IMPROVING THE TENDERNESS OF HOT-BONED STRIP LOINS BY USING A NOVEL PACKAGING METHOD

N. Magnus Wahlgren and Kjell Ivar Hildrum *
Norwegian Meat Cooperative, P.O.Box 396, Økern, N-0513 Oslo, Norway, * Matforsk - Norwegian Food Research Institute, Osloveien 1, N-0513 Oslo, Norway

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Background

The effect of muscle shortening during rigor development on meat tenderness has been recognised since the beginning of the 1950's (Bendall, 1951) and has been characterised by a number of scientists (Olsson *et al.*, 1994 and Devine *et al.*, 1999). It has been observed that restricting muscle contraction during rigor enhances the tenderness both in lamb (Koohmaraie *et al.* 1996) and beef (Devine *et al.*, 1999). The latter authors studied the effects of pre rigor wrapping of *m. longissimus dorsi* using cling film in the temperature range 15°C to 35°C, and found beneficial effects on the tenderness. The wrapping technique has also been shown to have a beneficial effect at rigor temperature under 10°C where cold shortening occurs (Hildrum *et al.*, 2000). In Norway about 20 % of the total volumes of beef cuts are hot boned. Hot boning implies different challenges to achieve tender beef compared to cold boning. By removing pre rigor muscles from the restriction of the bones, the muscles become more vulnerable for muscle contraction during rigor development and thereby more sensitive to chilling regimes.

Objective

In this study a novel packaging method, **Pi-Vac Elasto-Pack**, was evaluated (Stiebing & Karnitzschky, 1997). The film has a high degree of elasticity that creates forces directed towards the beef cuts. The forces are supposed to hinder the diametrical expansion, which is caused by the longitudinal contraction obtained during rigor development.

Materials and methods

Pairs of strip loins (*m. longissimus dorsi, LD)* from 12 non-electrically stimulated young bulls were used. The carcasses were slaughtered at a commercial abattoir (Gilde HedOpp BS, Otta). The muscles were excised warm (1h ***post mortem***). All muscles were divided in two equal parts across the muscle direction where they were systematically allocated to four treatments. The two pieces from one of the muscle pairs were packed in traditional vacuum bags. The two other muscle pieces from the same carcass were packed in a Pi-Vac Elasto-Pack (Pi-Vac GmbH Verpackungssysteme, Wettenberg, Germany). The meat was placed in a single layer in plastic trays and subjected to air chilling at 4°C or followed the ordinary conditioning regime for hot boned beef cuts used at the plant (14°C for 8h→ 8°C for 6h→ 4°C-end). The samples were aged at 4°C until the day of tenderness measurements (2, 9 and 26 days *post mortem*). After ageing, slices of 3.5cm thickness from each sample were cut across the muscle for Warner Bratzler shear (WB) shear force measurements. All samples were vacuum-packed in polyethylene bags, heated at 70°C for 50 min in a water bath and afterwards chilled in ice water for 45 min. The samples were stored at –1.5°C until the day of analysis. Before WB shear force measurements, the samples were conditioned at 20°C, and slices of 1cm thickness were cut along the fibre direction of the muscles. A second cut was also performed in the fibre direction to give the final samples (cross-section dimensions of 1cm x1 cm). The approximate length of the samples was 3cm. Structures of visible fat and sinew were avoided. WB shear force measurements were performed on 10 replicates, which were cut perpendicular to the fibre direction with the WB shear force device (triangular version) in an Instron Materials Testing Machine (Model 4202, Instron Engineering Corporation, High Wycombe, U.K.). The averages of the maximum force were used in the data analysis. Samples for sarcomere length measurements were collected 9 days *post mortem*, fixed in a borate solution containing 2.5% glutaraldehyde and homogenized using a Polytron PT3000 homogenizer. The sarcomere lengths were measured with an image analysing program (Image-Pro Plus 4.0, Media Cybernetics, Silverspring, Maryland, USA) of pictures taken with a camera (Hitachi KP-D50 Color Digital, Hitachi Denshi Ltd, Japan) connected to a light microscope (Leica DMLB, Leica Mikroskopie & Systeme GmbH, Wetzar, Germany).

Results and discussion

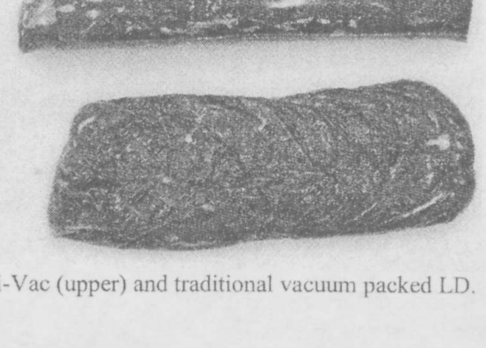

Figure 1. Pi-Vac (upper) and traditional vacuum packed LD.

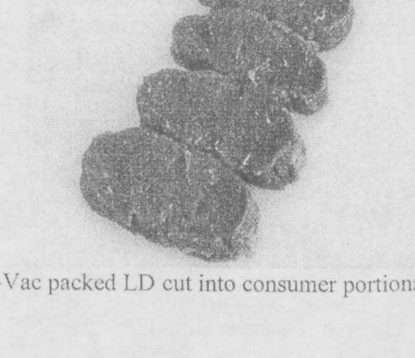

Figure 2. Pi-Vac packed LD cut into consumer portions.

The Pi-Vac packaging system results in a round and attractive shape of the hot boned strip loins. This is not always the case for traditional hot boned and vacuum-packed beef. When these are placed in boxes or trays, they usually loose their natural shape due to the pressure from the surrounding beef cuts. The round shape was kept even after the film was removed and the LD had been cut into consumer slices. This is a big advantage when the meat is displayed to the customers.

All three variables packaging method, rigor temperature and ageing was shown to have significant effect on the tenderness of the LD muscle, Table 1. Largest impact had packaging method and ageing time which is shown by the large improvement in tenderness when vacuum packed at 4°C (VAC4°C) is compared with Pi-Vac packed at 4°C (Pi-Vac 4°C) two days *post mortem*. The impact from ageing time is visualised by the large decrease in shear force between 2 and 9 days *post mortem*. The results indicate that packaging and rigor temperature had an additive effect on the tenderness on hot boned strip loin. Another observation is that ageing of hot boned vacuum packed strip loin chilled at 4°C had a small impact of the tenderness. This indicates that a severe cold shortened strip loin does not become tender.

Table 1. WB-shear force and sarcomere length values as a function of packaging and chilling of the hot boned strip loin.

Variable	Vac 4°C mean±std	Vac Cond mean±std	Pi-Vac 4°C mean±std	Pi-Vac Cond mean±std	Method p-value	Temperature p-value	Treatment p-value
WB-day2 (N/cm^2)*	$128^{d}\pm12$	$108^{c}\pm17$	$85^{a}\pm17$	$75^{a}\pm9$	<0.0001	<0.001	<0.0001
WB-day9 (N/cm^2)*	$97^{c}\pm17$	$66^{b}\pm20$	$54^{a}\pm13$	$48^{a}\pm11$	<0.0001	<0.001	<0.0001
WB-day26 (N/cm^2)*	$104^{b}\pm26$	$59^{a}\pm20$	n.m	n.m	-	-	-
Sarcomere length (μm)	$1{,}52^{d}\pm0{,}20$	$1{,}69^{c}\pm0{,}08$	$1{,}84^{b}\pm0{,}20$	$2{,}05^{a}\pm0{,}19$	<0.0001	<0.0001	<0.0001

*) Mean values with different superscript in the same row differs significantly P<0.05, not measured (n.m.).

The packaging method was also shown to have a significant effect on sarcomere length, Table 1. This indicates that the Pi-Vac packaging system is able to reduce the muscle contraction obtained during rigor development. Furthermore, the packaging method was shown to have a larger impact on sarcomere length than the two chilling regimes studied. The correlation between WB shear force and sarcomere length was significant ($r= -0.68$, $p<0.0001$) indicating that the toughening process occurring during rigor development is less important for the tenderness of hot boned strip loins.

The overall results imply that the Pi-Vac packaging method secure the tenderness of hot boned strip loins better than the controlled chilling regime used in this experiment. The industrial benefits of this packaging method are that a faster chilling regime can be used with a higher throughput and better hygiene as the results.

Conclusions

- The elastic film used in the Pi-Vac packaging system reduces muscle contraction during rigor development.
- The Pi-Vac packaging system secures the tenderness of hot boned strip loins.
- The Pi-Vac packaging system makes it possible to chill hot boned strip loins faster without any detrimental effect on tenderness.
- The Pi-Vac packaging system improves the shape of hot boned strip loins.

References

Bendall, J. (1951) *J. Physiol. 114, 71-88.*

Devine, C.E., Wahlgren, N.M. and Tornberg, E. (1999) *Meat Sci. 51, 61-72.*

Hildrum, k.I.,Narum Nilsen, B. Andersen, T and Wahlgren, N.M. (2000). Proc. 46th ICoMST, Buenos Aires, 445

Koohmaraie, M., Doumit, M.E. and Wheeler, T.L. (1996) *J. Anim. Sci. 74,2935-2942.*

Olsson, U., Hertzman, C. and Tornberg, E. (1994) *Meat Sci. 37, 115-131.*

Stiebing, A. & Karnitzschky, I. (1997) Fleischwirtsch. 77, 20