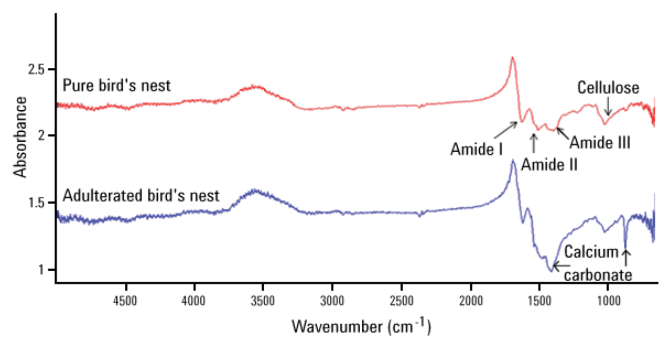


Figure 4. Identification of calcium carbonate contamination of a bird's nest measured with the Agilent 4100 ExoScan FTIR in diffuse sampling mode

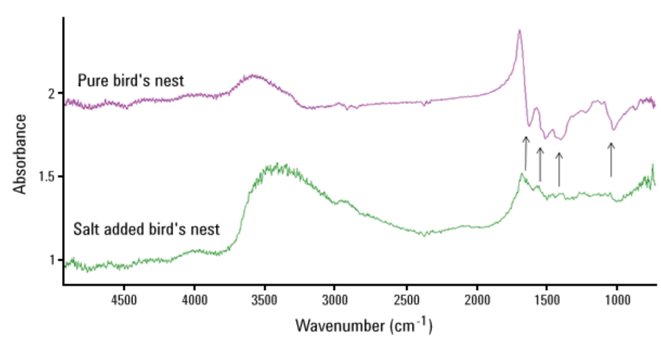


Figure 5. Identification of salt present in bird's nest measured with the Agilent 4100 ExoScan FTIR in diffuse sampling mode

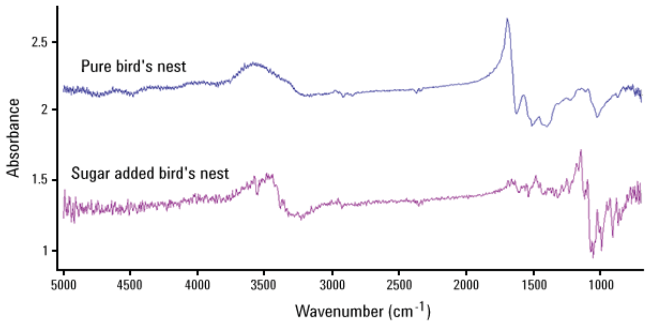


Figure 6a. Clear identification of sugar (sucrose) present in an edible bird nest measured with the Agilent 4100 ExoScan FTIR in diffuse sampling mode

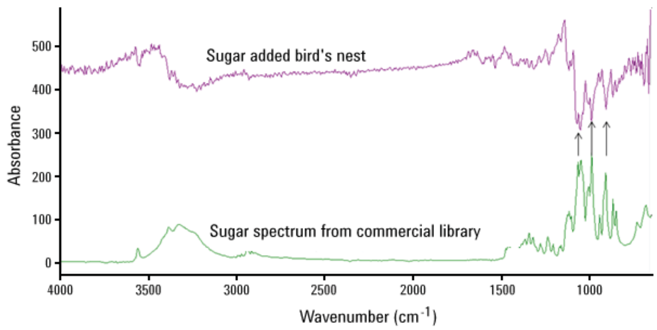


Figure 6b. Comparison of a commercial library ATR spectrum of sucrose and the Agilent 4100 ExoScan FTIR spectrum of sugar added to a bird's nest

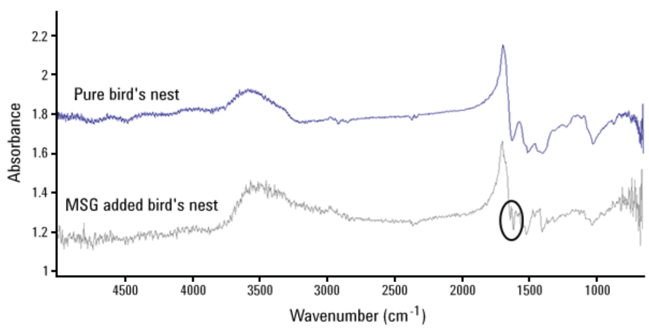


Figure 7. Identification of MSG added to an edible bird's nest measured with the Agilent 4100 ExoScan FTIR in diffuse sampling mode

Like salt, table sugar (sucrose) can also be added to a bird nest to increase its weight and improve its taste. Sucrose is easily identifiable in edible bird nests using FTIR as shown in Figure 6a. The spectrum of the adulterated sample shows strong sucrose bands at 1050 cm^{-1}, 980 cm^{-1} and 905 cm^{-1}. This is confirmed by reference to a commercial library ATR spectrum of sucrose (Figure 6b).

Mono sodium glutamate (MSG) is another common food additive that is added to edible bird nests as a flavor enhancer. As shown in Figure 7, edible bird nests adulterated by MSG can be identified by a doublet that overlaps with the protein Amide I band corresponding to the glutamate, which is the salt of a carboxylic acid.

Pass/Fail Methodology

The results show that many types of common adulterations can be observed in the infrared spectrum of edible bird nests. In order to provide a conclusive answer for inspectors, a unique method was developed that gives both a pass/fail result and the identity of common contaminants. This method is implemented in the Agilent MicroLab Mobile FTIR software. MicroLab Mobile operates the 4100 ExoScan FTIR, and is designed to provide easy to interpret qualitative or quantitative results. In this case a quantitative component was defined for each adulterant. If the measured component is above a predefined threshold, the adulterant is displayed in red. This gives the user an easy to interpret indication that the sample is adulterated, and the identity of the adulterant. Figure 8 shows an example of a bird's nest adulterated with both carbonate and salt. Also included is a measurement of the residual feather material, which reduces the value of a bird nest. This method is superior to more common library search or correlation methods because it can detect small quantities of adulterants that would be invisible to most library search methods.


Results:

Name	Value	Low Threshold	High Threshold
Carbonate 1400	May contain Calcium Carbonate (Critical)		25
salt	May contain salt (Critical)		34
Feather 1	May contain feather material		

Figure 8. Agilent 4100 ExoScan FTIR results screen showing additives and contamination of a sample of an edible bird nest

Conclusions

FTIR spectroscopy is a valuable technique for the identification, quality assurance and authentication of edible bird nests as it is non-destructive, fast and direct, requiring no sample preparation, with good sensitivity and specificity. These attributes are important to help prevent the fraudulent trade of counterfeit or adulterated bird nests and also to assure food safety and health standards. The industry surrounding the supply, processing and selling of swiftlet nests is expanding rapidly due to a growing affluence in China, the largest market for edible bird nests, and publicity surrounding the health and well-being benefits of consuming bird nests.

The Agilent 4100 ExoScan FTIR analyzer fitted with an integrated diffuse reflectance sampling interface provides an ideal analytical capability for the application:

- It is easy to operate using a Select-Point-Press mode, making it ideal for unskilled operators.
- Samples can be analyzed in the field using the light and portable analyzer ensuring quick results and fast sample turnaround, allowing adulterated samples to be rejected at source.
- A number of areas on the sample can be analyzed in a non-destructive manner allowing each nest to be tested.
- The results are easy to interpret using the unique quantitative method available with the MicroLab Mobile software.
- The results generated are reliable, as illustrated by comparison with data acquired using conventional technology.

References

1. Li, X., Xi, X. & Che, W. (2003) Analysis and assessment of quality in import-export bird nest. *Guangzhou Food Science and Technology*. 19:72 & 89.

www.agilent.com/chem

Published January 19, 2012
Publication number: 5990-9789EN

Agilent Technologies