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Microbial Counts of Selected Hot-Boned Primals and Ground Beef

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ABSTRACT

Twenty-four dairy cows were slaughtered under commercial conditions, muscles were excised from one side within 3 h of slaughter and from the second side after 24 h chill at 3°C. Surface aerobic bacterial plate counts, ($APC_{5,\ 20,\ and\ 35°C}$, that is, plates were incubated at 5, 20 and 35°C, respectively) obtained from the rounds immediately before deboning did not vary significantly between the hot and chilled carcasses. The APC ($_{5,\ 20,\ and\ 35°C}$) increased ($P<.01$) during removal of rounds from both hot and chilled carcasses, and the magnitude of the increase was greater than one logarithm. The bacterial count on loins and rounds that were overwrapped and frozen generally was lower than on loins and rounds held at 3°C for 7 and 14 d before being frozen. The APC ($_{5,\ 20,\ and\ 35°C}$) of fresh ground beef fabricated in 450-kg batches from trimmings of hot cow carcasses were not significantly different from that made from the chilled carcasses. Addition of chilled USDA Choice plates to increase the fat content and lower the temperature of the manufactured ground beef increased ($P<.01$) APC counts in most instances. The log count of the USDA Choice plates was about 5 to 6/cm^2; whereas that of the cow beef was about 2 to 4/cm^2. The mean counts of coliforms, fecal coliforms and *Escherichia coli* were usually less than one log, so significant treatment differences, when they did occur, were unimportant. Results of this research indicate that hot boning does not adversely affect the microbial quality of selected primals and ground beef.

The many potential benefits of hot boning of beef have been described repeatedly *(1,4,6,7,8,9)*. Some of the early considerations in the evaluation of hot boning of beef included concern about palatability and microbiological quality. Research efforts directed toward improving palatability of hot boned beef continue, whereas studies by Schmidt and Gilbert *(13)*, Kastner et al. *(10)*, Kotula and Emswiler-Rose *(11)* and Lee et al. *(12)* had, for all practical purposes, laid to rest the fears that inordinate bacterial contamination occurs on hot boned beef. Cuthbertson *(2)* indicated that, although the total viable bacteria on hot boned beef were similar to cold boned beef at the beginning of vacuum packaged storage at 1°C, the counts were 1,000 times higher on hot boned beef than on the cold boned beef after 3 weeks. Further, Cuthbertson *(2)* indicated that the hot boned beef had a slightly higher incidence of those bacteria associated with hazards to health. Lee et al. *(12)* found no obvious pathogenic bacteria in 2,312 isolates obtained from hot boned beef. Since most of the reports differed from Cuthbertson's *(2)* in that he used dual purpose cattle, whereas the other authors used graded beef, the question still remained whether the microbial contamination of primals and ground meat from low grade hot boned cattle might be of potential concern. The purpose of our study was to evaluate, under commercial conditions, the effects of hot boning of USDA Cutter and Utility cows on spoilage bacteria and bacteria that serve as indicators of potentially pathogenic microorganisms.

MATERIALS AND METHODS

Twenty-four USDA Cutter and Utility cow carcasses were selected after slaughter in a commercial plant that slaughters about 1,200 cattle/d. After splitting, one side was placed in a cooler at 3°C for 24 h, whereas the other side was boned while the side was still unchilled. Two 12.3-cm^2 areas of the top round lean were swabbed with cotton swabs moistened with Butterfield's phosphate diluent before the rounds were hot boned from the beef side. The top rounds (semimembranosous) and loins, excised by a team of about 8 plant boners, were also sampled by swabbing after boning. Microbiological samples were enumerated as shown in Table 1. The loins and rounds were assigned randomly to one of three packaging-storage treatments.

The rounds and loins in the first treatment were overwrapped with polyvinylchloride (PVC) film and placed on a rack, one layer thick in a blast freezer at -39°C for 14 d. The second treatment was similar to the first, except the meat was stored on racks for 7 d at 3°C before freezing. In the third treatment, the meat was vacuum packaged and stored 14 d at 3°C before being frozen at -39°C. These treatments simulate procedures that are normally used or may be employed at that plant. After freezing, the cow meat is ordinarily blade-tenderized, enzyme-dipped, formed and cut before shipment. Because too much variability would be introduced during the enzyme treatment,

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TABLE 1. *Enumeration procedure for bacteria.*

Microorganism	Medium	Incubation	
		Temperature (°C)	Time (h)
Aerobic plate count	Plate count agar	5	168
		20	72
		35	48
Coliforms	Lauryl sulfate broth (gas)[a]	35	24, 48
	Brilliant green lactose bile broth	35	24, 48
Fecal coliform	*E. C.* broth (gas)[a]	45.5	24, 48
Escherichia coli	Levine eosin methylene blue agar[b]	35	18, 24

[a]Food and Drug Administration *(5)*, 3-tube MPN (most probable number).
[b]Streak on agar, greenish metallic sheen colonies are usually *E. coli*.

we ended our microbiological sampling of the primals after they had been tempered before tenderization. The primals from chilled carcasses were handled in the same manner, but the procedures were delayed 24 h to allow for the carcass chill time. The primals were held at -39°C for 14 d. They were then tempered at -3°C for 60 h before microbiological sampling and subsequent tenderization treatments.

The beef trimmings were collected in plastic, lined drums and fabricated into 450-kg batches of ground beef. The beef pieces were sent through a 5.2-cm kidney-shaped breaker plate, mixed for 2 min, adjusted for fat content by addition of chilled USDA Choice plates and ground through a .32-cm final plate. Fat content was measured by Anyl Ray device (Kartridg Pak Co., Davenport, IA 52808). The chilled USDA Choice plates also served to lower the temperature of the hot boned meat during grinding. The USDA Choice plates were swabbed to discern microbial levels of this ingredient. Six batches of ground beef were processed and sampled from both hot and chilled beef. Two of the six batches of the hot and chilled beef did not have the added USDA Choice plates so the effect of the plates could be evaluated. In these two batches, CO_2 snow (.1 kg of CO_2/kg of meat) was added during fabrication of the ground beef to lower the meat temperature as described by Emswiler and Kotula *(3)*. The grinding equipment was washed with 82°C water and rinsed with 12°C water between each batch. Ground beef was sampled aseptically after the final grinding was underway and once again before the grinding of the batch was completed. These subsamples were then combined. Ground beef from each batch was packaged in moisture-vapor-proof film to form 2.5-kg chub packs. The remainder of the ground beef from each batch was shaped into 112-g patties with a Formax 26 patty machine (Formax, Inc., Mokena, IL 60448). Chub packs and beef patties were frozen at -20°C for 24 h, stored about 3 weeks and then sampled for bacteria. Samples (25 g) of ground beef were mixed with 225 ml of Butterfield's phosphate diluent before enumeration, as outlined in Table 1. Microbial counts were reduced to a count per g, the value .1 was added to preclude difficulties in analyzing zero counts and the counts were converted to logarithms (base 10) before they were treated by analysis of variance *(14)* and the mean separation test *(15)*.

RESULTS AND DISCUSSION

The microbial counts, including APC_{20} and APC_{35} but not APC_5, were not influenced ($P>.05$) by whether the carcasses were hot- or cold-boned (Table 2). The packaging condition exhibited a significant effect, but this can be attributed to the increase in counts when the primals were held 7 or 14 d at 3°C before freezing. The holding period had been incorporated into the experimental design because of its potential value in ensuring more tender meat. Vacuum packaging reduced bacterial growth. The effect of sampling time, whether the primals were on the carcass, excised or stored, and some of its interactions were highly significant, however variation in counts between primals was generally less than one logarithm, and therefore of limited importance. The mean squares and their significance for coliforms, fecal coliforms and *E. coli* are presented in Table 2. The actual numbers of these bacteria were so few that data are not presented in tabular form. Since *E. coli* is often associated with enteric pathogenic bacteria, its low numbers is presumptive evidence suggesting that pathogenic bacteria are also present in very low numbers, if at all.

Bacterial samples from rounds and loins on carcasses for $APC_{5,\ 20\ and\ 35}$ yielded significant ($P<.05$) differences for only the $APC_{20\ and\ 35}$ between hot and cold boning, but the magnitude of the difference was less than one logarithm (Table 3). Excision of the round significantly increased the $APC_{5,\ 20\ and\ 35}$ and the magnitude of the difference was of importance because it exceeded 1 log. Additional research is needed to develop procedures to reduce the inordinate increase in microbial count during the boning of both hot and chilled carcasses. Procedures for improved handling of hot primals are particularly germane because the APC_{35} for the rounds excised from hot carcasses were significantly greater ($P<.05$) than the counts on those cuts from chilled carcasses. After storage, the differences in $APC_{5,\ 20\ and\ 35}$ between chilled and hot excised primals were less than 1 log. The APC_5 for rounds and loins increased during storage and the $APC_{20\ and\ 35}$ for the rounds decreased during storage ($P<.05$), but the magnitude of the change is of questionable importance.

Primals that were overwrapped with PVC and frozen at -39°C generally yielded the lowest $APC_{5,\ 20\ and\ 35}$ (Table 3). When the PVC overwrapped primals were stored 7 d at 3°C before freezing, the $APC_{5,\ 20\ and\ 35}$ on the loins and the APC_5 on the rounds were significantly higher ($P<.05$) than on the beef primals that were frozen without a holding period to enhance tenderness (Table 3). The magnitude of the difference exceeded one logarithm for the loins, therefore the desire to improve tenderness by unfrozen storage needs to be reevaluated with regard

TABLE 2. *Analysis of variance mean squares of bacterial numbers for rounds and loins.*

Source[a]	df	APC_5	APC_{20}	APC_{35}	Coliforms	Fecal Coliforms	*E. coli*
Round							
Packaging (P)	2	11.80**	0.48	3.50	0.07	0.61*	0.61*
Sampling time(S)	2	74.42**	62.19**	62.88**	0.10	0.03	0.03
P×S	4	54.36**	23.10**	10.87**	1.42	0.17	0.17
Carcass	51	23.42	23.09	26.96	1.42	0.17	0.17
Chill (C)	1	.00	5.14**	12.92**	0.03	0.00	0.00
P×C	2	5.36**	1.17	4.12*	0.09	0.01	0.01
S×C	2	4.21*	1.23	2.67	0.03	0.01	0.01
P×S×C	4	2.13	0.64	1.20	0.05	0.03	0.03
Loin							
Packaging (P)	2	53.02**	26.80**	20.13**	0.34	0.00	0.00
Sampling time(S)	1	12.61**	0.00	0.08	0.04	0.04**	0.04**
P×S	2	45.60**	18.84**	12.68**	0.66	0.00	0.00
Carcass	30	12.52	7.92	9.16	3.19	0.17	0.17
Chill (C)	1	0.79	3.00*	4.69**	0.76	0.04	0.04
P×C	2	2.13	2.49	1.73	0.08	0.00	0.00
S×C	1	0.11	2.22	1.46	0.00	0.04**	0.04**
P×S×C	2	2.73	1.17	1.07	0.28	0.00	0.00

[a]Packaging; Overwrap with PVC, frozen at -39°C; overwrap with PVC stored at 3°C for 7 d, frozen at -39°C; vacuum packaged, stored 14 d at 3°C and frozen at -39°C: Chill; One side of each carcass was chilled at 3°C for 24 h, whereas, the other side was boned within 3 h while still hot: Sampling of rounds, on carcass, after excision and after frozen storage; Sampling of loins, after excision and after frozen storage. *P<.05; **P<.01.

TABLE 3. *Bacterial counts (log_{10}/cm^2) on rounds and loins as influenced by hot boning, sampling time and packaging[a].*

Variable	Primal	Treatment	(n)	APC_5	APC_{20}	APC_{35}
	Round:					
		Hot boned	60	2.03	3.21^b	3.51^b
Chilling		Chilled	60	2.06	2.84^c	2.94^c
	Loin:					
		Hot boned	36	3.07	4.00^b	4.20^b
		Chilled	36	3.01	3.81^c	3.85^c
	Round:					
		On Carcass	48	1.22^c	2.19^d	2.40^d
		Excised	24	2.52^b	3.85^b	4.13^b
Sampling time		Stored	48	2.63^b	3.45^c	3.60^c
	Loin:					
		Excised	24	2.73^c	4.10	4.14
		Stored	48	3.20^b	3.81	3.96
	Round:					
		A	60	1.66^d	2.95	3.08
		B	30	2.66^b	3.22	3.54
Packaging		C	30	2.18^c	2.99	3.20
	Loin:					
		A	36	1.92^d	3.14^d	3.36^d
		B	18	4.51^b	5.00^b	4.97^b
		C	18	3.80^c	4.33^c	4.38^c

[a]APC_5, APC_{20}, APC_{35}: aerobic plate counts incubated at 5, 20 and 35°C, respectively. Packaging: A, Overwrap with PVC and frozen at -39°C; B, Overwrap with PVC, stored 7 d at 3°C and frozen at -39°C; C, Vacuum packaged, stored 14 d at 3°C and frozen at -39°C, respectively.

[bcd]Means within a type of bacterial count, for a specific primal, within a particular variable evaluated, having dissimilar superscripts are different (P<.05) according to the mean separation analysis *(15)*.

to its side effect of increased microbial numbers. The APC_5 of the frozen vacuum packaged aged rounds and the $APC_{5,\ 20\ and\ 35}$ of frozen vacuum packaged aged loins were significantly greater (P<.05) than on the respective rounds or loins frozen immediately, but less than the rounds and loins that were aged in PVC.

Analysis of variance of the microbial counts of ground beef (Table 4) indicated that the main effects of chill, method of preparation and form had a significant effect on $APC_{5\ and\ 20}$. The APC_{35} generally did not differ be-

TABLE 4. *Mean squares and their significance from analysis of variance of their bacterial numbers from ground beef.*

Source[a]	df	APC_5[b]	APC_{20}[b]	APC_{35}[b]	Coliform	Fecal coliform	*E. coli*
Time	1	.13	.00	.00	1.15	.38	.38
Chill	1	3.38*	1.82**	.00	.04	.63	.63
Prep	2	13.52***	3.26***	.37**	.11	.56	.56
Chill × prep	2	1.34	.39	.21*	.51	1.18	1.18
Form	2	2.65**	.52*	1.31***	4.33**	.70	.70
Chill × form	2	.14	.03	.03	.15	.45	.45
Prep × form	4	.29	.12	.11	.31	.62	.62
Chill × prep × form	4	.09	.01	.03	.23	.17	.17

[a]Time - a.m. or p.m.; chill: hot-boned or chilled boned; prep: with or without plates, and with CO_2 when plates not used; form: bulk ground beef, chub packs or beef patties.

[b]APC_5, APC_{20}, APC_{35}: Aerobic plate counts incubated at 5, 20, and 35°C, respectively.

*P<.05

**P<.01

***P<.001

TABLE 5. *Bacterial count (log_{10}/g) of ground beef manufactured from hot boned and chilled boned beef trimmings.*

Count[k]	Treatment	Prep[i]	Ground beef form[j] Bulk	Chub pack	Patties	Average
APC_5	Hot	1	6.35^{ab}	5.63^{abcde}	5.59^{abcde}	5.86^{a}
		2	6.62^{a}	5.88^{abcd}	5.93^{abc}	6.14^{a}
		3	3.87^{f}	3.34^{f}	3.61^{f}	3.61^{c}
	Chilled	1	5.91^{abcd}	4.88^{bcdef}	4.38^{def}	5.06^{b}
		2	5.87^{abcd}	4.33^{ef}	4.72^{cdef}	4.97^{b}
		3	3.99^{f}	3.35^{f}	3.87^{f}	3.74^{c}
APC_{20}	Hot	1	6.54^{ab}	6.12^{abcde}	$5.98^{abcdefg}$	6.21^{a}
		2	6.68^{a}	6.39^{abc}	6.23^{abcd}	6.44^{a}
		3	5.07^{gh}	5.18^{fgh}	5.14^{gh}	5.13^{c}
	Chilled	1	6.07^{abcdef}	$5.69^{bcdefgh}$	5.31^{efgh}	5.69^{b}
		2	6.06^{abcdef}	5.43^{defgh}	5.51^{cdefgh}	5.55^{b}
		3	5.18^{fgh}	5.02^{h}	5.02^{h}	5.07^{c}
APC_{35}	Hot	1	5.74^{ab}	4.99^{d}	5.00^{d}	5.24^{bcd}
		2	5.93^{a}	5.56^{abc}	5.40^{bcd}	5.63^{a}
		3	5.26^{cd}	5.04^{d}	4.94^{d}	5.08^{d}
	Chilled	1	5.99^{a}	5.35^{bcd}	5.07^{d}	5.47^{ab}
		2	5.97^{a}	5.13^{cd}	4.94^{d}	5.35^{bc}
		3	5.33^{bcd}	5.16^{cd}	5.10^{cd}	5.20^{cd}

[abcdefgh]Means within a type of bacterial count having the same letter are not different (P>.05) according to the mean separation analysis *(15)*.

[i]Prep 1 and 2 include chilled USDA choice plates, prep 3 does not.

[j]n = 4 for bulk; n = 6 for chub pack; n = 12 for patties.

[k]APC_5, APC_{20}, APC_{35}: Aerobic plate counts incubated at 5, 20 and 35 °C respectively.

tween hot- and cold-boned ground beef. The bulk ground beef had a higher coliform count than the ground beef in chub packs or the patties (P<.05), but the differences were not large enough to be of practical importance.

The average log bacterial count (APC_5, APC_{20}) of the bulk, chub pack and patty ground beef manufactured from chilled meat was only slightly, but significantly lower (P<.05), than the average count of the ground beef manufactured from hot-boned meat (Table 5). However, the difference between means were usually less than 1 log and, therefore, probably were not of practical importance.

The addition of chilled USDA Choice plates, to increase the fat content to the desired level and help reduce the temperature, increased (P<0.5) the APC_5 bacterial count more than 1 log in most instances, increased the APC_{20} in some instances, and had less influence on the APC_{35} counts. After the chilled bulk ground beef was fabricated into chub packs or patties and frozen, the resultant reduction in bacterial count minimized the influence of the added plates in the chilled product. The addition of plates to the hot-boned beef continued to be of importance in relation to the APC_5 and APC_{20} in the product manufactured from the hot beef even after the chub packs and patties were frozen.

The mean log bacterial count (APC_{20}) of the product

from chilled meat (5.47) was significantly lower than the count (5.92) of the product from the hot meat, but the difference was small. Similarly, APC_{35} did not differ greatly between chilled or hot meat.

This evaluation of the microbiological condition of hot-boned beef primals and ground meat products, from USDA Cutter and Canner carcasses, under commercial conditions, did not demonstrate inordinate bacterial populations as suggested by Cuthbertson *(2)*. Rather, hot boning of beef can yield meat and meat products of good microbiological quality.

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