Bacterial Populations Response to Surface Flaming In Beef Trim Destined for Retail Markets

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ABSTRACT

Frozen, vacuum packaged semitendinosus muscles, from "cull" cows were used as beef trim. Meat was tempered at 0°C for 48 h with half of the muscles trimmed of all visible fat while the remainder were allowed to retain all external fat. Muscles were sliced into 1.27 cm^2 wide strips, with the length of the strips determined by the width of the muscle and then tempered at 4.4°C for an additional 12 h. This experiment utilized four treatments, a low and high fat control in which flame was not applied and low and high fat treatments in which 10 seconds of surface flaming was utilized. After treatment, beef trim was ground, formed into patties, and placed in cooler storage for 0, 1, 2, 4, or 8 days. Treatment HF0 patties (high fat, no flame) had higher (P<0.01) aerobic-plate-counts (APC) than all other patties. High fat products were shown to display higher (P<0.01) APC than lower fat patties. LF0 (low fat, no flame) patties and LF10 (low fat, 10 seconds flame) had similar (P>0.05) psychrotrophic-plate-counts (PPC), however, were lower (P<0.01) than both HF0 and HF10 (high fat, 10 seconds flame) patties. Moreover, HF10 patties had less (P<0.01) PPC than did HF0 patties. Also, lower fat products showed fewer (P<0.01) PPC than higher fat products. Evaluation of pseudomonas counts (PSU) showed HF0 patties to possess more (P<0.01) organisms than all other products. Additionally, F10 and LF0, and LF10 and HF10 had similar (P>0.05) values.

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3 INTRODUCTION

4 The production of ground beef in this country is vital to the
5 processing industry, since 44% of the fresh beef consumed in this
6 country is in this form (2). Research must be conducted that will
7 allow processors to utilize resources that currently exist within
8 their facilities to reduce microbial populations of beef trim
9 without physically degrading the product.

10 Whether it be a high or low fat product, maximizing the
11 shelf-life of red meat can be accomplished by controlling
12 microbial contamination and further growth during fabrication of
13 primal, subprimal, and retail cuts (1). However, differences do
14 occur in microbial populations which are dependent upon fat type.
15 (10, 18) reported that microbial populations for certain
16 organisms were higher on fat tissue than on lean tissue. They
17 postulated that this difference was pH linked. With countless
18 articles devoted to the storage of meat products, very few deal
19 with the direct application of heat to the lean surface for the
20 explicit purpose of reducing microbial populations. Most of the
21 past research in this area has been aimed at the reduction of
22 microorganisms obtained from fully cooking a product. Surface
23 sterilization by surface heating would surely require an
24 inordinate length of contact between the heat source and the meat
25 surface, but for microbial population reductions, contact between
26 the heat source and lean meat surface can be minimized.

27 The objective of this experiment was to determine the effect

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of surface flaming on low and high fat beef trim in reference to possible microbial population reductions in both and the possible differing effect surface flaming might impart upon either.

Materials and Methods

Processing Procedure:

Whole semitendinosus muscles from carcasses of "cull" cows were obtained from Lambert Meats Laboratory (Auburn University, AL) and vacuum sealed before freezing at -20°C for one month. Upon experimental initiation, meat was tempered at 0°C for 48 h with half trimmed of all visible fat and the remainder retaining all external fat. Muscles were sliced into 1.27 cm^{2} strips, with the length of the strips determined by the width of the whole muscle. Low fat (1.60% fat) and high fat (20.25% fat) (3) beef strips were placed in covered pans and tempered at 4.4^{o}C for an additional 12 h. Lean beef strips were then divided into four, 2.95 kg treatments. At this time all equipment contact surfaces were sterilized with a 70% ethyl alcohol solution. Beef strips were weighed and placed on a sterile stainless steel mesh belt which allowed for simultaneous treatment of beef strips at a distance of 6.35 cm (between the meat and heat source) both dorsally and ventrally. Flame was used as a heat source in this experiment, with meat and flame contact lengths of 0 and 10 seconds used. Treatments used were: LF0 = low fat, no heat, HF0 = high fat, no heat, LF10 = low fat, flame 10 seconds, HF10 = high fat, flame 10

1 seconds. After treatment, beef strips

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4 were weighed, ground twice through a 4.5 mm grinding plate using a

5 Mixer/Grinder (Kitchen Aid Model #KSM90WH, St. Joseph, MO), formed

6 with a conventional hand pattie press into 113.5 g patties, placed

7 onto styrofoam meat trays and covered with an oxygen permeable

8 film. Patties from each treatment were stored for one of five

9 periods (0, 1, 2, 4, and 8 days) of cooler storage at 1.7^{o}C.

10 Microbial Analysis:

11 Populations of aerobic, lactic acid bacteria, and

12 psychrotrophic bacteria were enumerated during each storage

13 period. At each sampling period, meat patties were removed from

14 storage and two 11 g samples were aseptically removed from pattie

15 centers and placed into sterile plastic bags (Fisher Whirl Pak,

16 530 ml, Pittsburgh, PA) with 99 ml of Butterfield's phosphate

17 buffered diluent (35 g KH_2PO_4 in 500 ml of distilled water adjusted

18 to pH 7.2 with 1 N NaOH and brought to 1 liter with distilled

19 water). Each sample was homogenized using a Model 400 Stomacher

20 (Tekmar Company, Cincinnati, OH) for two minutes. Samples were

21 serially diluted and plated using a Spiral Plater Model D (Spiral

22 Systems Instruments, Bethesda, MD). Aerobic-plate-counts (APC)

23 were enumerated on standard methods agar (SMA) (BBL Microbiology

24 Systems, Cockeysville, MD) with plates incubated at 40°C for 48 h.

25 Psychrotrophic-plate-counts (PPC) were determined on standard

26 methods agar (SMA) (BBL Microbiology Systems, Cockeysville, MD)

27 with plates incubated at 4.4^{o}C for 7 days. Pseudomonad counts

1 (PSU) were enumerated on heart infusion agar (Difco, Detroit, MI)
2 with 1% Beef Trim and Surface Flaming
3 ceporin, 1% fucidin and 1% cetrimide added (CFC agar), with plates
4 incubated at 30°C for 48 h. Lactobacillus-plate-counts (LPC) were
5 determined on MRSA broth with 2% added agar (Difco, Detroit, MI)
6 with plates incubated at 40°C for 48 h. After appropriate
7 incubation, plates were counted with a Bacteria Colony Counter
8 Model 500A (Spiral Systems Instruments, Bethesda, MD). All
9 microbial data were expressed in $\log_{10}$ cfu's/g of sample.
10 Metmyoglobin:
11 Determination of metmyoglobin concentration (4) was performed
12 in duplicate at each storage period. Samples (5 g) were added to
13 50 ml of 0.04 M phosphate buffer (pH 6.8) and homogenized for 30
14 seconds with a Pro250 Homogenizer (Monroe, CT). The homogenate
15 was then centrifuged for 30 minutes at 5°C (50,000 x g) with the
16 supernatant filtered through Whatman No. 1 filter paper and
17 analyzed spectrophotometrically at 525, 572, and 730 nm using a
18 Perkin-Elmer model #C688-0000 Lambda 4 UV/VIS spectrophotometer
19 (Norwalk, CT). Measurement of metmyoglobin was calculated using
20 the following formula (13) which utilized a turbidity correction
21 (9).
22 $Met\ \% = (1.395 - ((572^A - (730^A * 1.45)) / (525^A - (730^A * 1.73)))) * 100$
23 pH Determination:
24 Determination of product pH was performed in duplicate at
25 each storage period using 100 ml of deionized distilled H_2O and 10
26 g of product. The water and meat were mixed for 30 seconds using
27 a Pro250 Homogenizer (Monroe, CT). Extech Instruments Corporation

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3 model #120505 pH Meter (Waltham, MA) was used to determinate final

4 product pH.

5 Hunter Color Analysis:

6 Objective product color measurements were obtained in

7 triplicate for patties at each storage period using Hunter Labs

8 D25 DP9000 (Reston, VA) Color Difference Meter. The unit was

9 standardized using a white C2-36852 standard plate. Expression of

10 values obtained were in Hunter Color "L", "a" and "b" units (11).

11 TBARS Analysis:

12 Analysis of 2-thiobarbituric acid reactive substances (TBARS)

13 was determined in duplicate (12).

14 Product Temperature:

15 Post-treatment temperatures were obtained from freshly ground

16 treatments at five randomly selected sites using Koch Supplies

17 Incorporated AT-500 Digital Thermometer (Kansas City, MO).

18 Compositional Analysis:

19 Moisture, fat and protein analysis were performed in

20 triplicate (3) on randomly selected samples taken from lean beef

21 strips immediately prior to treatment.

22 Visual Evaluation:

23 Pattie surface discoloration was monitored at each storage

24 period by a four member experienced panel. Each panelist viewed

25 patties in a retail display case, which also approximated retail

26 lighting conditions. The panelists were asked to determine

27 percent pattie surface discoloration while viewing three patties

from each

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treatment. In addition, panelists were asked to evaluate percent surface fat smearing on three patties from each treatment immediately after processing was complete.

Statistical Analysis:

This experiment was arranged as a 2X2 factorial in a split plot over time with two fat levels, 1.5% and 22.5%, two time periods of surface heating (0 and 10 seconds), and five periods of cooler storage (0, 1, 2, 4, and 8 days) (16). This experiment utilized two replications with data being analyzed by general linear model (GLM). When differences were detected, means were separated by Student-Newman-Kuels (SNK) (15).

Results and Discussion

Microbiological Stability

Fat surfaces comprise a significant part of red meat carcasses. For example, most of the surface of a freshly dressed carcass consists of subcutaneous fat. Hence, this tissue is most likely one of the first to become contaminated during the slaughter process (18). This would allow for greater microbial contamination of fat surfaces than for lean surfaces in processed products such as ground beef, which is usually manufactured using lean beef trim and a very high fat and potentially more contaminated fat/lean beef trim. The effectiveness of flame on high fat beef trim was shown as HF10 patties had lower ($P<0.01$)

1 APC than HF0, but was similar (P>0.05) to both low fat products
2 (Table 1). As expected, APC
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5 increased as cooler storage lengthened (Table 3) with Day 0, 1,
6 and 2 having similar (P>0.05), but lower values (P<0.01) than Day
7 4 or 8. Day 4 patties had lower (P<0.01) aerobic populations than
8 Day 8. APC over fat level (Table 4) showed higher fat products to
9 be more contaminated (P<0.01) than lower fat patties. These
10 findings are important, in that, although more highly
11 contaminated, the use of surface flaming of 20.25% fat beef trim
12 can lower microbial populations to that of very low fat beef trim.
13 Since ground beef is a perishable product and in most retail
14 instances is stored at temperatures conducive to psychrotrophic
15 proliferation, these organisms become very significant in regards
16 to product stability. As with APC, the use of flame in a high fat
17 product (HF10) showed lower (P<0.01) PPC than HF0 patties (Table
18 1). However, HF10 exhibited populations higher (P<0.01) than low
19 fat products, which were similar (P>0.05). Psychrotrophic
20 populations over time (Table 3) showed increases (P<0.01) at every
21 day of storage. PPC values among fat types (Table 4) showed
22 higher fat products to have higher (P<0.01) populations than
23 products with less fat. Even though containing higher initial
24 populations, the use of flame on high fat products could not lower
25 PPC to that of low fat products.
26 Pseudomonas has been found to be one of the most important
27 spoilage organisms in reference to red meats (14). Pseudomonas

can be a particular problem in reference to ground beef, in that, it can grow at moderate temperatures, but is classified a psychrotroph Beef Trim and Surface Flaming
(8, 6). As with other forms of microbial enumeration mentioned previously, HF10 had lower (P<0.01) PSU when compared to HF0 and was similar (P>0.05) to LF10 (Table 1). LF0 had lower (P<0.01) PSU than the higher fat products but was similar (P>0.05) to LF10. Over storage time, PSU counts were similar (P>0.05) for Days 0 and 1, but lower (P<0.01) than Days 2, 4 and 8 which increased (P<0.01) chronologically (Table 3). Among fat types (Table 4), higher fat products displayed greater (P<0.01) PSU counts. Findings for PSU combined with those for PPC suggest that use of flame on high fat beef trim might not decrease populations of psychrotrophs as effectively as for overall aerobic populations.

As previously stated, ground beef for retail consumption is usually displayed in an aerobic condition. However, even though presented in this state, proliferation of organisms which are basically anaerobic in nature can occur. One such facultative anaerobe is lactobacillus. Lactobacillus (LPC) showed no effects (P<0.05) over fat types (Table 4). This finding is of particular interest since higher fat patties were shown to display higher microbial populations than low fat patties. This was probably due to low LPC displayed by both high and low fat products. A significant (P<0.01) interaction was detected in reference to analysis of storage time * treatment for LPC (Figure 1). In general, values for LPC tended to be higher as storage time increased. Additionally, HF10 patties tended to have lower LPC

when compared to all other patties, while HF0 patties displayed the Beef Trim and Surface Flaming

highest LPC at Day 8.

In general, high fat patties were shown to contain higher microbial levels than low fat patties. The effect of surface flaming of high fat beef trim on pattie microbial populations seems very positive and in some cases produces microbial populations equivalent to those noted in the lower fat patties.

TBARS Values

Determination of lipid oxidation using the 2-thiobarbituric acid reactive substances test (TBARS), showed no differences (P>0.05) among treatment patties (Table 1) or fat types (Table 4). Among storage times (Table 3), TBARS values were different (P<0.01). Days 0 and 8 had similar (P>0.05) TBARS values, with Day 8 having higher (P<0.01) values than any other day. However, Day 0 while similar (P>0.05) to Days 1 and 2, displayed higher (P<0.01) TBARS values than those of Day 4. This effect of fluctuating oxidation values over time is probably due to breakdown of malonaldehyde to subunits which are not detectable by TBARS analysis (5). Also, a reduction in TBARS values may result if breakdown of malonaldehyde is greater than formation (19).

pH

Product pH affects microbial growth and product longevity. The closer the pH is to 7.0, usually the greater the population of microorganisms found. (18) found red meat carcasses to have fat tissue pH's about 1.0 pH higher than lean tissue. This higher pH value for fat tissue has been shown (18, 10) to result in

increased Beef Trim and Surface Flaming
microbial growth when compared to lower pH lean tissue samples. LF10 had greater ($P<0.01$) pH values than HF10 and HF0, and HF0 displayed a higher pH than ($P<0.01$) HF10 patties (Table 1). A general trend was revealed when analyzing by treatment. LF0 and HF0 products when compared to their low or high fat flamed counterparts had different product pH's (Table 4). This could be due to the fact that when initially heated, lipases and phospholipases, produce free fatty acids, thus, lowering product pH (7). Product pH over storage (Table 3) showed pH on Days 0 and 1 to be similar ($P>0.05$), but higher ($P<0.01$) than Days 2, 4 and 8 which were all similar ($P>0.05$). Lower fat patties possessed a higher ($P<0.01$) final product pH than the higher fat products. The findings for pH reported here are confusing, in that, as beef trim fat level increased, a similar increase should have been noted for ground beef pattie pH.

Color Stability

Metmyoglobin content of beef products, particularly retail ground beef patties is extremely important, since consumer purchasing choices of red meats are based to a high degree upon product color (17). Analysis for metmyoglobin content was conducted to determine pigment conversion in the final product. Significant ($P<0.01$) interactions occurred for storage time * treatment (Figure 2) and storage time * fat type (Figure 3). These two interactions are very much related, in that both reveal slight increases as storage time lengthened. However, between Days 4 and

8 of storage the higher fat patties showed marked increases in metmyoglobin content.

Visual evaluation of product surface discoloration revealed significant (P<0.01) interactions for analysis of storage time * treatment (Figure 4) and storage time * fat type (Figure 5). In general, values for patties increased over time, however, as with the significant interaction of storage time * treatment in the analysis of metmyoglobin, HF0 patties displayed a marked increase in product discoloration between Days 4 and 8 of storage. Also, noted was that HF10 showed the lowest surface discoloration scores at Day 8. On the whole, increases were noticed for low and high fat patties over storage, with high fat patties initially displaying higher values. However, between Days 0 and 1 of storage, low fat patties showed greater increases in discoloration and over the remainder of storage magnitudes of differences between low and high fat products were extremely variable.

Hunter color "L" values (lightness) were different (P<0.01) among treatment patties (Table 2) with high fat patties displaying similar (P>0.05), but higher (P<0.01), "L" values than either low fat product. LF10 displayed a lighter (P<0.01) colored pattie than LF0. No differences (P>0.05) were revealed for product "L" values over 0, 1, 2, and 4 days of storage (Table 3), however, each had higher (P<0.01) "L" values than Day 8. Product "L" values among fat types (Table 5) indicated higher fat patties had much lighter (P<0.01) colored patties than low fat products which

was entirely

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due to fat content.

The use of Hunter "L", "a" and "b" values for evaluation of ground beef products is important, however, the Hunter "a" value, as it relates to ground beef, is the most effective of these. Hunter "a" values are an objective tool to evaluate meat redness properties. Hunter "a" values showed no differences (P>0.05) over fat types (Table 5). A significant (P<0.01) interaction was detected for Hunter "a" values for storage time * treatment (Figure 6). This interaction is probably closely related to those previously mentioned, in that over the first four days of cooler storage HF0 patties exhibited values superior to other treatment patties. However, between Days 4 and 8 the rate of degradation was much more rapid than that of other treatment patties. While tending to lower scores for product surface discoloration, HF10 patties showed trends of lowering "a" values when compared to other lower fat products.

Hunter "b" values (yellowness) were significant (P<0.01) among treatment patties (Table 2). Yellowness values were higher (P<0.01) for HF0 patties than for all other patties. HF10 patties displayed higher (P<0.01) values than either low fat product. Over storage (Table 3) the highest (P<0.01) "b" values were displayed on Days 1 and 2 while values on Days 4 and 8 were similar (P>0.05). Day 0 had lower (P<0.01) "b" values than Day 4. Due to fat content (Table 5), the higher fat products displayed

greater (P<0.01) "b" values than those of low fat products.

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While many interactions existed in reference to color stability, findings indicated that fat level probably played a more important role for color effects than the use of surface flaming. This was shown by the lack of extreme effects for LF10 coupled with HF10 not showing the highest discoloration scores.

Fat Smearing

Surface fat smearing revealed differences (P<0.05) among treatment patties (Table 2). As expected, HF10 patties had greater (P<0.05) amounts of surface fat smearing than all other patties, which were similar (P>0.05). Among fat types, (Table 5) high fat patties displayed higher (P<0.01) smearing values than low fat patties.

Post-Treatment Temperature

Post-treatment temperature means were different (P<0.01) among treatments (Table 2). Post-treatments temperatures of LF0 and HF0 while similar (P>0.05) were lower (P<0.01) than for the flamed treatments, which were also similar (P>0.05). No differences (P>0.05) were noted for post-treatment temperature in relation to fat type (Table 5).

CONCLUSIONS

Higher fat products contained greater microbial growth than their lower fat counterparts. However, the use of surface flaming on high fat beef trim showed very positive effects for microbial

growth and directly conflicts with the notion that increased

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microbial growth on fatty tissue is linked to high pH. Moreover, no effects of lipid oxidation was noted, even when surface flaming was used. The use of flame on high fat beef trim tended to lower surface discoloration scores at 8 days of storage and high fat patties had similar Hunter "a" values to those of the lower fat products. The use of surface flaming on high fat beef trim destined for ground beef production needs to be investigated more fully. Use of this system on even higher fat beef trim (50%) would be of great use to the beef processing industry and ultimately have applications to the "fast food" industry.

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Table 1. Effects of heat treatment on microbial, chemical and physical characteristics of low and high fat beef trim.

TRT[a]	APC[b]	PPC[c]	PSU[d]	TBARS[e]	pH
	log_{10} cfu/g	log_{10} cfu/g	log_{10} cfu/g	mg/kg	
LF0	2.51[g]	2.75[h]	2.28[h]	0.88[f]	5.72[f]
LF10	2.52[g]	2.69[h]	2.41[gh]	0.95[f]	5.67[g]
HF0	3.23[f]	3.48[f]	2.91[f]	0.90[f]	5.60[h]
HF10	2.70[g]	3.18[g]	2.59[g]	0.98[f]	5.56[i]
SEM[j]	0.08	0.06	0.08	0.04	0.01

[a]LF0=low fat, no surface heating, LF10=low fat, 10 seconds of surface flaming, HF0=high fat, no surface heating, HF10=high fat, 10 seconds of surface flaming. [b]aerobic-plate-counts. [c]psychrotrophic-plate-counts. [d]pseudomonad counts. [e]2-thiobarbituric acid reactive substances. [f-i]Means within columns with common letters are not different ($P>0.05$). [j]SEM=standard error of the mean.

Table 2. Effects of heat treatment on color and physical characteristics of low and high fat beef trim.

TRT[a]	L[b] VALUE	b[c] VALUE	TEMP[d] C°	SMEAR[e] %
LF0	31.57[h]	8.98[i]	11.94[g]	0.50[g]
LF10	32.57[g]	9.35[h]	16.94[f]	0.33[g]
HF0	37.12[f]	10.66[f]	10.28[g]	2.33[g]
HF10	37.56[f]	10.23[g]	16.11[f]	6.17[f]
SEM[j]	0.23	0.10	0.20	1.22

[a]LF0=low fat, no surface heating, LF10=low fat, 10 seconds of surface flaming, HF0=high fat, no surface heating, HF10=high fat, 10 seconds of surface flaming. [b]"L" (lightness) value. [c]"b" (yellowness) value. [d]post-treatment temperature. [e]percent product surface smearing. [f-i]Means within columns with common letters are not different (P>0.05). [j]SEM=standard error of the mean.

Table 3. Effects of storage period on microbial, chemical, physical and color

characteristics of low and high fat beef trim.

DAY[a]	APC[b]	PPC[c]	PSU[d]	TBARS[e]	pH	L[f] VALUE	B[g] VALUE
	$\log_{10}$ cfu/g	$\log_{10}$ cfu/g	$\log_{10}$ cfu/g	mg/kg			
0	1.51[j]	1.52[l]	1.22[k]	0.99[hi]	5.68[h]	35.26[h]	9.12[j]
1	1.64[j]	1.80[k]	1.21[k]	0.83[ij]	5.67[h]	34.69[h]	10.50[h]
2	1.86[j]	2.30[j]	1.61[j]	0.90[ij]	5.62[i]	34.75[h]	10.37[h]
4	3.02[i]	3.54[i]	3.15[i]	0.79[j]	5.61[i]	34.94[h]	9.63[i]
8	5.66[h]	5.97[h]	5.55[h]	1.14[h]	5.62[i]	33.90[i]	9.39[ij]
SEM[m]	0.09	0.06	0.09	0.05	0.01	0.25	0.11

[a]0, 1, 2, 4 and 8 days. [b]aerobic-plate-counts. [c]psychrotrophic-plate-counts. [d]pseudomonad counts. [e]2-thiobarbituric acid reactive substances. [f]"L" (lightness) value. [g]"b" (yellowness) value. [h-l]Means within columns with common letters are not different (P>0.05). [m]SEM=standard error of the mean.

Table 4. Effects of fat type on microbial, chemical and physical characteristics of low and high fat beef trim.

FAT[a] TYPE	APC[b] log_{10} cfu/g	PPC[c] log_{10} cfu/g	PSU[d] log_{10} cfu/g	LPC[e] log_{10} cfu/g	TBARS[f] mg/kg	pH
LF	2.51[h]	2.72[h]	2.35[h]	1.77[g]	0.92[g]	5.70[g]
HF	2.96[g]	3.33[g]	2.75[g]	1.82[g]	0.94[g]	5.58[h]
SEM[i]	0.07	0.05	0.06	0.06	0.03	0.01

[a]LF=low fat, HF=high fat. [b]aerobic-plate-counts. [c]psychrotrophic-plate-counts. [d]pseudomonad counts. [e]lactobacillus-plate-counts. [f]2-thiobarbituric acid reactive substances. [g-h]Means within columns with common letters are not different (P>0.05). [i]SEM=standard error of the mean.

Table 5. Effects of fat type on color and physical characteristics of low and high fat beef trim.

FAT[a] TYPE	L[b] VALUE	a[c] VALUE	b[d] VALUE	TEMP[e] C°	SMEAR[f] %
LF	32.07[h]	15.43[g]	9.17[h]	14.44[g]	0.42[h]
HF	37.34[g]	14.92[g]	10.44[g]	13.19[g]	4.25[g]
SEM[i]	0.18	0.22	0.08	0.76	0.92

[a]LF=low fat, HF=high fat. [b]"L" (lightness) value. [c]"a" (redness) value. [d]"b" (yellowness) value. [e]post-treatment temperature. [f]percent product surface smearing. [g-h]Means within columns with common letters are not different (P>0.05). [i]SEM=standard error of the mean.

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