

Raman Spectroscopy of Edible Oils and Fats



Introduction

Raman spectroscopy is an ideal method for the analysis of edible fats and oils, which are composed of esters of fatty acids and glycerol.

Samples which come from natural sources have a very complex composition, but the key parameters that need to be determined are typically the average chain length of the fatty acids and the extent of saturation. Taken together, these properties determine the melting/softening temperature of the fat sample, which is important in spreading fats such as margarines and butters. In addition, there is a growing interest in the potential health benefits of increasing/decreasing the amounts of various fatty acids in our diet.

Raman spectroscopy is ideally suited for analysis of fats and lipids since the spectra contain strong bands that can be directly correlated with the most important parts of the molecular structure. This is most apparent in simple model systems, particularly FAMES (fatty acid methyl esters) where the spectra of compounds with the same chain length (see Figure 1) and increasing

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degrees of unsaturation (i.e. double bonds) show a simple monotonic increase in the intensity of the C=C bond at 1655 cm⁻¹ (see Figure 2).

This direct link between readily identified spectral feature and the composition of the samples is also found in complex edible oils and fats. Figure 2 shows the spectra of three different plant-derived oils where, again, differences between the oils are reflected in the spectra. Here

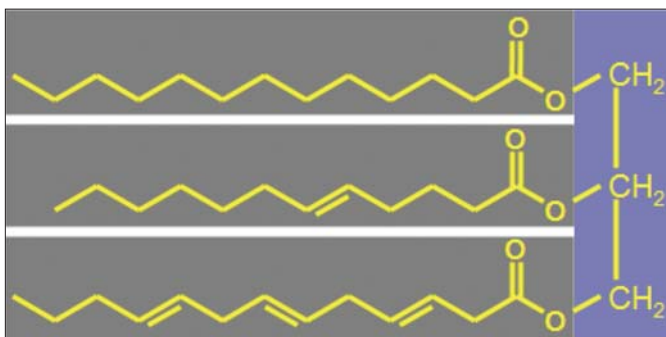


Figure 1. Structure of a Fatty Acid Methyl Ester (FAME).

Wavelength (cm ⁻¹)	Assignment
1276	Symmetric rock in <i>cis</i> (=C-H)
1302	In phase methylene twist
1443	Scissoring mode of methylene (CH ₂)
1655	<i>cis</i> double bond stretching (C=C)
1747	Ester carbonyl stretching (C=O)
2850-2980	Symmetric and asymmetric C-H stretching of methyl and methylene groups
3007	Symmetric C-H stretch in =C-H

the C=O vibration at 1747 cm⁻¹ can be used as an internal standard while different degrees of unsaturation give variations in the relative intensity of the 1655 cm⁻¹ (C=C stretch) absorption band. Similarly, increasing chain length will give increased intensity in the CH₂ scissor and twist vibrations which lie at ca. 1442 and 1302 cm⁻¹.

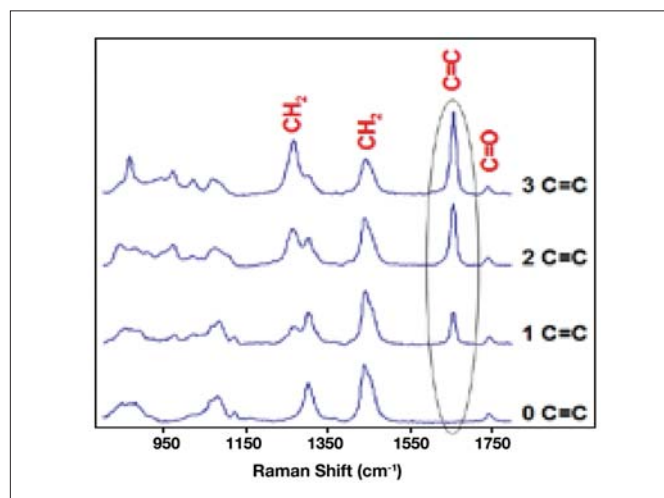


Figure 2. Raman spectra of a series of FAMEs with unsaturation ranging from 0 to 3 C=C.

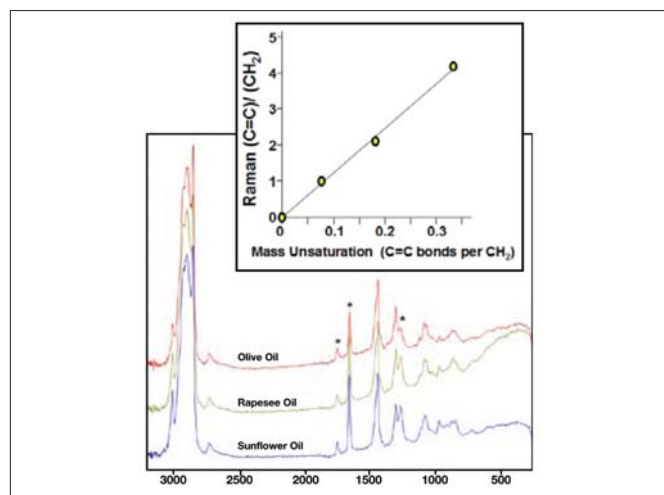


Figure 3. Raman spectra of a range of edible oils.