Screening of margarine adulteration in butter

Key Issues

- Butter adulteration is a common example of food fraud
- QA/QC of butter is performed in the laboratory
- Laboratory measurements are time-intensive and requires special training

Benefits at a glance

- Raman spectroscopy measures the chemical composition of a sample
- Raman spectroscopy can be performed quickly with little or no sample preparation
- Raman easily distinguishes margarine from butter
- Study demonstrates quantification of margarine in butter

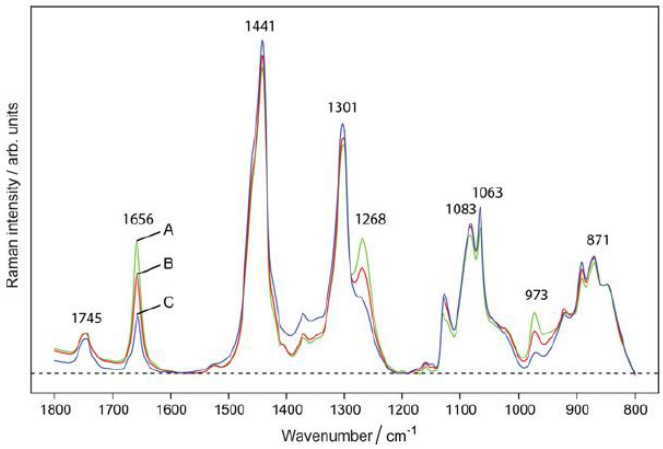

Figure 1. Raman spectra of (A) margarine, (B) 50:50 margarine–butter mixture, and (C) butter show that peaks at 973, 1268, and 1656 cm^{-1} are indicative of margarine in the sample. Reprinted with permission from Ref. 1. © 2016 Springer.

Introduction

Adulteration of food products is a threat to consumer confidence and to public health, especially in developing countries. Dairy products such as liquid milk, milk powder, and butter are common targets for adulteration because they are expensive to produce.

Adulterating butter with margarine, starch, or plant-based oils is common practice. Detection of these lower cost items in butter is difficult. Their presence does not change the taste or mouth feel of butter, so adulterated butter is virtually undetected by the consumer. Thus, detection relies upon chemical analysis.

Chromatography laboratory-based measurement may be used, but this technique is expensive and requires specially trained staff and consumables.

Raman advantages

Raman spectroscopic techniques are currently being investigated because results are specific, fast, and the material does not needs to be prepared or destroyed. The specificity of Raman spectroscopy is especially powerful because it has the ability to differentiate vegetable fats from milk fat. Raman-based screening tools could be standardized and automated.

This work demonstrates a fast, accurate method of measuring margarine content in butter using Raman spectroscopy.[1] The Raman technique shows promise for a robust and easy-to-use operation, with potential as a technology platform for ensuring integrity of dairy products.

ⓘ All Raman analyzers and probes referenced in this application note are Endress+Hauser products powered by Kaiser Raman technology.

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Experimental

Samples of commercially available pure butter, pure margarine, and graded mixtures of the butter and margarine were prepared and analyzed. Thirty spectra were acquired on each sample to account for heterogeneity, with an acquisition time of 20 seconds for each.

The data were analyzed using the R statistical software package. The spectra were baseline corrected and normalized, and the spectral range was restricted to 800 to 1800 cm^{-1}, which contained information to easily distinguish between margarine and butter in the samples. PCA was used to construct a quantitative model for the butter and margarine in the samples.

Results

Spectra of margarine, butter, and a 50:50 mixture of the two can be seen in Figure 1. Margarine was distinguishable by the presence of bands at 1268 and 1656 cm^{-1} associated with the C=C double bond and at 973 cm^{-1} associated with the choline group in the phospholipid. Raman-predicted margarine content agreed with known values measured by weight is seen in Figure 2.

Principal components analysis (PCA) was used to identify spectral regions that could distinguish margarine from butter. The PCA data confirmed that the known chemical moieties of margarine (the C=C double bond and the choline group) varied with concentration. Negative peaks at 973, 1268, and 1656 cm^{-1} indicated margarine content in the calibration samples. Partial least squares regression (PLSR) was used to quantify margarine content in known and test samples. PLSR confirmed good overall model performance, shown in Figure 2.

PLSR coefficient plots showed large positive values at the locations of margarine peaks at 973, 1268, and 1656 cm^{-1}. For the calibration data, the model predicted margarine content with an R^2=0.991 and RMSECV=3.199. For the test data, the model predicted margarine content with an R^2=0.994 and RMSEP=2.757.

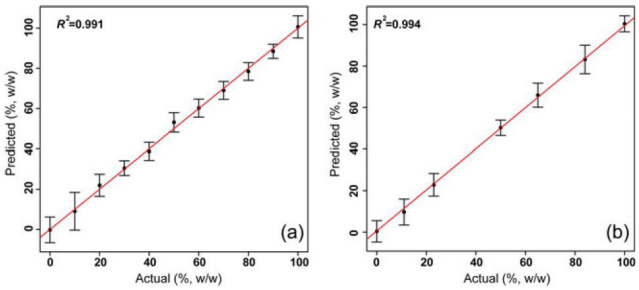

Figure 2. Predicted versus actual values of margarine in mixed samples: (a) calibration, (b) test. Measured values corresponded closely with predicted. Reprinted with permission from Ref. 1. © 2016 Springer.

Spectra shown in Figure 1 and PCA of model mixtures demonstrate the three Raman peaks at 973, 1268 and 1656 cm^{-1} can be attributed to vegetable fat in margarine and that those peaks can be used to quantify margarine content in butter. This important feature means that the fat does not have to be isolated from the rest of the sample, as was necessary in the traditional chromatographic method. The removal of the fat extraction step is a major improvement toward automating the analysis.

Conclusions

Raman spectroscopy for screening of margarine adulteration in butter represents a significant advance over the traditional chromatographic method. The model developed in this work was robust to the concentration of margarine in the samples. The Raman method was simple to deploy and eliminated the need for a fat extraction step required by chromatography. Raman spectroscopy shows great potential as a robust method for routine QA/QC of butter and other dairy products.

References

1. Nedeljković, A., Rösch, P., Popp, J., Miočinović, J., Radovanović, M., and Pudja, P.; "Raman spectroscopy as a rapid tool for quantitative analysis of butter adulterated with margarine" *Food Analytical Methods*, **2016**, *9(5)*, 1315–1320.