# IMPROVING PROTEIN DIGESTIBILITY AND TEXTURE OF BEEF MEAT WITH NOVEL PROCESSING TECHNOLOGIES

Lovedeep Kaur[1*], Feng Ming Chian[1], Xiaojie Zhu[1], Thierry Astruc[2], Indrawati Oey[3], and Mike J. Boland[1]

[1]Riddet Institute and Massey Institute of Food Science and Technology, Massey University, Palmerston North, New Zealand;

[2] INRA Clermont-Ferrand Theix, UR370 QuaPA, F-63122 Saint-Genès-Champanelle, France;

[3] Department of Food Science, University of Otago, PO Box 56, Dunedin 9054, New Zealand

*Corresponding author email: L.Kaur@massey.ac.nz

**Abstract – We examined the effects of mild processing technologies, such as pulsed electric field, *sous vide*, enzyme and high pressure processing on protein digestibility and texture of meat. Beef meat was exposed to different treatments before subjecting to *in vitro* digestion; and textural and microstructural analyses. The meat processed using the above-mentioned technologies showed greater protein digestibility than the non-treated meats, depending on the level of processing intensity. Pre-treatments of low value meat cuts with exogenous protease were also studied to reduce cooking time whilst achieving faster and more complete protein digestion.**

**Key Words – Actinidin; High Pressure Processing; Pulsed Electric Field; Sous Vide**

## I. INTRODUCTION

Cooking meat leads to structural changes in the connective tissue, myofibrillar and sarcoplasmic proteins, which not only affect the texture and colour of the meat but also its nutritional quality. Previous research has shown that meat protein digestibility and the release of amino acids during simulated gastro-intestinal digestion is affected by the meat processing parameters [1-2], meat microstructure [2] and the other components of the food matrix [3]. We have investigated the effects of high pressure processing (HPP), pulsed electric field (PEF), and sous-vide cooking on meat microstructure, texture and protein digestion using advanced microscopy techniques and *in vitro* protein digestion models.

We have also investigated the use of green kiwifruit extract (which contains the proteolytic enzyme actinidin, KE) along with *sous vide* cooking to achieve optimum tenderization of low-value, high-collagen meat cuts (such as brisket) in shorter periods, followed by inactivation of enzymes to prevent over-tenderization.

This is work in progress. The preliminary results obtained will be presented and discussed in detail.

## II. MATERIALS AND METHODS

This paper demonstrates results of three different experiments, which were carried out as mentioned below:

1. *PEF treatment:* Two-day post-mortem bovine (*M. longissimus dorsi*) muscles were exposed to batch mode PEF equipment (Elcrack-HVP 5, DIL Quakenbruck, Germany). The gap between two stainless steel electrodes of the PEF chamber was 4 cm. Electric field strength of 1.00 - 1.25 kV/cm was used at different pulse numbers of 500 (PN500) and 2000 (PN2000) to create specific energy of 48.65 ± 15.65 kJ/kg and 173.91 ± 34.62 kJ/kg respectively, at a constant pulse width of 20 µs and frequency of 50 Hz.
2. *HPP of meat* [4]: Fourteen day post-mortem bovine (*M. longissimus dorsi*) muscles were subjected to HPP treatments at 175 MPa for 3 min and 600 MPa for 10 min, at room temperature.
3. *KE and Sous vide cooking:* The enzyme kinetics [5] of the extract prepared from fresh kiwifruit (KE, *Actinidia deliciosa* var. 'Hayward') and a commercial kiwifruit extract (CEE) were studied as a function of temperature (under *sous vide* conditions, 35-70 °C), both in the presence or absence of homogenized beef brisket (*pectoralis profundi*). This was done in order to understand the thermal inactivation profile of the actinidin so that the enzyme can be thermally inactivated once optimum meat tenderization has been achieved.

An extract prepared from commercial kiwifruit powder (Actazin, Anagenix Ltd., New Zealand) was introduced into meat steaks (brisket point end) followed by vacuum packaging and heating in water baths at different temperatures (60-70° C) for different times. Samples were analysed for texture (shear force analysis, TATX2, Stable Micro

Systems, Surrey, UK), colour (Minolta CR200 Chroma-meter), cooking losses, and residual enzyme (actinidin) activity.

*In vitro protein digestibility*: The above-mentioned unprocessed controls and processed samples were subjected to *in vitro* gastro-small intestinal digestion by modifying the method of Kaur *et al.* [2]. Samples were taken at different time points for protein digestibility determination using Ninhydrin assay and SDS-PAGE; and microstructural analyses as described by Kaur *et al*. [2,4] .

## III. RESULTS AND DISCUSSION

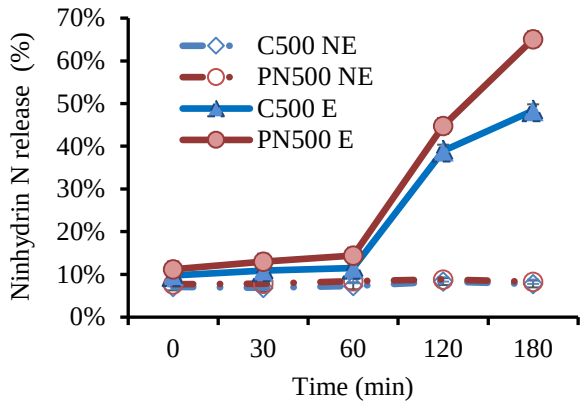


Figure 1. Ninhydrin N release (%) during simulated oral-gastro-small intestinal digestion of PEF treated and control meat samples
C 500, control; PN 500, pulse number 500; NE, no added digestive enzymes; E, with digestive enzymes

*PEF Treatments*: Both PEF treated samples possessed improved protein digestibility where PN 500 (Fig. 1) and PN 2000 were 35 % and 11 % more digestible than the control, non-treated samples after three hours of digestion.

*HPP:* Pressure treatment of meat at 600 MPa resulted in a texture similar to cooked meat; led to a decrease in connective tissue but showed higher amino N (%) at all digestion times than the raw meat [4].

*KE enzyme kinetics and sous vide conditions:* The enzyme in the KE and CEE was effectively inactivated at 60 °C in 3 and 5 min, respectively; and at 55 °C for 10 and 15 min, respectively. Interestingly, the enzyme inactivation temperatures and times increased significantly (for both KE and CEE) when the extracts were added to meat, showing a protective effect of meat on the enzyme's proteolytic activity. Introduction of 5 % CEE into meat reduced the Warner-Bratzler shear force of the cooked brisket (70 °C for 1 h) by about 30 % compared to the control. Digestibility studies are now underway.

## IV. CONCLUSIONS

Novel processes and technologies like low intensity PEF, HPP and *sous vide* cooking, when used optimally, have the potential to add value to low-value cuts of meat by improving the texture and nutritional value.

## ACKNOWLEDGEMENTS

Funding from the Riddet CoRE and FIET programs is gratefully acknowledged. We also thank Ms Amali U. Alahakoon from the University of Otago for their support in carrying out the PEF treatments.

## REFERENCES

1. Santé-Lhoutellier, V., Astruc, T., Marinova, P., Greve, E. & Gatellier, P. (2008). Effect of meat cooking on physicochemical state and in vitro digestibility of myofibrillar proteins. Journal of Agricultural and Food Chemistry 56: 1488-1494.
2. Kaur, L., Maudens, E., Haisman, D. R., Boland, M. J. & Singh, H. (2014). Microstructure and protein digestibility of beef: The effect of cooking conditions as used in stews and curries. LWT - Food Science and Technology 55: 612-620.
3. Kaur, L. & Boland, M. J. (2013). Influence of kiwifruit on protein digestion. Influence of Kiwifruit on Protein Digestion. Advances in Food and Nutrition Research 68: 149-167.
4. Kaur, L., Astruc, T., Vénien, A., Loison, O., Cui, J., Irastorza, M. & Boland, M. (2016). High pressure processing of meat: Effects on ultrastructure and protein digestibility. Food and Function 7: 2389-2397.
5. Boland, M. J. & Hardman, M. J. (1972). Kinetic studies on the cysteine proteinase from Actinidia chinensis. FEBS Letters 27: 282–284.