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Quantitative analysis of lipid composition in biomedical sample using Raman spectroscopy

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Obesity is becoming a worldwide issue as societies develop. It is characterized by the significant accumulation of fat in the subcutaneous and visceral adipose tissue. It has been reported to induce various types of medical conditions, including diabetes and heart-related diseases. Visceral adipose tissue (VAT) abnormality has been reported to be directly correlated with numerous medical conditions, such as insulin resistance, diabetes, gallstone disease, and coronary heart diseases. Excessive visceral fat has been reported to be closely related to obesity and type II diabetes mellitus. An important role of visceral fat – in addition to energy storage, glucose and lipid metabolism, and producer of a number of hormones – is strongly related to inflammation, which results in the high risk of cardiovascular disease associated with obesity. The fat in subcutaneous adipose tissue (SAT) has also been reported to be involved in insulin resistance and inflammation in overfed humans. The development of analytical techniques for adipose can contribute to the diagnosis and investigation of lipids for biomedical applications.

The purpose of this study is to develop non-invasively quantitative analysis of the relation between dietary fat and lipid accumulation/metabolism using Raman spectroscopy. In the first step, the Raman spectra from diatom lipid droplet were used for developing the analytical technique of lipid in biological sample based on MCR-ALS algorithm to extract the concentration of fatty acids. The lipid analysis was further developed for investigating the dietary fat metabolism in hamsters. Syrian hamsters treated with trilinolein (TL) and tricaprin (TC) were used to evaluate the lipid accumulation/metabolism in the subcutaneous and visceral adipose tissue and skin-lipid. Ball lens installed hollow fiber Raman probe (BHRP) with quartz and fuse-silica were used for acquiring the spectra adipose tissue and skin lipid. The result from qualitative study shows the variation of lipid accumulated in hamsters especially in the C=C bond. Raman spectra together with gas chromatography were employed to construct the quantitative model using partial least square regression (PLSR) and the developed technique. By using the quantitative model, the fatty acids concentrations were successfully extracted with high accuracy and reliability in comparison with gas chromatography. The dietary fat treatment animal study indicated the quick decomposition of TC and quick accumulation of TL, suggesting differences in the metabolic pathways for different chain-length fats. This study demonstrates the great potential of fiber-optic Raman spectroscopy for fat metabolism studies, as well as for dietary fat control for the maintenance of good health.