

## Effects of two-stage thermal sous-vide cooking on the toughness of beef *semitendinosus* (#642)

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### Introduction

One of the applications of sous-vide cooking is to increase the low value of tough meat cuts by transforming into tender meat cuts. The tough meat cuts require cooking interventions to improve the level of tenderness. This can be done by manipulating the temperature-time control that directly affects the two components related to toughness, i.e., myofibrillar proteins and connective tissue. Therefore, two-stage sous-vide at different combination of the temperature-time methods were developed, and sous-vide steak tenderness factors such as soluble collagen, perimysium thickness, sarcomere length, and proteolytic activity, as associated to myofibril and connective tissue were objectively assessed.

### Methods

*Semitendinosus* (ST) muscles were obtained from 27 Hanwoo steers (24-32 months old; low-quality grade 3) at 36 h postmortem. Steaks were cooked at different combination of temperature and time in water baths (Travellortech precision cooker immersion, USA) as follows:

Group 1: Steaks were cooked at 60 °C, 65 °C, 70 °C, and 75 °C for 6 h and 12 h.  
Group 2: Steaks were first cooked at 45 °C and then at 60 °C (45+60 °C), 65 °C (45+65 °C), 70 °C (45+70 °C), and 75 °C (45+75 °C) for 6 h (3 h for first temperature + 3 h for second temperature) and 12 h (3 h for first temperature + 9 h for second temperature).

Group 3: Steaks were first cooked at 49 °C and then at 60 °C (49+60 °C), 65 °C (49+65 °C), 70 °C (49+70 °C), and 75 °C (49+75 °C) for 6 h (3 h for first temperature + 3 h for second temperature) and 12 h (3 h for first temperature + 9 h for second temperature).

Following cooking, steaks were submerged in icy cold water for 1 h and subsequently, steaks were kept under refrigeration at 4 °C overnight before analysis.

### Results

In the present study, collagen solubility was recorded higher at 65 °C and 49+70 °C for 6 h and 12 h, respectively. However, our result shows that at 45+60 °C for 6 h sous-vide steak, heat-solubility collagen was only 4.12% and it was more tender than at 65 °C sous-vide steak that has 15.18% heat-solubility collagen as shown in Fig. 1A. Similarly, treatment at 49+60 °C (10.15% soluble collagen) was tender than at 49+70 °C (33.04% soluble collagen) for 12 h of cooking period. It seems that myofibrillar component is more dominant to cause toughness at temperature above 60 °C which counteract the effect of soluble collagen. This myofibrillar toughening effect can also be

evidenced by sarcomere length observations in Fig. 1B.

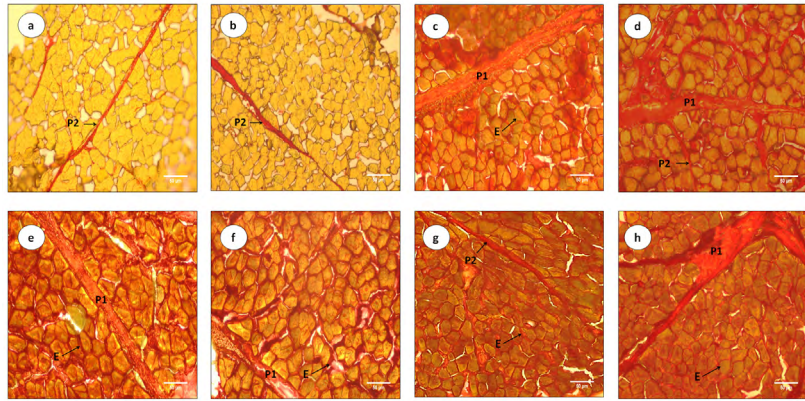
Limited information is available concerning the sarcomere length of sous-vide meat by assessing the distance between two adjacent Z-lines of a sarcomere. Our result shows a negative correlation for both cooking times (6 h,  $r = -0.764$ ; 12 h,  $r = -0.644$ ) and with increasing temperature, sarcomere length decreased and resulted to a higher value of shear force (Fig. 1B). Although cooking time ( $P = 0.001$ ) had a significant effect towards sarcomere length, this longitudinal shrinkage seems to have reached its maximum even with the short period of cooking (6 h) thereby it would have no further decreased in sarcomere length with extended cooking time (12 h).

In our study, there is a significant influence of temperature ( $P < 0.001$ ) on TCA-soluble peptides, but it did not differ between cooking time ( $P = 0.127$ ) (Fig. 1C). We believed that there is the possibility of proteolytic enzymes activity could be captured during two-stage sous-vide, but not in the single-stage sous-vide. This could be elaborated further by a shear force decrease of 10-19% beyond that of the single-stage sous-vide treatment if the steak was treated at early cooking temperature of 45 °C (45+60 to 45+75 °C for 6 h), although this was not enumerated. Nevertheless, this overlapping in temperature ranges was difficult to conclude because no correlation in 6 h of cooking duration of proteolytic activity on meat tenderness was seen.

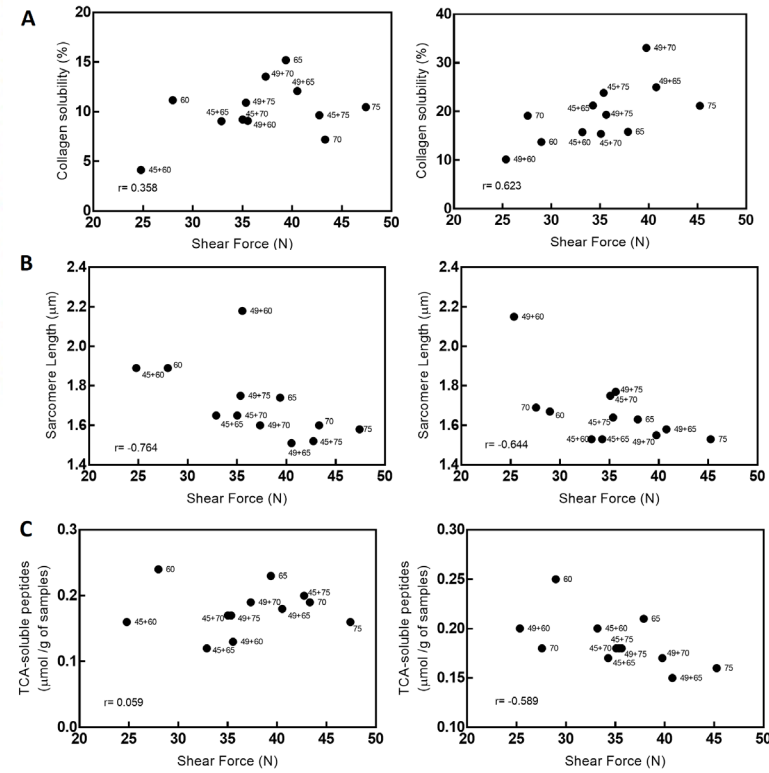
The perimysium is thought to be the main components of connective tissue that contributes to meat toughness. In our study, beef steaks cooked at 60 °C for 6 h (either single-stage or two-stage thermal) consisted a greater broken and shrinkage of denatured fibers than other steak samples, concomitant with the reduction in the shear strength values (Fig.2). However, no clear influence of cooking time on the perimysium thickness although there was significant ( $P = 0.006$ ), because the difference was very small after cooking up to 12 h.

### Conclusion

Combination of temperature and time play a significant role in sous-vide cooked beef *semitendinosus*. However, the effect of temperature is higher than the effect of time, as it strongly influences factors to cause tenderness. Perimysium thickness and sarcomere length appeared to be the main factors related to the reduced shear force of sous-vide steaks studied. All these factors have the greatest influence on toughness at 45+60 °C and 60 °C for 6 h cooking time. However, the effect of collagen solubility and proteolytic activity on toughness were possible to not occur in a short time but instead in the long run.



**Figure 2** Fig. 2. Optical microscopy images (10×) of beef steaks sous-vide cooked at different temperatures and time durations (a, b, c, and d cooked for 6 h at 60 °C, 65 °C, 70 °C and 75 °C, respectively; e, f, g, and h cooked for 12 h at 60 °C, 65 °C, 70 °C and 75 °C, respectively). Red stained fibers refer to perimysium (P) and endomysium (E). P1= primary perimysium, and P2= secondary perimysium. Scale bar represents 50 μm.



**Figure 1** ssFig. 1. The relationship between shear force and collagen solubility (A), sarcomere length (B) and TCA-soluble peptides (C) of twelve sous-vide treatments cooked for up to 6 h (left) and 12 h (right).

## Notes