Toward Non-invasive Measurement of Meat Quality in Live Animals Using Deep Tissue Raman Spectroscopy

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I. INTRODUCTION

Quality reduction caused by dark-cutting (DFD) meat is a problem for the meat industry in Australia and worldwide. One way to reduce the level of dark cutting meat is by developing a sensor technology that can be used to screen cattle in real-time at the abattoir, either at receival of cattle or immediately pre-slaughter. The first step toward developing this novel technology was to understand the biochemical process resulting in DFD meat, beyond just monitoring for pH changes. Four key chemical compounds involved in the formation of DFD meat are glycogen, glucose, lactate and cortisol. Here, we used spatially off-set Raman spectroscopy (SORS) to measure the chemical composition of meat at a sub-surface level, with minimal fluorescence background. This approach enabled us for the first time to identify biochemical marker bands for each individual chemical component 5-8 mm below the surface, as well as studying their interaction with other meat features such as protein, lipid and connective tissue. To our knowledge this is the first time SORS has been applied as a possible means for reducing levels of DFD meat.

II. MATERIALS AND METHODS

Commercial meat samples were purchased from a local supermarket in Melbourne. The same beef cut, rump beef, was used throughout these experiments. Spectroscopic analysis was undertaken using a RapID portable spatially offset Raman (SORS) spectrometer (Cobalt Light Systems, UK; now Agilent). The SORS spectra were collected from various areas of the meat samples below the surface and through the clear plastic packaging. The excitation wavelength was 830 nm with laser power of <500 mW at the source and penetration depth of 5-8 mm.

III. RESULTS AND DISCUSSION

Biomarkers such as glycogen, glucose, lactate as well as cortisol are important indicators of the quality of meat [1, 2]. Figure 1 presents SORS spectra of rump beef with additions of lactate (a), glycogen (b), cortisol (c) and glucose (d). Overall, the Raman spectra of rump beef with and without added lactate, glycogen, cortisol and glucose showed very similar features in the amide I, II and III regions, however, changes in intensity with addition of these chemicals were observed over the entire spectrum. Table 2 lists the spectral marker bands that we were able to link to addition of lactate, glycogen, glucose and cortisol in the rump beef.

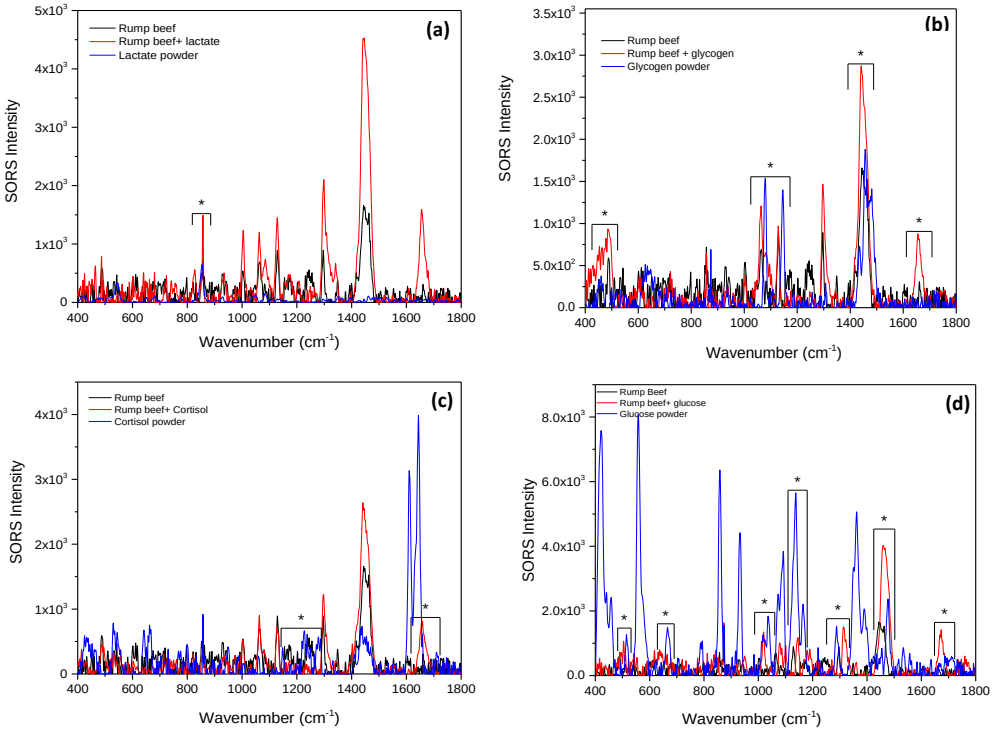

Figure 1: SORS spectra of rump beef without and with addition of lactate (a), glycogen (b), cortisol (c) and glucose (d), along with spectra of the pure compounds (blue line).

	marker bands (cm^{-1})												
Lactate							857						
Glycogen	491				1062							1441	1655
Cortisol													1658
Glucose	504	636	873	1019	1079	1086	1101	1146	1270	1314	1360	1459	1673

Table 1: Marker bands we identified for lactate, glycogen, glucose and cortisol in rump beef.

IV. CONCLUSION

The results in this paper show the potential application of SORS in quality screening of meat. We consider SORS to be an ideal technology for this, as it enables real-time, non-destructive measurement of the chemical composition of meat beneath the surface. SORS spectra also provide fluorescence free background signals, distinguishing them from spectra obtained from conventional Raman spectra of tissue samples. While the non-invasive nature of SORS is known, our successful detection of spectral bands representing four key biomarkers of meat quality shows the potential of this method for live-animal screening to prevent DFD meat. To our knowledge this the first report of the method's potential application for this purpose.

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