THE EFFECT OF SHOCKWAVE PROCESSING ON MUSCLE PROTEIN STRUCTURE AND DIGESTIBILITY *IN VITRO*

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I. INTRODUCTION

In recent decades, novel technologies such as hydrodynamic shockwave (SW) processing have been explored for meat tenderization, to improve the organoleptic and technological properties of meat. SW processing has been reported to alter muscle structure [1] and these changes are likely to influence the bioaccessibility of digestive enzymes to their substrates, which may affect the nutritional value of the meat products [2]. However, little or no information is available on the effect of SW processing on muscle protein molecular structure, or any effect on protein digestibility. Hence, the objective of this experiment was to study the effect of SW processing on bovine muscle protein molecular structure using FT-IR microspectrometry approach, with and without cooking and also after *in vitro* gastric digestion. The protein digestibility of the treated meat will be determined at a later stage.

II. MATERIALS AND METHODS

Steaks obtained from three 11 days *postmortem* Simmental beef briskets (21 – 22 months old) were exposed to hydrodynamic SW (intensity = 11 kJ/pulse, one pulse per step, continuous system), followed by *sous-vide* cooking at 60°C for 12 hours and simulated gastric digestion for 1 hour at pH 3 and 37°C in the presence of pepsin. Raw, cooked and digested samples were rapidly frozen using liquid nitrogen and were stored at -20°C for future analysis.

Blocks of 5 mm x 5 mm x 5 mm of all samples were cut transversely into 6 µm thick sections using a cryostat (Leica, CM1950) at -20°C, which were then collected on a BaF_2 window. Infra-red spectra were acquired using a FT-IR microspectroscope (Thermo Scientific, Nicolet iN10), where at least 20 points of both myofibers (MF) and connective tissue (CT) were scanned for each sample with a 64 scans accumulation (15 X 15 µm spatial resolution). The spectra were analyzed using Unscrambler X software (v10.4, Camo Software AS, Norway). Extended multiple signal correction (EMSC), followed by a second derivative treatment based on 9 Savitzky-Golay smoothing points were performed for spectra correction.

III. RESULTS AND DISCUSSION

SW processing caused a change in the second derivatives spectra of the connective tissue at 1655 cm^{-1} (p<0.001, figure 1(i)), indicating SW processing alters the native α-helix structure [3] of connective tissue. After *sous-vide* cooking, the intensity of 1655 cm^{-1} band of the myofibers of SW treated samples was significantly lower than the control untreated meat (p<0.005, figure 1(ii)), showing more severe protein denaturation of the treated sample during heat treatment. After an hour of *in vitro* gastric digestion, the intensity of 1655 cm^{-1} band at the center of the SW cooked meat was significantly higher than the control untreated cooked meat (p<0.05, Figure 1(iii)), showing the acidic gastric condition has more and faster impact on the untreated control sample, resulting in a higher extent of α-helix denaturation of the myofibers in the latter. The determination of *in vitro* protein digestibility of SW-*sous-vide* cooked meat is now underway. The results will be correlated to the findings of the protein molecular structure.

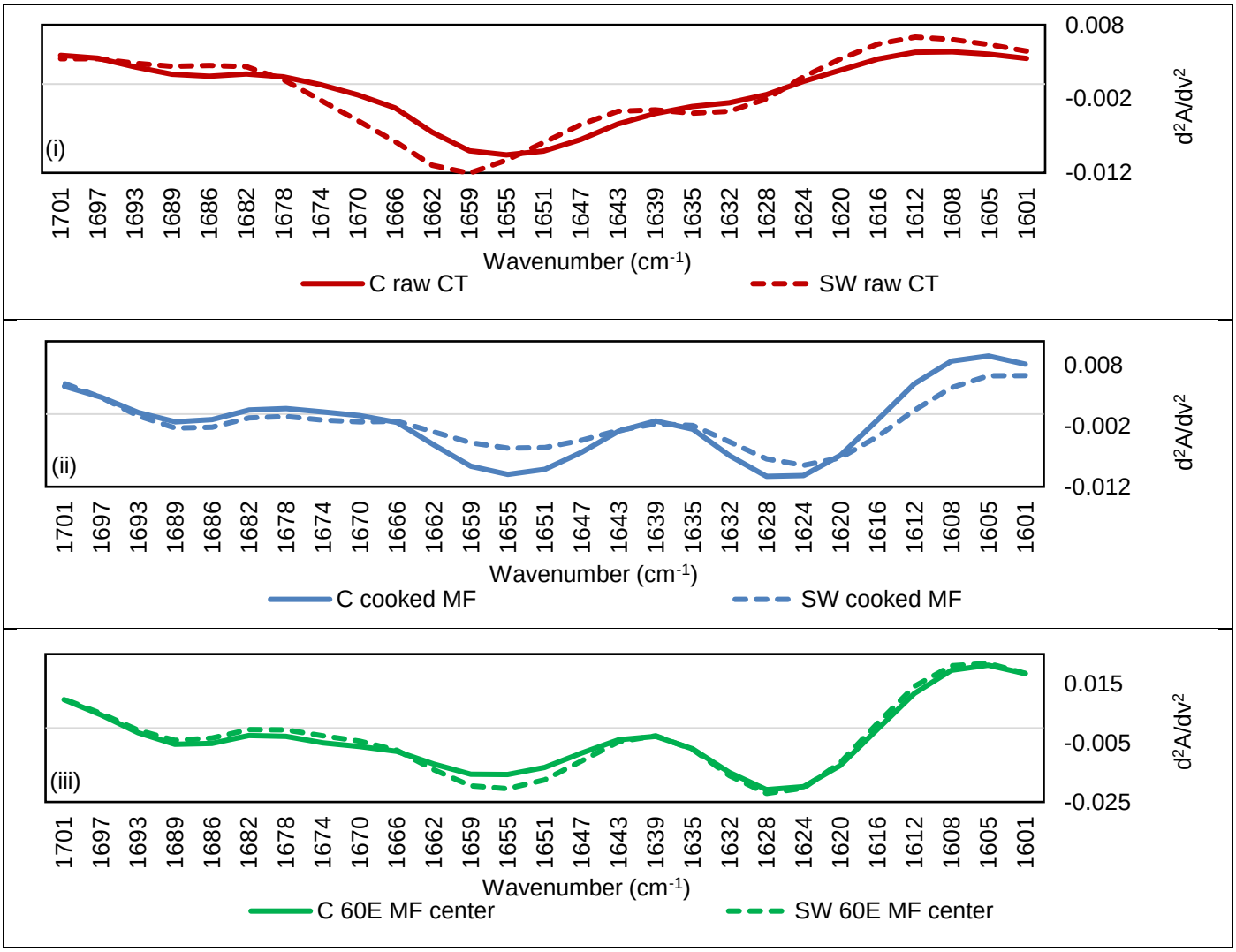

Figure 1. Amide I region second derivative spectra of (i) connective tissue of raw, (ii) myofibers of cooked and (iii) myofibers at the center of cooked, gastric digested (60E) control (C) and SW samples

IV. CONCLUSION

Hydrodynamic SW processing, with and without cooking, modify the protein secondary structure, which may affect the functional and nutritional quality of the meat and meat products.

ACKNOWLEDGEMENTS

Experimental support from DIL and funding from the Riddet CoRE and INRA are appreciatively acknowledged.

REFERENCES

1. Bolumar, T., Bindrich, U., Toepfl, S., Toldra, F., & Heinz, V. (2014). Effect of electrohydraulic shockwave treatment on tenderness, muscle cathepsin and peptidase activities and microstructure of beef loin steaks from Holstein young bulls. Meat Sci, 98(4), 759-765.
2. Astruc, T. (2014). Muscle structure and digestive enzyme bioaccessibility to intracellular compartments. In Boland, M., Golding, M., & Singh, H., Food structures, digestion and health (pp. 193-222). London: Academic Press.
3. Motoyama M., Vénien A., Loison O., Sandt C., Watanabe G., Sicard J., Sasaki K., Astruc T. (2018). In situ characterization of acidic and thermal protein denaturation by infrared microspectroscopy. Food Chemistry, 248, 322–329.