Raman spectroscopy to assess nutritional quality in dairy

TEAGASC researchers are developing methods to predict the composition of dairy products using faster alternatives to conventional labour-intensive techniques. One of them is Raman spectroscopy.

What is Raman spectroscopy?

Spectroscopy techniques study the interaction between matter and light. In particular, Raman spectroscopy is based on the phenomenon of inelastic light scattering. When a sample is illuminated, part of the incident light is scattered in different directions. Most of it is elastically scattered; that is, there is no change in the energy of the scattered photons. However, a tiny fraction of that light (typically 0.0000001 %) exchanges energy with the sample by causing changes in the vibrational levels of its molecules. This is known as inelastic scattering of light, and it results in photons with a different wavelength (colour) than the incident light. Raman spectrophotometers detect this tiny amount of inelastically scattered photons, generating Raman spectra that feature a number of peaks or bands. Some examples are shown in **Figure 1**. These spectra are like ‘chemical fingerprints’ for compounds, as they are specific for each particular substance.

Applications of Raman spectroscopy

Since the Raman scattering of a molecule depends on the type of bonds within its chemical structure, Raman spectroscopy can be used as an extremely sensitive method to detect specific compounds within a product. This technique not only provides detailed information about the chemical structure of molecules, but also about their phase, polymorphy, and even intermolecular interactions within a complex product.

Additionally, by combining Raman spectroscopy with microscopy tools, it is possible to obtain not only compositional information, but also information about the spatial distribution of components in complex matrices with micrometric spatial resolution. Plus, it is a non-destructive, label-free analysis technique. Its capability to detect and identify analytes even at trace concentrations has already been exploited in a number of fields, including forensic sciences, biomedicine and materials engineering, where it has led to important technological breakthroughs. In recent years, new applications of Raman spectroscopy have also emerged to assess food quality and safety.

To further exploit and validate the potential of this technique, Moorepark researchers are currently working on expanding its application to raw milk and other dairy products, in collaboration with University College Cork and funded under VistaMilk.

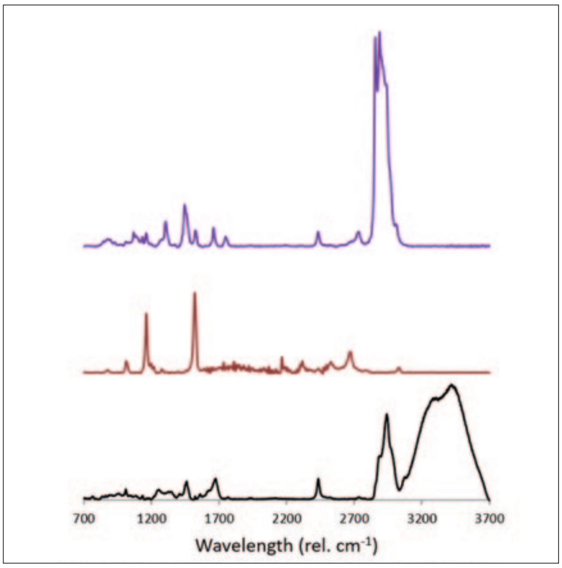

FIGURE 1 (Top to bottom): Raman spectra of butter, β-carotene and whey protein gel.

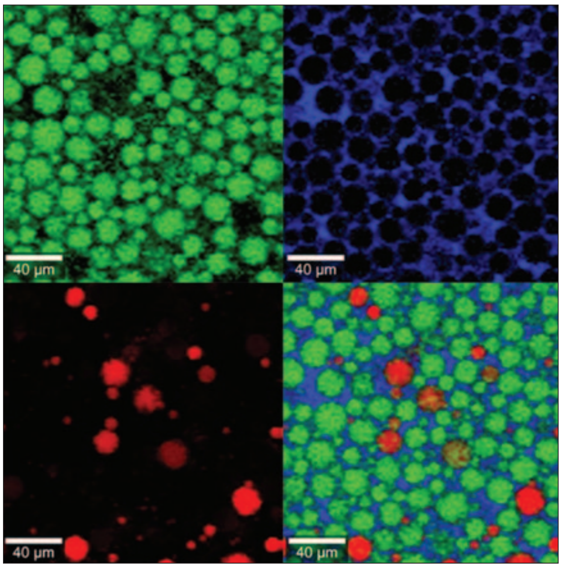

FIGURE 2. Raman micrograph of an emulsion containing β-carotene only in some of its fat droplets. Green, blue and red colours depict fat, water and β-carotene, respectively.

Raman spectroscopy in dairy

Pioneering work carried out on butter samples at Teagasc has demonstrated the ability of Raman spectroscopy to distinguish pasture-derived butter from that produced from indoor feeding systems (Gómez-Mascaraque *et al.*, 2020).

The information obtained from the Raman spectra of butter correlated well with the fatty acid profile of the butter samples, with the advantage that the testing time was greatly reduced using Raman spectroscopy. In addition, strong correlations were found between the Raman spectra of butter and indicators of its nutritional quality, such as the thrombogenic index, which could be used for predictive purposes.

Raman microscopy has also allowed Teagasc researchers to map the distribution of micronutrients such as carotenoids within dairy emulsions (**Figure 2**). To further exploit and validate the potential of this technique, Moorepark researchers are currently working on expanding its application to raw milk and other dairy products, in collaboration with University College Cork and funded under VistaMilk.

This will allow the collection of larger spectral datasets to build more accurate and robust prediction models that are expected to broaden the application of Raman spectroscopy as a rapid tool to evaluate the nutritional quality of milk and dairy products.

Industry impact

Milk composition, functionality and processability vary considerably due to a number of factors (e.g., animal feed, cow genetics, seasonality). This poses considerable challenges for milk processors and manufacturers, so there is a need for prediction of these variations. However, most of the methods used for quantitative compositional analysis and assessment of milk quality are time consuming and expensive. The implementation of robust and rapid verification techniques to predict the quality of milk and dairy products is therefore essential to support the growth and development of the Irish dairy industry. As 'grass-fed' labelling becomes more prominent on the market, rapid and label-free methods for verification of feeding systems are also required.

Acknowledgments

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Reference

Gómez-Mascaraque, L.G. *et al.* (2020). 'Raman spectroscopy: a rapid method to assess the effects of pasture feeding on the nutritional quality of butter'. *Journal of Dairy Science*, 103 (10): 8,721-8,731.

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