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EFFECT OF THE COOLING PATTERN AND FREEZING DURING RIGOR ON THE QUALITY OF MUTTON

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It is now well established that the solubility of muscle protein fractions, particularly that of myofibrillar proteins, has a positive influence on the tenderness and associated quality characteristics of meat. Hamm and Deathrage,[1] and Hegarty, Bratzler and Pearson[2] reported significant relationships between water holding capacity, tenderness and the solubility of beef muscle proteins. Ushborne, Kemp and Moody,[3] and Topel, Merkel and Wismer-Pedersen[4] showed a significant correlation between muscle protein solubility and the juiciness, firmness, overall eating satisfaction and ease of P.S.E. (pale, soft and exudative) muscle development in pig muscle. Summarizing various studies on poultry muscle, Donnelly, Rongey and Bursuko[5] reported that protein composition alters with the desirable functional properties of the meat during rigor. In the present study also, the muscle proteins solubility was used as a measure of ovine meat quality.

Animal carcase does not cool uniformly due to the different position of the muscles with respect to the (chill room) environment. This gives rise to slow cooling rate for deep muscles and fast cooling rate for surface muscles. In the present study the slow and fast cooling regimes for ovine muscle were deduced from the cooling data of the *longissimus dorsi* (4th thoracic) and triceps muscles respectively of a flock of 146 sheep of various breeds. Solubility and associated determinations were made from 8 additional sheep of unknown history.

Immediately after slaughter, a portion of minced *longissimus dorsi* muscle was allowed to go into rigor according to the cooling regimes shown in Table 1. Another portion quick frozen in a solid CO_2 and ethanol mixture 20 min after slaughter, was also thawed according to slow and fast cooling regimes. The solubility of the protein fractions was determined by the method of Hill.[6] The pH was measured with a radiometer pH meter using a glass electrode. The standardization of the pH meter was done at room temperature (23°C) against a phosphate buffer of pH 6.86. The sarcomere length was an average of 25 measurements recorded from five different muscle photographs taken by a phase contrast microscope. Expressible juice ratio was determined with the filter paper press technique reported by Briskey, Hoekstra, Phillips and Crummer.[7]

TABLE 1.—TIME TABLE FOR SLOW AND FAST COOLING MUSCLE SAMPLES.

Temp °C	Time in hr	
	Slow	Fast
37°C	0.5	—
30°C	1.0	0.5
20°C	1.5	2.0
15°C	3.0	5.0
10°C	4.0	10.0

5°C until ultimate pH was reached.

The two cooling regimes did not affect the amount of soluble myofibrillar, soluble sarcoplasmic, W.H.C., time to reach ultimate pH, % moisture and % fat of the ovine muscle at the time of its ultimate pH. The characteristics which showed the influence of cooling regimes were the sarcomere length of the muscle and the ultimate pH value. It was interesting to note that if the muscle was frozen immediately post mortem, the influence of cooling regimes on sarcomere length and ultimate pH value disappeared (Table 2). The data suggests that as long as the tissue is undergoing chemical changes of rigor mortis, the slow and fast cooling muscles should not differ in their eating quality based on protein solubility, particularly when the freeze treatment is rendered beforehand. Another interesting feature which came to light was that the common assumption of the more relaxed the muscle the higher the solubility of myofibrillar proteins[8] does not hold good if the muscles reached a certain contraction state under different cooling regimes.

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TABLE 2.—AVERAGE VALUE OF VARIOUS PROPERTIES FOR SLOW AND FAST COOLING REGIMES AT THE TIME OF ULTIMATE pH VALUE.

(Eight sheep were used)

Properties	Slow		Fast	
	Unfrozen	Frozen	Unfrozen	Frozen
Soluble sarcoplasmic proteins	42.95^{a}_{x}	43.10^{a}_{x}	43.18^{a}_{x}	43.90^{a}_{x}
Soluble myofibrillar proteins	82.50^{a}_{x}	70.36^{a}_{x}	75.70^{a}_{x}	67.96^{a}_{x}
% expressible juice ratio	59.63^{a}_{x}	68.44^{a}_{x}	57.23^{a}_{x}	68.13^{a}_{x}
Ultimate pH	5.50^{a}_{x}	5.40^{a}_{x}	5.39^{a}_{x}	5.37^{a}_{x}
Time to reach ultimate pH (hr)	4.71^{a}_{x}	5.31^{a}_{x}	5.65^{a}_{x}	5.44^{a}_{x}
Sarcomere length (μ)	1.28^{a}_{x}	1.09^{a}_{x}	1.50^{a}_{x}	1.15^{a}_{x}
% moisture	75.6^{a}_{x}	75.4^{a}_{x}	75.5^{a}_{x}	75.7^{a}_{x}
% fat	16.19^{a}_{x}	16.61^{a}_{x}	16.59^{a}_{x}	16.57^{a}_{x}

1. Within the same freeze condition, a property with the same superscript not significantly different for slow and fast cooling regimes.
2. Within a cooling regime, a property with same subscript not significantly different for frozen and unfrozen samples.
3. Proteins as mg/g wet wt and % moisture and % fat on wet wt basis.

This was suggested by the data in Table 2 where sarcomere length of 1.50μ and 1.28μ resulted in 75.70 and 82.50 mg/g of soluble myofibrillar proteins for unfrozen slow and fast cooling muscles respectively. However, if the comparison of sarcomere length and myofibrillar protein solubility was made within a cooling regime (Table 2), irrespective of freeze state, the earlier assumption was supported.

Pre-rigor freezing lowered water holding capacity, sarcomere length and the amount of soluble myofibrillar proteins in both slow and fast cooling muscle samples. The ultimate pH value was lowered by freezing only in the case of the slow cooling samples. From the data for sarcomere length and the solubility of muscle protein fractions it may be concluded that the relationship between them may not be the same at the end of rigor mortis as after ageing.

It is concluded, therefore, that during rigor, slow-cooling (deep) and fast-cooling (surface) ovine muscles do not show significant variation in protein quality and associated properties. Difference in chilling rates amongst the deep and surface muscles may well be important in determining quality, and this is an area of useful study.

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