EFFECT OF MECHANICAL TENDERISATION AND TUMBLING TIME ON THE PROCESSING CHARACTERISTICS AND TENDERNESS OF COOKED ROAST BEEF.

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Background

Most consumers judge quality and overall acceptability of beef products based on tenderness. Therefore, it is critical for the consumer acceptance of beef that a commercially applicable method be developed to ensure a consistently tender product. Beef round and chuck are traditionally marketed as low priced steaks or roasts and have been described as the most under-utilized wholesale cuts from the beef carcass. Treatments to improve tenderness of round muscles would add value to the whole carcass by enabling processors to market consistently tender products, increasing returns to processor and satisfying consumer demands. Mechanical treatment of meat tissue including tumbling or massaging is a well recognized and accepted technique in the meat industry. Both processes are commonly used to disintegrate external surfaces of meat pieces and to release myofibrillar proteins. Many reports have shown that mechanical tenderisation (e.g. blade tenderisation) significantly improves the tenderness of less tender cuts of meat and is one of the most effective and efficient technologies currently used to ensure tenderness (Mandigo and Olson, 1982; Loucks et al., 1984; Shackelford et al., 1989). Although injection technology followed by tumbling is now routinely used by the majority of pork processors to enhance and maintain the tenderness, juiciness and flavour of lean pork cuts it has not been adopted for widespread commercial use by the beef industry. There is little information is available on the effect of extended tumbling regimes on binding and textural characteristics of roast beef (Boles and Shand, 2002). The combination of mechanical tenderisation with the tumbling process may provide a useful means of improving both textural and water binding properties.

Objective

The objective of this study was to determine the combined effects of blade tenderisation, tumbling time and injection level on the chemical, binding and textural properties of precooked roasts made from beef round muscles.

Methods

Post-rigor beef inside rounds were used for this study. The *gracilus* and *adductor* muscles were removed, and *semimembranosus* muscles were trimmed of all visible fat and connective tissue. Each *semimembranosus* muscle was cut into six small roasts (700 g). The major variables investigated were tenderisation (T and NT), tumbling time (0, 2 and 16 h) and injection (20 and 40%). The roasts designated for tenderisation were blade tenderised, and then all roasts were injected to 120 or 140% over the raw meat weight with brine formulated to give 1.8% sodium chloride and 0.3% sodium tripolyphosphate in the final product. After injection the non tumbled treatments were placed directly into Cry-O-Vac CN 510 cook bags, while the roasts designated for tumbling were vacuum packaged into polyethylene bags and intermittently (20 min. on, 10 min. off) tumbled (8.5 rpm) for either 2 or 16 h at 4-6°C. The roasts were then water cooked (approx. 150 min.) in an air-agitated waterbath at 75°C to a final internal temperature of 72°C. The variables measured on each roast included: cook yield (% of green weight), expressible moisture (EM) and purge during storage of vacuum packaged slices. Warner Bratzler shear force (WBS) of 1.27x1.27x2.54cm core samples sheared perpendicular to the fibre direction was determined. Instrumental texture profile analysis (TPA) was performed on six samples per roast using a TMS-90 texture system. Data were analysed as a 2x3 factorial treatment design with tenderisation (T, NT) and tumbling time (0, 2, 16 h) as main factors. All treatments were applied to a single cut so that cut was considered a replicate (6 cuts were used for each injection level). Injection levels were analysed separately. Least significant differences ($p<0.05$) were used to identify differences among treatment means.

Results and discussion

Effect of tumbling regime on processing characteristics and texture of cooked roast beef

Increasing tumbling time up to 16 h markedly improved ($p<0.05$) cooking yield of the roasts that were injected 120% above original weight, but did not have a significant effect on yield of roasts processed to a 140% pump level (Table 1). Regardless of the injection level, tumbling for 16 h resulted in lower storage losses than the samples non tumbled or tumbled only 2 h. Extending tumbling time to 16 h also significantly decreased the percentage of water loss from meat samples after centrifugation, indicating that the longer tumbling improved water retention of beef roasts. Tumbling for 2 h generally did not improve hydration properties of roasts. For roasts injected 20%, there was a slight reduction in purge but no difference in cook yield and EM compared to non tumbled controls. It was observed that the storage losses from roasts injected 140% above original weight and tumbled 2 h were even higher than those from non tumbled roasts. This may be due to the higher moisture content and thus more free moisture in the roasts tumbled for 2 h.

The tumbling regime had a greater effect on textural parameters when roasts were injected 140% than when roasts were injected 120% above original weight (Table 2). Shear force was substantially reduced with increased tumbling time. Furthermore, variability among samples was also decreased as a result of longer tumbling time. Roasts tumbled for 16 h, both tenderised (T) and NT exhibited lower hardness and chewiness than those non tumbled or to which tumbling was applied for 2 h. Longer tumbling time also resulted in a decrease of their cohesiveness and led to the formation of softer but more brittle roasts (data not shown).

The effect of tumbling time on processing properties shown in our study was consistent with other published reports in which extended tumbling time has been described as a factor that improves the water binding characteristics of massaged/tumbled and cooked meats. Generally, increasing the tumbling time improved the hydration properties of roasts, resulting in improved water holding capacity and significantly lower cooking and purge losses.

Effect of mechanical tenderization on processing characteristics and texture of cooked roast beef

No significant effect on cook yield and EM was reported due to blade tenderising of the meat prior to injection. However, for both injection levels, trends for increased yield were seen when muscles were tenderised ($p=0.06$ and $p=0.07$, for 120% and 140% respectively). Regardless of the injection level, the mechanical tenderisation of the beef muscles significantly ($p<0.05$) decreased moisture losses after 3 wk storage. In all treatments more moisture was retained in samples tenderised as compared to those without mechanical treatment.

Mechanical tenderisation had significant effects on tenderness and some of the measured textural characteristics of the roasts. Application of blade tenderisation prior to injection substantially decreased shear force, TPA hardness and TPA chewiness of beef samples. Mechanical tenderisation also resulted in a substantial reduction of variation in the tenderness among the roast samples. In addition for shear values, a significant interaction between tumbling time and tenderisation effect occurred (Table 2). The presence of significant interactive effects indicates that the influence exerted on shear force by tenderisation was affected by time of tumbling. In fact, tenderisation resulted in decrease in shear force only in roasts produced without tumbling or tumbled 2 h, while its effects was insignificant for roasts tumbled for 16 h. Our results support a number of previous findings, which indicated that blade tenderisation of tougher cuts such as round muscles could greatly enhance tenderness (Mandigo and Olson, 1982; Loucks et al., 1984; Shackelford et al., 1989). So it seems that the cutting action of the mechanical tenderiser causes sufficient disruption of the muscle fibers and connective tissue to make the roasts tender. Also our results indicate that the effect of tenderisation was dependent on tumbling time. Tenderisation improved beef texture only for non tumbled or tumbled for 2 hours but was not able to significantly decrease shear force of roasts tumbled for 16 h. This suggests that blade tenderisation may not be necessary to ensure more tender meat when extended tumbling is applied, but would be beneficial when little or no tumbling is applied. It was observed that the significant improvement of shear values of roasts injected to 120% due to tenderisation had already been achieved after 2 h tumbling. This was not seen when roasts were injected to 140% for which significant reduction in shear force had been recorded only after 16 h tumbling. The longer tumbling time combined with the tenderisation however had beneficial effects on water holding and moisture retention. This combination likely facilitated the extraction and solubilization of myofibrillar proteins due to the increased surface area for extraction and may have allowed more moisture to be bound by the protein, thus increasing the cooking yield and assuring better binding and textural properties.

Conclusions

Extended tumbling (to 16 h) favourably affected hydration properties and thermal stability, yielding lower cooking loss and purge and higher WHC for beef roasts. It also decreased shear force and hardness of beef samples by 50-60%, but was unable to improve springiness or cohesiveness. Mechanical tenderisation prior to injection generally was found to be beneficial for textural characteristics, tended to improve cook yield, but did not influence other hydration properties. An interaction between tenderisation and tumbling was observed for shear force. Blade tenderisation decreased shear values by 15-20% for roasts tumbled for 0 or 2 h, but did not improve tenderness with extended tumbling.

Pertinent literature

Boles, J.A., Shand, P.J. 2002. Tumbling regime effects on the processing characteristics and tenderness of cooked roast beef. *Journal of Muscle Foods*, In press.

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Table 1. Effect of tenderisation and tumbling time on the processing characteristics of cooked roast beef.

	Injection level, %							
	20				40			
	Cooking yield [%]	EM [%]	pH	Purge [%]	Cooking yield [%]	EM [%]	pH	Purge [%]
Tumbling time, h								
0	104.60b	20.41a	5.95	6.81a	101.53	24.19ab	5.89	7.39b
2	105.75b	19.32a	5.95	5.96b	103.23	25.19a	5.90	8.02a
16	112.12a	15.37b	5.99	5.21c	107.79	22.75b	5.93	6.96b
Tenderisation								
NT	106.40	18.67	5.97	6.27a	101.38	24.64	5.89	7.86a
T	108.58	18.06	5.96	5.72b	106.99	23.45	5.93	7.06b

a-c, Means in the same column with different letters are significantly different ($p<0.05$)

Table 2. Interaction of tenderisation and tumbling time for WBS force [N].

		Injection level, %	
		20	40
Tenderisation	Tumbling time, h		
NT	0	57.10a	64.70a
	2	51.15b	55.92b
	16	39.58c	39.12cd
T	0	48.66b	43.06c
	2	40.57c	45.25c
	16	38.13c	32.53d

a-d, Means in the same column with different letters are significantly different ($p<0.05$)