

Calcium Injection

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It has recently been reported that inconsistency in meat tenderness is a major quality defect in our current beef production systems (Morgan et al., 1991b). A major part of this concern is the large variation in tenderness, especially the occurrence of tough meat, in beef and beef cuts classified by the grading system as being tender (i.e. Choice). USDA quality grades were designed to segment beef carcasses based on various levels of expected meat palatability. However, the goal of the beef industry should be to produce 100% desirable meat, and not have to identify meat that has unacceptable tenderness to consumers.

Experiments involving the role of the calpain proteolytic system in post-mortem tenderization (Koochmaraie et al., 1988a) led to the discovery that elevating the calcium concentration of muscle by infusing calcium chloride immediately post-mortem would result in maximizing tenderization by 24 h post-mortem (Koochmaraie et al., 1988b, 1989, 1990). The initial work involved infusing lamb carcasses immediately post-mortem with 300 mM CaCl_2 at 10% of live weight. The utility of this process for improving meat tenderness was demonstrated in specific situations where tough meat was expected: Brahman crossbred steers (Koochmaraie et al., 1990), β -adrenergic agonist-fed sheep (Koochmaraie and Shackelford, 1991), and 12 to 17-yr old cows (Morgan et al., 1991b). Wheeler et al. (1991) have extended this work by demonstrating that the use of calcium chloride in combination with hot-boning will improve tenderness of round muscles from *Bos indicus* cattle. This early work had clearly shown that 300 mM CaCl_2 infused or injected at 10% by weight into prerigor meat results in accelerated and accentuated tenderization, such that all tenderization had occurred by 24 h post-mortem.

It was recognized that this process had potential for commercial application to ensure desirable tenderness in the beef industry. Subsequent studies were designed to modify the process for industry application. Carcass infusion of calcium chloride is too time-consuming and would likely create problems for USDA inspection and grading procedures. Prerigor injection of calcium chloride in meat could be used in conjunction with hot-boning or in intact carcasses, but would be difficult to implement in normal slaughtering procedures. Morgan et al. (1991a) indicated that the average length of post-mortem aging before meat becomes available in a retail store

is 17 days post-mortem and the estimated earliest time that consumers would buy and prepare the product would be 7 days post-mortem. Therefore, studies designed to develop a calcium chloride injection protocol that would facilitate industry use of the process were conducted to test the efficacy of injection at 24 h post-mortem and measuring palatability and other meat quality traits at 7 days post-mortem. Wheeler et al. (1992) demonstrated that calcium chloride injection at 24 h post-mortem, followed by 7 days aging resulted in tenderization similar to prerigor injection followed by 1 day aging (Figure 1). This effect also can be accomplished with a lower calcium level (200 mM at 5% by weight) compared to 300 mM CaCl_2 at 10% used in the early work (Figure 2; Wheeler et al., 1993). This work also showed that not only was the tenderness level improved, but the variation in tenderness was reduced. In addition, retail lean color, flavor desirability and microbial quality are not affected by the injection process (Cook et al., 1993; Lansdell et al., 1993; Wheeler et al., 1993). The injection process has been tested under industry conditions in a commercial beef processing plant (Lansdell et al., 1993) and the injected product evaluated by consumers in a white tablecloth restaurant setting (Cook et al., 1993). This test indicated that the process can be applied in the industry and that consumers perceived the injected loin steaks to be more tender and desirable in flavor with no effect on juiciness (Table 1).

This reciprocation session gave you, the audience, a chance to compare calcium-injected steak to controls. We demonstrated that commercial injection equipment can be used to inject subprimals using a similar process to that for injecting cure into pork products. Cuts are injected up to 5% by weight with a 200 mM CaCl_2 solution made by dissolving food grade calcium chloride in water. No off-flavor problems have been detected in taste panel or consumer work using 200 mM CaCl_2 . On the average, about 3.5% of the weight increase is retained through the packaging and aging process, so a slightly higher than normal purge is expected. The cost of the calcium chloride injection materials and labor would probably be paid for by the increased weight of the product. The USDA regulations allow for fresh meat to be injected up to 5% of weight with a solution containing approved ingredients (including CaCl_2) for the purpose of improving tenderness and juiciness. This addition would have to be declared on the label. A sample label was shown. A label acceptance survey with 600 consumers will be conducted this summer in a retail supermarket. The product will be displayed in the retail case and will judge consumer response to a label containing the statement: "Up to 5% of a calcium chloride solution added to improve tenderness." Use of this product in the food service area would not require labeling and could be the easiest route for initial commercialization.

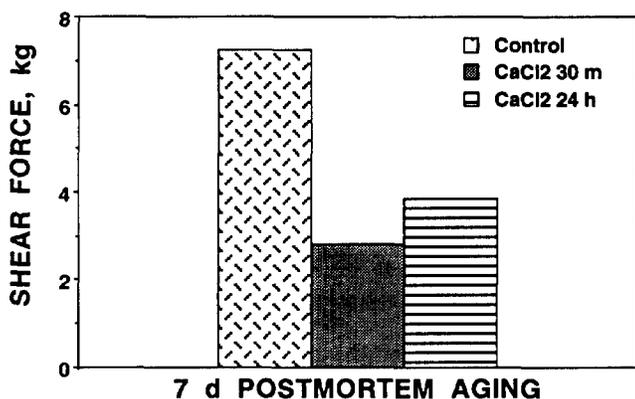
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Figure 1. Comparison of Prerigor vs Postrigor Injection of Calcium Chloride in Beef Longissimus Muscle.



From Wheeler et al. (1992)

Table 1. Effect of Commercial Application of Postrigor Calcium Chloride Injection on Shear Force and Consumer Evaluations of Beef.^a

	Control	CaCl ₂
Shear Force, d 7	6.40 ^b	4.84 ^c
Consumer Ratings		
Tenderness	5.1 ^c	5.5 ^b
Juiciness	5.7	5.8
Flavor Desirability	5.6 ^c	5.9 ^b

^aFrom Cook et al. (1993) and Lansdell et al. (1993).

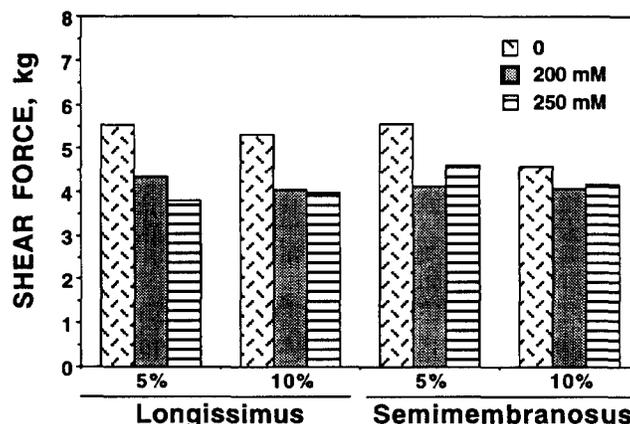
^{b,c}Means in a row lacking a common superscript differ ($P < .05$).

Evaluation of the data from several recent studies has indicated that the variation in tenderness is reduced by about 30%, thus the calcium-injected product is more uniform in tenderness. Regarding the question of effect on already tender meat or meat from tender muscles (such as psoas major), the results indicate that there would be no additional tenderization effect. The meat also does not become overtenderized and mushy because the calpains once activated by the calcium not only degrade muscle proteins but also themselves; thus, it is a self-limiting process unlike the uncontrolled degradation such as occurred with papain.

The results of the reciprocation participant's sensory evaluation of broiled steaks from control and calcium chloride-injected semimembranosus muscle are presented in Table 2. A total of 106 evaluations were completed in the three sessions. The results demonstrated that the participants detected an improvement in tenderness in the calcium-injected muscles, but perceived no differences in either flavor or juiciness.

The session conclusion was that the results to date indicate that the current calcium chloride injection procedure may have considerable commercial application. Several skeptical

Figure 2. Effect of Injection Level and Concentration of Calcium Chloride on Shear Force of Postrigor Injected Beef Aged 7 d.



From Wheeler et al. (1993)

Table 2. Reciprocation Participants' Evaluation of Calcium Chloride-Injected Beef.^{a,b}

Treatment	Sensory Traits ^c		
	Tenderness	Juiciness	Flavor Desirability
Control	4.20 ± .13 ^e	5.40 ± .10	5.40 ± .12
CaCl ₂ ^d	5.63 ± .13 ^f	5.61 ± .10	5.30 ± .12

^a106 evaluations.

^bSemimembranosus muscle.

^c1 = Extremely tough, dry or undesirable; 8 = Extremely tender, juicy or desirable.

^dInjected on d 1 post-mortem with 200 mM calcium chloride at 5% by weight and aged until 8 d post-mortem.

^{e,f}Means in a column lacking a common superscript differ ($P < .05$).

participants appeared to be convinced of its potential after tasting it themselves. Application of the process should be feasible for branded beef programs, the food service industry, for cow meat and possibly even retail beef.

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