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Department of Animal & Poultry Science, University of Guelph, Canada

HOWARD J. SWATLAND

Fibre-optic spectrophotometry of beef relative to sarcomere length
(short communication)

Summary

Fibre-optic spectrophotometry of beef *longissimus thoracis* showed reflectance was correlated negatively with sarcomere length, reaching a maximum at 470 nm ($r = -0.46$, $P < 0.025$, $n = 20$) with mean sarcomere length 1.75 ± 0.15 µm. The beef had never been frozen and was extensively aged (30.5 ± 5.0 days). This conflicts with other relationships in attempts to predict tenderness from light scattering.

Key Words: beef tenderness, sarcomere length, fibre-optics, spectrophotometry

Zusammenfassung

Titel der Arbeit: **Fiberoptisch-spektrophotometrische Messungen des Reflektionsspektrums bei Rindfleisch in Bezug zur Sarkomerlänge** (Kurzmitteilung)

Fiberoptische Messungen des Reflexionsspektrums am Brustteil des *longissimus thoracis (Musc. Long. Thoracis*) von Fleischrindern ergaben sich negative Beziehungen zur Sarkomerlänge, welche einen maximalen Reflexionswert von 470 nm ($r = -0{,}46$, $P < 0{,}025$, $n = 20$) bei einem mittleren Wert der Sarkomerlänge von $1{,}75 \pm 0{,}15$ µm aufwiesen. Das widerspricht Ergebnissen anderer Versuche zur Zartheit mit geringeren Streuungswerten. Die Ergebnisse werden diskutiert.

Schlüsselwörter: Fleischzartheit, Sarkomerlänge, Fiberoptik-Spektrophotometrie

Introduction

Beef toughness is important, yet we have no reliable on-line method to predict it (SWATLAND, 1995). Sarcomere length has a strong effect on meat toughness. Rapid post-mortem refrigeration causes unrestrained muscles to contract, and the increased overlap of thick and thin myofilaments when *rigor mortis* develops causes toughness. Muscles cooled slowly or stretched have little myofilament overlap and are tender (MARSH and CARSE, 1974). Carcasses lacking adipose insulation, with a high surface to volume ratio, or first into an empty meat cooler have the highest risk of cold shortening. It is difficult to predict tenderness or identify its genetic components if sarcomere length is unknown.

The working hypothesis tested here was that an increased overlap of thick and thin myofilaments might increase light scattering. Fibre-optic spectrophotometry was used to search for relationships of internal scattering with sarcomere length.

Materials and methods

For 20 weeks, rib roasts (ribs 11 and 12) were purchased from a retail butcher. At no time was the meat frozen. Results reported here may not necessarily hold for beef with

ultrastructural damage from ice crystal formation. Nothing was known about breed of origin, but all the roasts were top quality beef (Canada Grade A) and had the same relatively high level of marbling (Canada AAA). The roasts were extensively aged (30.5 ± 5.0 days between slaughter and testing). Results reported here may not necessarily hold for beef soon after slaughter.

The principles of fibre-optic spectrophotometry of meat are described by SWATLAND (1995). A halogen lamp with a tungsten filament was powered at 12 V 8 A DC from a stabilized source (6642A, Hewlett-Packard, Palo Alto, California). The collimated output passed through a solenoid-operated shutter and was launched into one branch of a bifurcated light guide. The common trunk of the light guide was pushed two to three millimetres into the *longissimus thoracis* at 10 equally spaced positions across its width at the rib 10-11 interface. Internally scattered light was collected through the other branch of the light guide and passed through a grating monochromator (474345, Carl Zeiss, Oberkochen, Germany), through stray light filters to remove higher-order harmonics (Zeiss 477215), and on to a side-window photomultiplier (HTVR928 with S-20 characteristics, Hamamatsu, Hamamatsu City, Japan). The bifurcated light guide (WW100, Guided-Wave, El Dorado Hills, California) had six optical fibres in the illuminating branch and one in the recording branch. In the common trunk of the light guide, the six illuminating fibres were arranged in a ring closely around the single recording fibre.

Samples of meat totalling about 10 g were taken across the width of *longissimus thoracis* at the rib 10-11 interface and placed in 25 ml water in a miniature blender (Waring 51BL32, Torrington, Connecticut). Blending for 30 seconds produced a suspension of muscle fibre parts. A drop was placed on a microscope slide, covered with a slip, then examined with a polarizing microscope. Lengths of 100 sarcomeres along myofibrillar fragments were measured with a x 90 oil-immersion objective.

The 10 spectra from each sample were averaged. Mean spectra were analyzed using simple correlation coefficients and stepwise regression (STEEL and TORRIE, 1980) programmed in HP BASIC.

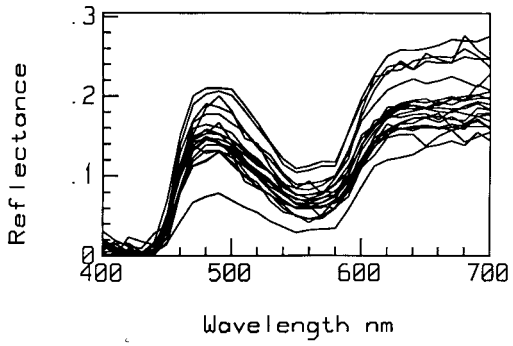

Fig. 1: Fibre-optic reflectance spectra

Results

Mean reflectance spectra are shown in Fig. 1. As expected (SWATLAND, 1995), they showed very low reflectance in the Soret absorbance band from 420 to 440 nm and low reflectance of green light around 560 nm. Mean sarcomere length was 1.75 ± 0.15 µm.

Simple correlations of reflectance with sarcomere length are shown in Fig. 2. Correlations with $r < -0.4$ are significant, $P < 0.05$. The strongest correlation was at 470 nm, $r = -0.46$, $P < 0.025$. With stepwise regression, $R = 0.70$, $P < 0.05$ using reflectance at 470, 440, 540 and 510 nm.

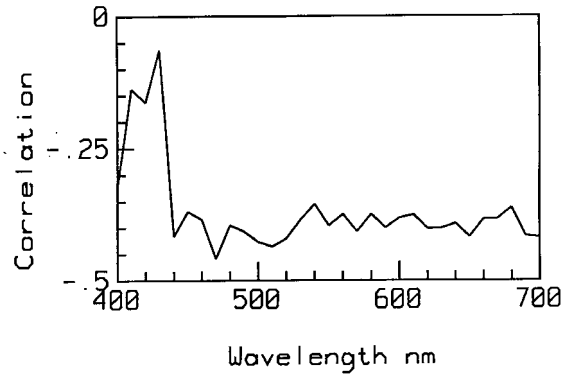

Fig. 2: Simple correlations of fibre-optic reflectance with sarcomere length

Discussion

The relatively weak correlations reported here offer no hope of predicting sarcomere length from reflectance measurements using current methodology. But this does not mean the results lack interest or the methodology cannot be improved. The importance of the topic encourages persistence in the face of great difficulties.

The particularly low correlations at 410, 420 and 430 nm were in the Soret absorbance band. Factors such as variation in myoglobin concentration or changes in the state of myoglobin may have been involved. Also, at low levels of reflectance, one would expect instrumental error (primarily noise from the photomultiplier) to be a problem. Across the remainder of the visible spectrum, negative correlations imply that beef with short sarcomeres has higher reflectance than beef with long sarcomeres. This poses a formidable problem.

Reduced postmortem glycolysis caused by antemortem glycogen depletion allows beef to retain a high pH. It is dark and tough (WULF, EMNETT, LEHESKA and MOELLER, 2002). Thus, two strong factors affecting beef tenderness act in opposite directions on light scattering. If the beef is tough because of a high pH it will be dark with low reflectance. But if beef is tough because of short sarcomeres it will be pale with high reflectance. Thus, if the range in pH is low while the range in sarcomere length is high, pale beef may be tougher than dark beef. But if the range in pH is high while the range in sarcomere length is low then pale beef may be more tender than dark beef. The scientific challenge is to improve our understanding of the biophysical basis of light scattering in beef. It may be the only hope of separating these two conflicting effects.

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Author's address
Prof. HOWARD J. SWATLAND
Department of Animal & Poultry Science
University of Guelph,
Guelph, Ontario N1G 2W1
Canada

E-Mail: HSWATLAND@APS.UOGUELPH.CA