PHYSICAL-CHEMICAL QUALITY TRAITS OF TURKEY BREAST MUSCLES AS AFFECTED BY EARLY POSTMORTEM CHILLING RATE

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SUMMARY

The effects of cold and heat shortening on physical-chemical quality traits, particularly tenderness, of two turkey breast muscles (M. pectoralis profundus and M. pectoralis superficialis) were studied. Immersion of the muscles in water of 0, 16 or 30°C for 3h resulted in distinct differences in early post mortem chilling rates. These produced significant differences in rate of glycolysis, as evidenced by toughening due to cold shortening (0°C treatment) and heat shortening (30°C treatment).

It is concluded that chilling rate is an important tenderness determinant in turkey breast muscle. Further research is necessary to establish the relevance of both cold and heat shortening in practice.

INTRODUCTION

The sensory quality of turkey meat is dependent on numerous ante- and post mortem factors such as breed, sex, age, nutrition, transport conditions and stunning, scalding/plucking, refrigeration and boning procedures. Considerable variation in these parameters among countries and turkey processors as well as inherent animal-to-animal and muscle-to-muscle variation makes it very difficult to derive practical recommendations from different scientific studies. An additional point of concern for research and development officers in the turkey meat industry is that day-to-day variation in processing conditions appear to appreciably affect turkey meat quality, particularly tenderness. As research efforts on sensory quality of poultry have been largely concerned with chicken, reliable data pertaining to turkey are relatively scarce (Nixey and Grey, 1989).

An important determinant of tenderness is the extent of post mortem shortening, as regulated by the rate of post mortem glycolysis. Among factors reported to affect the rate of muscle glycolysis in turkey muscle, stunning and refrigeration procedures stand out as major influences (Hillebrand et al., 1990).

The consequences of chilling rates on meat tenderness have been well-documented. Both extremely rapid chilling and extremely slow chilling are known to induce toughening in beef as a result of cold and heat shortening, respectively. The risk of occurrence of these quality aberrations depends on the rate of glycolysis. Bendall (1972) calculated that a temperature fall to below 10°C when the pH is still > 6.2 results in cold shortening. This would seem to indicate that cold shortening does not occur in fast glycolysing muscle. Yet, recent reports suggest that cold shortening may also occur in fast glycolysing pig muscle, although short sarcomeres are generally associated with tough pork only in relatively slow-glycolysing pig carcasses (Møller and Vestergaard, 1987). Turkey muscle exhibits an even faster post mortem pH decline than normal pork muscle, but nevertheless, cold shortening has been observed in rapidly chilled turkey (Smith et al., 1969; Lockyer and Dransfield, 1986; Wakefield et al., 1989). Heat shortening may occur when rigor sets in at a high temperature, making fast glycolysing turkey muscles more prone to heat shortening than to cold

shortening.
The purpose of the present study was to assess the magnitude of cold and heat shortening effects on physical-chemical quality traits of turkey breast muscles with a relatively slow rate of glycolysis.

MATERIALS AND METHODS

Treatments

A model-study, consisting of two experiments on two different days, was conducted with a total of 28 broad-breasted white turkey toms of 19 weeks age with a live-weight of ca. 14 kg. Carcasses having a pH >6.2 in the M. pectoralis superficialis and M. pectoralis profundus at 24 min post mortem were selected at the slaughter plant. Selected carcasses were subsequently split through the sternum, and all carcass sides were packaged in water-tight polythene bags. In each experiment, one carcass side (left or right) of each animal was randomly assigned to one of the following treatments, with the remaining side assigned to the other treament: 1st experiment, n=14 i) 3h immersion in melting ice, ii) 3h immersion in water of 16°C, or 2nd experiment, n=14 iii) 3h immersion in water of 16°C, iv) 3h immersion in water of 30°C. The temperature of the water baths was monitored and kept within a ±1°C range. After the 3h immersion, all carcass sides were stored at 1±1°C until 24h post mortem.

Sample preparation/physical-chemical measurements

At 5 min, 30 min, 3h and 24h post mortem the muscle pH and temperature in the core of the Mm pectorales superficialis and profundus was measured with a portable pH meter (type CG 818, with glass electrode N 48A, Schott Geräte, Hofheim, FR Germany) and a digital thermometer (Comark Electronics Ltd, Rustington, England).

At 24h post mortem (day 1) meat colour of freshly cut muscle sections (M. pectoralis superficialis) or undissected muscle surface (M. pectoralis profundus) was measured with a Minolta reflectometer. Subsequently muscle samples were packaged in air-tight plastic bags for measurement of drip loss %, according to the methodology described by Honikel (1987).
In addition samples were taken from randomly located areas in the core of the muscle for measurement of sarcomere length using the method of Koolmees et al. (1986).

On day 1 (M. pectoralis superficialis) or day 3 (M. pectoralis profundus), muscles were cooked in a water bath of 72°C until a core temperature of 70°C was reached ('boil-in-the-bag' method of Boccard et al. 1981), then cooled under running tap water of ca. 10°C for 40 min. Cooking losses were assessed by reweighing muscle samples after cooking.
Rectangular samples of 1 cm^2 cross-section were cut at right angles to the muscle fibre direction. Subsequently shear forces were measured using a draw-bench (Adamel Lhomargy, Division d'Instruments S.A. Paris, Paris, France) equipped with a Warner Bratzler shearing device.

Data were analysed statistically with the Student t-test.

RESULTS AND DISCUSSION

Table 1 includes the results of pH and temperature measurements in both breast muscles.
Table 1 shows that the immersion treatment resulted in distinct differences in chilling rate. Generally, these produced significant differences in the rate of glycolysis in both breast muscles. At 3.5 h post mortem this resulted in pH/temperature combinations in the 0 and 30°C treatments that are reported to induce cold and heat shortening, respectively (Bendall,

1972).
Tables 2 and 3 include the results of measurements of physical-chemical variables that pertain to major sensory quality traits.
Chilling rates did not significantly influence meat colour or percentage of drip- or cooking-loss in either of the muscles investigated. In similar tests with pork muscle, drip loss percentages were found to be markedly (ca 2%) higher than those observed in this study (van Laack, 1989). More recent experience with turkey relying on the same methodology reveals even lower drip losses (Hillebrand et al., unpublished). This indicates a excellent water-holding capacity of fresh turkey muscles even after long storage periods. Average cooking losses of deep pectoral muscle were substantially lower than those of superficial pectoral muscle; the latter were generally of the same order of magnitude as those found in beef and pork (van Laack, 1989).

Table 1 The effect of immersion at 24 min post mortem (p.m.) in water-baths of 0, 16 and 30°C on pH and temperature fall in turkey breast muscles

Muscle	Time p.m.	Experiment 1 (n=14) 0°C pH	0°C T	16°C pH	16°C T	Experiment 2 (n=14) 16°C pH	16°C T	30°C pH	30°C T
M. pectoralis superficialis	5 min	6.8	40.4	-*	-	6.8	41.1	-	-
	0.5 h	6.6	38.8	-	-	6.4	41.2	-	-
	3.5 h	6.4	8.4[a]**	6.3	18.5[b]	6.2[a]	20.2[a]	6.0[b]	30.1[b]
	24 h	5.8	4.3	5.8	4.3	5.8	3.3	6.0	3.5
M. pectoralis profundus	5 min	6.8	41.1	-	-	6.7	41.5	-	-
	0.5 h	6.7	40.4	-	-	6.7	41.3	-	-
	3.5 h	6.6[a]	5.9[a]	6.4[b]	18.1[b]	6.3[a]	19.1[a]	6.2[b]	29.9[b]
	24 h	6.0	4.5	6.0	4.6	6.0	3.4	6.0	3.6

* - = not measured.
** Figures with different superscript differ significantly ($p<.05$).

With the exception of the 30°C treatment of deep pectoralis muscle, shear force measurements indicated significant effects of chilling rates on tenderness. In general, the toughening effect of 0 and 30°C treatment coincided with significant differences in sarcomere length, indicating that cold and heat shortening were probably responsible for toughening. In experiment 2 the tenderness of the M. pectoralis superficialis chilled at 16°C was markedly lower than in the first experiment. Since experimental conditions had been similar this is likely the result of biological variation in animal material.

Table 2 Physical-chemical quality traits of turkey M. pectoralis superficialis as affected by early post mortem immersion chilling of split carcasses; means and standard deviations.

	Experiment 1 (n=14)		Experiment 2 (n=14)	
Trait	0°C	16°C	16°C	30°C
Colour L	55.8±2.5	57.2±1.3	55.8±2.4	55.8±1.9
a	10.9±0.9	11.1±0.9	11.7±0.9	12.1±1.3
b	6.0±1.5	6.3±0.9	6.5±1.1	7.2±1.7
Drip loss (%)	0.8±0.2	0.9±0.2	0.8±0.2	1.1±0.5
Cooking loss (%)	25.9±2.0	23.0±7.3	24.7±2.3	25.6±1.7
Sarcomere length (μm)	$1.61\pm0.11^{b*}$	1.77 ± 0.11^{a}	1.67 ± 0.08^{b}	1.56 ± 0.08^{b}
Shear force (N/cm^2)	3.48 ± 1.76^{bd}	2.05 ± 0.79^{a}	3.22 ± 0.75^{b}	3.77 ± 0.39^{cd}

* Figures with different superscript differ significantly ($p<.05$).

Table 3 Physical-chemical quality traits of turkey M. pectoralis profundus as affected by early post mortem immersion chilling of split carcasses; means and standard deviations.

	Experiment 1 (n=14)		Experiment 2 (n=14)	
Trait	0°C	16°C	16°C	30°C
Colour L	54.7±1.8	54.5±1.4	54.5±2.1	54.6±2.1
a	10.6±2.8	12.0±0.8	13.3±1.3	12.9±1.2
b	6.1±1.1	6.3±1.4	7.2±0.9	7.3±1.3
Drip loss (%)	0.8±0.2	0.8±0.2	0.7±0.3	0.8±0.4
Cooking loss (%)	19.8±2.3	19.3±2.4	20.4±1.8	20.9±1.7
Sarcomere length (μm)	$1.73\pm0.18^{bd*}$	1.82 ± 0.06^{a}	1.76 ± 0.08^{b}	1.64 ± 0.14^{d}
Shear force (N/cm^2)	4.26 ± 1.43^{b}	3.46 ± 0.52^{a}	3.02 ± 0.87^{a}	3.31 ± 1.09^{a}

* Figures with different superscript differ significantly ($p<.05$).

CONCLUSION

From this 'model' experiment, conducted with relatively slow glycolysing breast muscles, it can be concluded that chilling rate may be an important determinant of tenderness in turkey muscle.

Extremely fast chilling may result in cold shortening. Slow chilling, induced by inappropriate chilling conditions, by undercapacity of chilling rooms or by excessively high conveyor speeds, may lead to heat shortening with similar detrimental effects on tenderness.

Heat shortening easily occurs in fast glycolysing muscles such as those of turkeys. Consequently, it may be extremely difficult in practice to adapt chilling rate so as to prevent heat shortening. Therefore, options for controlling the rate of glycolysis, e.g. by ante-mortem treatment or by adapted stunning procedures, must be addressed concurrently.

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