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This Week's Citation Classic

Locker R H & Hagyard C J. A cold shortening effect in beef muscles.
J. Sci. Food Agr. **14**:787-93, 1963.
[Meat Industry Res. Inst. of New Zealand (Inc.), Hamilton, New Zealand]

Isolated fresh beef muscles shorten more at 2°C than at 37°C. Minimum shortening occurs at 14-19°C. At higher temperatures, shortening coincides with the onset of rigor mortis, but at low temperatures it begins rapidly and shortening is reversible. Rabbit muscles do not show this effect. [This paper has been cited in over 125 publications since 1963. Based on *SCI*® data for 1961-82 it proved to be the fourth most-cited paper ever published in this journal.]

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"This paper has been often cited because it marked the beginning of recognition that the contribution of muscle fibers to toughness in meat can be greatly increased by misuse of the modern refrigerating plant, even to the point where it may overshadow the contribution of connective tissue.

"Conventional wisdom, based on rabbit muscle, claimed that during the onset of rigor mortis, muscles shorten more the higher the holding temperature. However, my attempt to use this result for a quite irrelevant purpose repeatedly produced maximal contraction in beef muscles at 0°-2°C. Since shortening began with cooling and was reversible, the effect was clearly distinct from rigor shortening.

"I published nervously, doubting that such a readily observable result could be new. At the time, these primitive experiments, done with that least sophisticated of instruments, the ruler, did not seem to me of any great moment. Yet the 'cold shortening' effect did become highly significant for meat science when read in conjunction with my earlier finding that toughness in meat increases with muscular contraction.[1] The link with practice was forged because by sheer good luck these findings emerged as a problem of severe toughening threatened New Zealand's vital exports of frozen lamb (1961). This was the first challenge to the newly formed Meat Industry Research Institute of New Zealand. It quickly became clear that the toughening was due to an advance in freezing technology, from old convection freezers to new blast freezers. My colleagues, particularly B.B. Marsh and C.L. Davey, lost no time in establishing the link with cold shortening, and the previously known 'thaw shortening' effect, and in finding solutions.[2,3]

"The end result was a swing of attention in centers of meat research from connective tissue, which had dominated studies on meat tenderness, to the contribution of the myofibril and the relationship between state of contraction and cold. The time was opportune because of contemporary advances in knowledge of the fine structure and functioning of the myofibril. This new emphasis on the myofibril has continued to the present and has finally led to a new structural basis for meat tenderness in terms of a neglected set of myofilaments: the 'gap filaments.'[4]

"The search for a cheap, effective, and convenient way of avoiding cold shortening has led to perhaps the greatest technical advance in meat technology of recent times. A technician at this institute, W.A. Carse, had the inspiration of reviving a disused US patent of 1951. This involves brief electrical stimulation of a carcass to greatly accelerate the rigor process. The carcass can be sent into rigor mortis within an hour or two of death, and rendered immune to a shortening stimulus. The technique has spread rapidly around the world. It has been much refined and widely applied to both lamb and beef, with improvement to tenderness, grading, etc.[2,3] It may ultimately change the shape of the meat industry, since, for the first time, the benefits of cutting and packing hot meat on the line now seem an attainable goal."

1. **Locker R H.** Degree of muscular contraction as a factor in tenderness of beef. *Food Res.* **25**:304-7, 1960.
2. **Locker R H, Davey C L, Nottingham P M, Haugbey D P & Law N H.** New concepts in meat processing. *Advan. Food Res.* **21**:157-222, 1975.
3. **Locker R H.** Cold induced toughening in meat. (Pearson A M & Dutson T R, eds.) *Advances in meat science. 1. Electrical stimulation.* Westport, CT: AVI Publishers. In press, 1983.
4. ----------. A new basis for meat tenderness in terms of gap filaments. *Proceedings of the 28th Congress of European Meat Research Workers, Madrid, Spain, 1982.* Madrid: Instituto del Frio, 1982. p. 117-20.