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Title: THE EFFECT OF HOT-BONING AND PRE-RIGOR PRESSURIZATION OF BONELESS BEEF CUTS ON YIELD OF TRIMMED RETAIL CUTS AND OTHER FACTORS OF ECONOMIC IMPORTANCE

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Abstract approved: Dr. Walter H. Kennick

One randomly selected side from each of ten beef carcasses was hot-boned and subjected to hydrostatic pressurization (103.5 MNm^{-2}) for 2 minutes, whereas the corresponding control sides were cold-boned at 48 hours. Twelve wholesale beef cuts were removed from each side. Parameters measured included boning yields, purge loss, wholesale cut yields and trimmed retail cut yields.

No significant differences were found in the yield of bone, fat, or lean trim between the hot- and cold-boned sides, nor was there any difference in purge loss between the twelve control and pre-rigor pressurized (PRP) wholesale cuts ($P>.05$). There was a higher ($P<.05$) yield in total wholesale cuts with the PRP-treated sides. There was some noticable distortion in three of the five major PRP-treated wholesale cuts processed into steaks, thereby reducing their trimmed retail yield. Overall, there was no significant difference ($P>.05$) in total

trimmed retail yield between the conventional (control) and the hot-boned, PRP sides.

The Effect of Hot boning and Pre-rigor Pressurization of Boneless Beef Cuts on Yield of Trimmed Retail Cuts and Other Factors of Economic Importance

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CONTRIBUTION OF AUTHORS

Michael S. Schumann	Senior author 1) carried out thorough literature review, 2) responsible for the design and implementation of the experiment, 3) worked out the details in the cutting procedures by running some preliminary tests, 4) carried out the hot boning, pressure treatments, and retail trimming, 5) collected and analyzed all data.
Dr. W.H. Kennick	Major professor 1) major consultant in the design and implementation of the experiment, 2) assisted in the vacuum packaging and pressure treatments, 3) consultant in the analysis of results.
Dennis F. Rock	Research assistant-unclassified 1) responsible for the slaughter of all animals used in this experiment 2) major consultant in carcass characteristic evaluations.

THE EFFECT OF HOT BONING AND PRE-RIGOR PRESSURIZATION OF BONELESS BEEF CUTS ON YIELD OF TRIMMED RETAIL CUTS AND OTHER FACTORS OF ECONOMIC IMPORTANCE

INTRODUCTION

With the increasing demand for efficient energy use, the meat industry, being quite energy intensive in both production and processing, needs to design and implement new methods of producing and processing low-cost, high quality beef.

Interest in forage-fed beef has increased greatly in recent years due to the world wide demand for grain as a human food. Overall palatability, especially tenderness, is markedly lower in forage-fed beef as compared to grain-fed beef (Bowling et al., 1977; Williams et al., 1979; Schroeder et al., 1980). Thus, new methods for processing beef must consider the conservation of energy and the maintenance of high quality, tender meat.

The hot processing (hot boning) of beef has been shown to have many potential economic advantages. The removal of fat before chilling results in substantial savings in refrigeration and shipping costs (Henrickson, 1975; Kastner, 1977). Hot boning improves cutting yields (Schmidt and Keman, 1974; Taylor et al., 1981) and drip loss (Taylor et al., 1981). Cross and Tennant (1980) reported that boning time has an important effect on the percent weight loss during storage. As postmortem boning time increased, percent weight loss increased significantly. Many investigators have reported the need for various conditioning periods to alleviate tenderness problems due to pre-rigor boning and possibly cold shortening (Schmidt and Gilbert, 1970; Kastner et al., 1973; Follett et al., 1974; Schmidt and Keman, 1974; Falk et al., 1975; Kastner and Russell, 1975; Kastner, 1977).

Hydrostatic pressurization of pre-rigor muscle, which requires the use of hot boning, has been shown to significantly improve tenderness without a conditioning period (MacFarlane, 1973; Bouton et al., 1977; Elgasim, 1977; Kennick et al., 1980). Kennick et al. (1980) reported that pre-rigor pressurized (PRP) muscle (1) produced very firm meat in muscles which had contracted to as little as 48% of their on-carcass length, 2) produced significantly lower water holding capacity (WHC), as mechanically measured, and 3) produced lower cooking losses but an overall loss which was not different between the PRP-treated and control samples. Elgasim and Kennick (1980) have shown that pre-rigor pressurization does not affect the apparent biological value (BV) or the net protein utilization (NPU) of meat, but does improve protein digestibility.

All of the above PRP researchers have utilized only small single muscles. No one has reported on the effects of PRP with larger commercial wholesale cuts of meat. The objectives of this study were to determine if (1) PRP affects large beef muscle masses in the same way it does smaller single muscles; 2) PRP distorts large boneless wholesale cuts, which may be multi-muscled, to the extent that cutting procedures are difficult; 3) the heavily contracted muscles cause a massive drip loss; 4) there is a difference in the yield of trimmed retail cuts between PRP and conventionally processed beef.

EXPERIMENTAL

Carcass fabrication

Ten head of Good to Choice cattle (406-620 kg live wt) were conventionally slaughtered at the Oregon State University Clark Meat Science Laboratory. Immediately after slaughter each side was weighed and then randomly selected as a control or pre-rigor pressurized (PRP) side. Twelve major wholesale cuts (Table 3) were removed from the PRP sides (hot-boned within 1 hr of slaughter), vacuum packaged (Cry-O-Vac Model 8200) and placed in a water bath (38°C). When enough samples were collected to fill the pressure chamber, they were removed from the water bath, placed in the chamber and pressure treated. After treatment the bags were heat-shrunk (∿93°C) and placed in a cooler for 10 days (1.0±1°C).

The control sides were removed from the cooler at 48 hrs, carcass data were taken, they were cold-boned and the twelve major wholesale cuts were vacuum packaged. The bags were then heat-shrunk and returned to the cooler (1.0±1°C) for 8 days to await purge and yield studies.

Pressure Treatment

The treatment consisted of placing the samples in a preheated (35°C) water-filled pressure chamber (30.48 cm in diameter and 60.96 cm long) and then applying 103.5 MNm^{-2} (15,000 lb/in^2) for 2 min.

Purge Study

At 10 days postmortem, both the Control and PRP samples were removed from the cooler. Purge (weep) was determined by weighing the packaged samples, removing the samples, blotting them of excess moisture and weighing. All packaging material for each sample was air-dried and weighed. The difference between the weight of the blotted sample plus the dried packaging material and that of the packaged sample was considered purge. This was expressed as a percentage of the initial wholesale weight.

Boning Yield Study

Eight head of cattle were used for this study. Carcass boning yields were determined by weighing the boneless wholesale cuts, bones, fat and lean trim after hot and cold boning. Lean trim was standardized to 30% fat after a fat analysis using a version of the modified Babcock method outlined by Kelley et al. (1954). Adjustments were then made to the fat and lean trim weights.

Retail Yield Study

Each of the five major wholesale cuts that are normally fabricated into steaks, top sirloin, ribeye, New York strip, tenderloin and top (inside) round were cut into 1-inch steaks. The other seven wholesale cuts were fabricated into roasts. The difference between the initial wholesale weight and the final retail weight was the retail yield.

Statistical Analysis

Data were analyzed by the paired t-test to determine significance of difference between the control and PRP samples (Rowe et al., 1978).

RESULTS AND DISCUSSION

Comparison of hot and cold boning yields are given in Table 1. The mean yield of total wholesale cuts was significantly higher in the hot-boned sides (44.46 kg) as compared to the cold-boned sides (42.67 kg). Mean yields for initial lean trim and initial fat weights were not significantly ($P<.05$) different between hot- and cold-boned sides. Two groups of investigators have reported higher yields in total usable meat with hot-boned beef sides (Schmidt and Keman, 1974; Taylor et al., 1981). These investigators had combined the values for the wholesale (or retail) cuts and the lean trim because of the difficulty in accounting for the boning and trimming variation between the hot and cold boning procedures.

Because of the substantial difference in value between boneless wholesale cuts and lean trim, they were weighed and reported separately. All lean trim was standardized to 30% fat, with the appropriate adjustments made in the weight of lean trim and fat. This allows for a valid comparison of the yield of boneless wholesale cuts, lean trim, fat trim, and bones.

With the fat adjustments, there were still no differences ($P>.05$) in the lean trim, fat, and bone weights between the hot- and cold-boned sides (Table 1). This is in agreement with Schmidt and Keman (1974) who reported no significant difference in fat and bone weights, however, Taylor et al. (1981) found a highly significant ($P<.01$) difference between the fat trim and bone weights. Taylor and his co-workers felt the difference in bone weights was probably caused by the less efficient removal of meat from the hot-boned carcasses. We found that efficient boning of some wholesale cuts was more difficult with the hot boning procedure, although it was much less difficult with others. Overall, total bone weights suggest that these boning differences balanced themselves out.

Wholesale and retail cut yields of ten PRP and ten control sides are shown in Table 2. Total wholesale cuts (as a percentage of hot carcass weight) were higher ($P<.05$) for the PRP sides while there was no difference ($P<.05$) between control and PRP-treated sides for total retail cuts (as a percentage of hot carcass weight). Total retail cuts (as a percentage of wholesale cut weight) shown a highly significant difference between control and PRP-treated, with the control sides having the higher yield. These results suggest that while the PRP-treated sides may yield more total wholesale meat, there is no overall difference in total salable retail meat when expressed as a percentage of hot carcass weight. This was a result of the lower ($P<.01$) retail cutting yield of three of the wholesale cuts from the PRP sides (total retail cuts as a percentage of wholesale cut weight).

There was no difference in percent purge loss between the PRP-treated and the control boneless wholesale cuts (Table 3). Overall, the mean percent purge loss for the control and PRP boneless wholesale cuts was 1.50% and 1.52%, respectively. These data differ from that of other investigators who found a significantly higher purge (weep) loss for the PRP samples of single muscles (MacFarlane, 1973; Kennick et al., 1980).

Table 4 shows the comparison in the processing yields of the five major boneless wholesale cuts when processed into retail steaks. While there was no significant difference in the retail yield of the tenderloin and top (inside) round, there was a higher ($p<.05$) yield from the control strip loin and an increased ($P<.01$) yield in the control ribeye and top sirloin. The favorable results for the PRP samples in the tenderloin and top (inside) round are due to the shortening and thickening of the thin ends of these wholesale cuts, thus allowing for greater utilization of the cut. Due to the multi-layered muscles of the top sirloin, the PRP sample had considerable distortion and shifting of these muscles, thus requiring considerably more trimming at both ends. The PRP strip loin and ribeye had some noticable distortion at the ends. The other seven wholesale cuts were fabricated into roasts and had essentially 100% retail yields.

CONCLUSION

Pre-rigor pressurization apparently affects large multi-muscled wholesale cuts in the same way as has been reported by other researchers on small single muscles (MacFarlane, 1973; Bouton et al., 1977b, Kennick et al., 1980). There was a very noticeable shortening and thickening of all the cuts utilized in this experiment. Kennick et al. (1980) reported that pressurization of pre-rigor muscle had supercontracted to as little as 48% of its on-carcass length and was very firm. The PRP meat in this study was quite firm and very easy to process into steaks.

There were no significant differences in the amount of purge or drip losses for the 12 boneless wholesale cuts. This disagrees with the contention by Marsh (1977) that for large muscle samples, supercontraction should result in massive drip loss.

PRP of boneless wholesale cuts does have a negative effect on the yield of trimmed retail cuts. Three of the five PRP wholesale cuts processed into steaks gave lower yields of trimmed retail cuts than the controls. This was largely due to the distortion of the wholesale cut when pressure treated.

Overall, nine of the twelve major PRP wholesale cuts were of a highly acceptable nature and were very recognizable. Possible methods to alleviate the cutting problems with the ribeye, strip loin and top sirloin may be in the use of packaging material that can hold or mold the ends of the cut into an acceptable shape. The values for total trimmed retail cuts and total lean trim indicate that the combination of hot boning and pre-rigor pressurization compare very favorably with the conventional methods of processing beef carcasses in the yield of total usable meat.

Table 1 - Composition and yield of hot- and cold-boned beef sides.[a]

	Means			
	Cold-boned side (kg)	Hot-boned side (kg)	Standard error[b]	Significance of difference
Hot carcass side wt	150.53	150.38	0.92	NS
Cooler shrink (%)	2.02	0.00		
Total wholesale cuts	42.67	44.46	0.71	*
Lean trim[c]	59.48	60.23	1.25	NS
Lean trim[d]	59.10	57.71	0.84	NS
Bones	22.48	22.79	0.57	NS
Fat[c]	21.64	19.80	1.06	NS
Fat[d]	22.02	22.32	0.96	NS

[a] n = 8

[b] standard error of the difference between 2 means

[c] weight of lean trim or fat as produced

[d] weight of lean trim or fat as adjusted to 30% fat content in lean trim

NS no significant difference

* significant ($P<.05$)

Table 2 - Comparison of wholesale and retail cut yields from hot-boned, pre-rigor pressurized (PRP) and conventional cutting procedures.[a]

	Means			
	Control	PRP-treated	Standard error[b]	Significance of difference
Total wholesale cuts (kg)	42.29	44.14	0.64	*
Total wholesale cuts as % of hot carcass wt	29.04	30.21	0.48	*
Total retail cuts (kg)	41.10	42.06	0.57	NS
Total retail cuts as % of hot carcass wt	28.21	28.79	0.45	NS
Total retail cuts as % of wholesale cut wt	97.17	95.30	0.38	**

[a]N = 10

[b]standard error of the difference between 2 means

NS no significant difference

* significant ($P<.05$)

** highly significant ($P<.01$)

Table 3 - Percent purge of pre-rigor pressurization (PRP) and control boneless wholesale beef cuts.[a]

Boneless cuts	Means: Control	Means: PRP-treated	Standard error[b]	Significance of difference
Inside chuck roll	1.38	1.70	0.36	NS
Arm chuck	0.93	1.17	0.13	NS
Shoulder clod	1.51	2.17	0.61	NS
Mock tender	3.37	2.09	0.72	NS
Ribeye	1.40	2.00	0.37	NS
Strip loin	1.97	1.99	0.32	NS
Tenderloin	3.68	3.87	0.88	NS
Top sirloin	1.40	1.05	0.22	NS
Sirloin tip	1.50	1.70	0.44	NS
Top (inside) round	1.32	1.10	0.11	NS
Bottom round	1.37	1.02	0.18	NS
Eye of round	1.50	0.73	0.43	NS
Overall wholesale cuts	1.50	1.52	0.08	NS

[a] n = 10

[b] standard error of the difference between 2 means

NS no significant difference between control and PRP-treated boneless wholesale cuts.

Table 4 - Comparison of processing yields from the five major wholesale cuts from control and pre-rigor pressurized (PRP) samples processed into steaks.[a]

Boneless Wholesale Cut	Mean yield[b] Control	PRP-treated	Standard error[c]	Significance of difference
Ribeye	99.41	95.99	0.64	**
Strip loin	96.79	90.14	2.08	*
Tenderloin	94.97	97.65	1.37	NS
Top sirloin	95.26	78.85	2.56	**
Top (inside) round	90.87	92.78	1.06	NS

[a] n = 10

[b] expressed as a percent

[c] standard error of the difference between 2 means

NS no significant difference

* significant (P<.05)

** highly significant (P<.01)

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APPENDIX

Table 5 - Carcass characteristics of the 10 animals used in the determination of trimmed retail yields from hot-boned, pre-rigor pressurized (PRP) beef.

Animal no.	Quality Grade	Yield Grade	Marbling Score	Ribeye area[a]	Maturity	Backfat thickness[b]	Kidney fat[c]
1	lo choice	2.8	small	11.3	A-	0.5	2.0
2	lo choice	2.6	small +	12.8	A-	0.5	2.5
3	hi good	2.3	slight +	10.4	A-	0.3	2.5
4	lo choice	3.2	small +	14.4	A-	0.7	2.5
5	lo choice	3.4	small -	11.9	A-	0.5	2.0
6	hi good	2.8	slight +	11.3	A-	0.4	2.0
7	lo choice	2.8	small +	10.7	A-	0.4	2.0
8	lo choice	2.8	small +	13.8	A-	0.4	2.5
9	choice	3.1	modest -	13.5	A-	0.4	3.0
10	choice	2.4	modest	10.5	A-	0.3	2.5
Average	lo choice	2.8	small	12.1	A-	0.44	2.4
Range	hi good → choice	2.3 → 3.4	slight + → modest	10.4 → 14.4	A-	0.3 → 0.7	2.0 → 3.0

[a] expressed in square inches
[b] expressed as tenths of an inch
[c] expressed as percent

Table 6 - Dressing percent and chill shrink of the 10 animals used in the determination of trimmed retail yield from hot-boned, pre-rigor pressurized (PRP) beef.

Animal number	Live weight (kg)	Hot weight (kg)	Dressing percent	Percent chill shrink
1	445.89	263.89	59.00	1.73
2	450.88	264.45	58.65	2.07
3	405.97	237.69	58.55	2.27
4	500.77	313.80	62.66	2.32
5	584.24	343.83	58.85	2.14
6	449.06	266.94	59.44	2.24
7	464.00	275.18	59.31	2.07
8	619.62	376.03	60.69	1.68
9	557.93	340.20	60.98	1.86
10	414.59	253.56	61.16	1.79
Average	489.30	293.48	59.93	2.02
Range	∿406 → 620	∿238 → 376	59 → 63	1.7 → 2.3

Fat Content Analysis: A version of the modified Babcock method

The materials and methods used to determine the fat content in the lean trim for the study of the yield of trimmed retail cuts from hot-boned, pre-rigor pressurized meat is as follows:

1. The meat to be tested was ground three times through a very fine plate (1/8").

2. Nine grams of the sample meat was placed in a Paley cheese test bottle (50%).

3. Ten ml hot water added (80°-90°C).

4. Mixed thoroughly.

5. 17.5 ml of sulfuric acid added. This was added slowly in small quantities and the bottles were shaken after each addition of acid.

6. When all acid added, bottle shaken until all lumps disappeared.

7. Bottles transferred to heated centrifuge (70°C). Counter balanced and whirled 5 min.

8. Bottles filled to above neck with hot water, (80°-90°C) and centrifuged 2 min.

9. Hot water (80°-90°C) added until liquid column approaches top graduation of scale (between 45 and 50), and centrifuge 1 min longer.

10. Temperature adjusted by immersion of bottles in hot water bath (70°C) and left until fat column is in equilibrium and when fat surface has assumed its final form (approx. 3 min).

11. Bottles removed from bath, wiped, and with the aid of dividers, the fat column was measured in terms of percent by weight, from lower surface to highest point of upper meniscus. A drop of Red Glymol was added to assist measurement.

12. The fat column, at the time of measurement, should be translucent, of golden yellow or amber color and free from visible suspended particles.

Fat Content Adjustment

The adjustment in fat content of the lean trim was made by the following procedure:

(1) Determine the percent fat in the lean trim by a version of the modified Babcock method.

(2) Subtract the value of (1) from 100, this leaves the percent value of lean meat in the lean trim that was initially produced.

(3) Multiply the percent lean meat (2) times the amount of lean trim. This gives the weight of lean meat in the lean trim.

(4) Standardize the fat content to 30% fat by dividing the weight of lean meat in the lean trim by .70. This value is then the adjusted weight of lean trim.

(5) a. The difference between the adjusted value for lean trim and the amount of lean trim initially produced is b. added or subtracted from the initial fat weight, depending upon whether the fat content in the initial lean trim was above or below 30%. An example follows:

A.	Initial lean trim weight (kg)	=	40.10
B.	Initial fat weight (kg)	=	8.20
	Total		48.30

Steps:

(1) Percent fat = 32.0% (from fat analysis)
(2) 100.0 - 32.0 = 68.0%
(3) 40.10 x .68 = 27.27 kg
(4) 27.27 ÷ .70 = 38.96 kg (Adjusted lean trim weight)
(5) a. 40.10 - 38.96 = 1.14 kg (difference between A and 4)
    b. 1.14 + 8.20 = 9.34 kg (Adjusted fat weight)

Table 7 - Adjustment of fat content in control and pre-rigor pressurized (PRP) lean trim and fat.[a]

Animal number	FAT[b] (kg)		LEAN TRIM[b] (kg)		Fat Content[c] (%)		FAT[d] (kg)		LEAN TRIM[d] (kg)	
	Control	PRP	Control	PRP	Control	PRP	Control	PRP	Control	PRP
1	10.90	11.26	48.74	46.70	27.00	26.00	8.81	8.59	50.83	49.37
2	26.88	21.05	59.23	60.62	32.30	33.80	28.83	24.34	57.28	57.33
3	26.48	22.25	65.15	72.48	29.50	35.80	26.01	28.26	65.62	66.47
4	13.58	16.39	53.39	53.80	31.40	34.00	14.65	19.46	52.32	50.73
5	18.37	14.42	52.30	54.78	27.80	33.00	16.73	16.78	53.94	52.43
6	25.33	24.71	80.58	77.50	32.70	32.70	28.44	27.70	77.47	74.51
7	34.49	30.72	66.44	63.36	28.50	31.70	33.07	32.26	67.86	61.82
8	17.08	17.59	50.00	52.60	33.50	34.80	19.58	21.20	47.50	48.99
Mean Value	21.64	19.80	59.48	60.23	30.34	32.73	22.02	22.32	59.10	57.71

[a] n = 8

[b] weight of lean trim or fat as produced

[c] as measured by a version of the modified babcock method

[d] weight of lean trim or fat as adjusted to 30% fat content in lean trim