EFFECT OF RAPID COOLING ON THE QUALITY OF TURKEY BREAST MEAT

Obanor F., Morton J.D., Bickerstaffe, R.
Molecular Biotechnology Group, Animal and Food Sciences Division, Lincoln University, Canterbury, New Zealand

Background

In recent years two factors have driven changes in the way turkeys are processed. Firstly there has been an increase in the use of processed turkey products[1]. This has meant that it has been more economic to remove the important cuts, the breast meat, from the carcass as early as possible. Thus it is now common to bone out turkey carcasses within three hours of slaughter. A second, related factor is the need to chill the carcasses rapidly to slow the growth of bacteria. The proliferation of bacteria determines the shelflife of turkey products. Rapid chilling also overcomes the recognised problems of pale, soft, exudate (PSE) meat that turkey, along with pork, is prone to[2,3].
However previous research in broilers has shown that early deboning adversely affects meat quality attributes.[4] There is also anecdotal evidence that these changes have led to turkey meat which is tough. In preliminary experiments we found that the tenderness of turkey breast meat was variable and the average shear force was higher than would be acceptable to consumers. This paper will address the hypothesis that rapid cooling and early deboning have caused rigor-shortening leading to tough meat and that adjusting the protocol can produce a significant improvement in the consistency and tenderness of the product.

Objectives

To determine whether the processing conditions for turkeys produce unacceptably tough breast meat and if altering the time of boning and rate of cooling can improve resulting meat tenderness. Also to investigate the mechanism underlying any toughening effect.

Methods

Twenty-four turkeys were electrically stunned and slaughtered by exsanguinations at a local processing plant. The carcasses were scalded, defeathered, washed and manually eviscerated. The carcasses were subsequently cooled in two separate baths containing refrigerated water held at 4° and 1°C respectively for 30-40 minutes. Following this they were held in a chiller at 0°C for a further 2-3 hours before deboning. For this experiment the right breast was removed from the bone and the left breast left on the carcass. Then twelve of the birds, carcass and excised breast, were subjected to blast freezing (-24°C) for 2 hours before storage in a chiller (0°C) while the other twelve were placed directly into the chiller. At 24 hours all the samples were taken to Lincoln University for further analysis.
The temperature and pH of the meat was determined using an Orion 8163 electrode attached to a Hanna HI 9025 meter. Shear force of turkey meat cooked to an internal temperature of 75°C was measured using a MIRINZ tenderometer as described previously[5]. Myofibrils were extracted for determination of the myofibril fragmentation index (MFI)[6] and also for sarcomere length analysis by phase contrast microscopy.
Significant differences were determined using Minitab 11 and all mean results are followed by the standard deviation in brackets.

Results and discussion

Temperature and pH

The mean internal breast temperature of all the birds was 36.5°C (± 2.35°C) at 30 minutes after slaughter. The combination of the two cooling baths lowered the breast temperature to 11.0°C(± 1.01°C) by 70 minutes post-slaughter. After another 2 hours in the chiller the temperature was at 7.8°C (± 0.64°C) when the right breast was removed. The blast freezing made a significant difference to the average temperature of the breast muscles at 6 hours post-slaughter. The temperature was 3.3°C (± 0.14°C) compared to 7.8°C(± 0.34°C) for the chilled only muscles. There were no significant differences in temperatures among the muscles whether boned out or still on the carcass.
The mean pH of the carcasses was 6.69(± 0.13) at 30 minutes after slaughter which declined steadily to pH 6.0 (± 0.17) at the time of deboning. The treatments had no significant effects on pH with the mean ultimate pH of all carcasses being 5.93 (± 0.09). The combination of the temperature of the muscle being below 10°C whilst the pH is above 6 are the conditions whereby meat could suffer cold shortening.

Shear force and cooking loss

Allowing the muscles to age on the bone significantly improved the tenderness of the resulting breast meat at both 1 and 7 days after slaughter (Table 1 and 2). The blast freezing increased the mean shear force by 20 –40 % in every case but the toughening effect was only significant at 7 days in the muscles that had been left on the bone. The MIRINZ tenderometer has recently been standardised in large scale consumer taste tests[7]. Using these figures the turkey aged on the carcass would be tender at 24 hours and very tender by 7 days whilst the meat that was boned at three hours would only be acceptable at 1 day and tender by 7 days.
Early boning also caused significantly greater cooking losses at 24 hours post-slaughter. However, this difference had disappeared by 7 days.

MFI and sarcomere length

The tenderness of meat results from how much the sarcomeres have shortened during the rigor process and the extent of post-mortem proteolysis. Measurements were taken to determine the contribution of each of these to the toughening effects of early boning and blast freezing (Tables 1 and 2). Removing the breast from the carcass at three hours post-mortem allowed a significant shortening of the sarcomeres and is likely to have contributed to the toughening of this meat. The meat that was boned out at 3 hours post-slaughter also showed significantly less proteolysis as measured by MFI at 24 hours post-mortem. At 7 days post-mortem the MFI values were still lower in the "hot-boned" breast meat but the difference was not significant. The reduced proteolysis may be associated with the shorter sarcomeres in that the proteases may be unable to access their substrates in contracted muscles.
Blast freezing the muscles caused no significant differences in either sarcomere length or MFI.

Conclusions

The processing conditions did have a toughening effect on the resultant turkey breast meat. Boning out at three hours post-slaughter caused a significant 90% increase in toughness. The use of the blast freezer to rapidly cool the breast also toughened the meat by an average of 30%. The mechanism responsible for the toughening of the meat involves a contraction of the muscle and a reduction in proteolysis. Adjusting the processing protocol affecting both of these changes improved the rate of tenderisation and, consequently, the consistency and tenderness of the final product. However, the impact of new processing protocols on shelflife will need to be monitored.

Pertinent literature

1. Owens, C. M. and Sams, A. R. (1997). Muscle metabolism and meat quality of pectoralis from turkeys treated with post mortem electrical stimulation. *Poultry Science* 76: 1047-1051.
2. Wakefield, D. K., Dransfield, E., Down, N. F. and Taylor, A. A. (1989). Influence of post mortem treatments on turkey and chicken meat texture. *International Journal of Food Science and Technology* 24: 81-92.
3. Sosnicki, A. A., Greaser, M. L., Pietrzak, M., Pospiech, E. and Sante, V. (1998). PSE-like syndrome in breast muscle of domestic turkeys: a review. *Journal of Muscle Foods* 9: 13-23.
4. Lyon, C. E., Lyon, B. G., Papa, C. M. and Robach, M. C. (1992). Broiler tenderness: effects of postchill deboning time and fillet holding time. *Journal of Applied Poultry Research* 1: 27-32.
5. Morton, J. D., Bickerstaffe, R., Kent, M. P., Dransfield, E. and Keeley, G. M. (1999). Calpain-calpastatin and toughness in m. longissimus from electrically stimulated lamb and beef carcasses. *Meat Science* 52: 71-79.
6. Geesink, G.H.; Mareko, M.H.D.; Morton, J.D.; Bickerstaffe, R. (2001). Effects of stress and high voltage electrical stimulation on tenderness of lamb longissimus. *Meat Science* 57: 265-271.
7. Bickerstaffe, R., Bekhit, A. E. D., Robertson, L. J., Roberts, N. and Geesink, G. H. (2001). Impact of introducing specifications on the tenderness of retail meat. *Meat Science* 59: 303-315.

Table 1 Effect of changing processing conditions on turkey meat quality at 24 hours post-slaughter

Time Boned	Blast Frozen	Shear force (kgF)	Cooking loss (%)	MFI	Sarcomere Length (μm)
3 hours	No	$8.61^{b} \pm 1.11$	$19.3^{b} \pm 1.61$	$54.8^{a} \pm 5.50$	$1.69^{a} \pm 0.20$
3 hours	Yes	$10.3^{b} \pm 2.5$	$20.3^{b} \pm 1.98$	$51.3^{a} \pm 6.80$	$1.70^{a} \pm 0.18$
24 hours	No	$4.60^{a} \pm 0.49$	$12.1^{a} \pm 0.42$	$83.9^{b} \pm 10.6$	$2.05^{b} \pm 0.14$
24 hours	Yes	$5.45^{a} \pm 0.43$	$12.1^{a} \pm 0.32$	$74.0^{ab} \pm 18.2$	$1.92^{b} \pm 0.11$

^{abc} Means in the same column with different superscript are significantly different, $p < 0.05$

Table 2 Effect of changing processing conditions on turkey meat quality at 7 days post-slaughter

Time Boned	Blast Frozen	Shear force (kgF)	Cooking loss (%)	MFI	Sarcomere Length (μm)
3 hours	No	$6.39^{c} \pm 1.13$	$11.9^{a} \pm 0.32$	$100.4^{c} \pm 17.7$	$1.77^{a} \pm 0.14$
3 hours	Yes	$8.20^{c} \pm 1.78$	$12.0^{a} \pm 0.26$	$93.4^{c} \pm 18.9$	$1.73^{a} \pm 0.09$
24 hours	No	$3.26^{b} \pm 0.89$	$11.7^{a} \pm 0.45$	$117.8^{c} \pm 14.3$	$1.96^{b} \pm 0.07$
24 hours	Yes	$4.35^{a} \pm 1.11$	$11.8^{a} \pm 0.27$	$112.2^{c} \pm 10.5$	$1.89^{b} \pm 0.06$

^{abc} Means in the same column with different superscript are significantly different, $p < 0.05$