Bacterial Populations Response to Surface Flaming

In Beef Trim Destined for Retail Markets

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1 Running Head - Meat microbiology, Ground beef, Fat, Flame
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4 <u>ABSTRACT</u>

5 Frozen, vacuum packaged semitendinosus muscles, from "cull"
6 cows were used as beef trim. Meat was tempered at 0°C for 48 h with
7 half of the muscles trimmed of all visible fat while the remainder
8 were allowed to retain all external fat. Muscles were sliced into
9 1.27 cm^2 wide strips, with the length of the strips determined by
10 the width of the muscle and then tempered at 4.4^{o}C for an
11 additional 12 h. This experiment utilized four treatments, a low
12 and high fat control in which flame was not applied and low and
13 high fat treatments in which 10 seconds of surface flaming was
14 utilized. After treatment, beef trim was ground, formed into
15 patties, and placed in cooler storage for 0, 1, 2, 4, or 8 days.
16 Treatment HF0 patties (high fat, no flame) had higher ($P<0.01$)
17 aerobic-plate-counts (APC) than all other patties. High fat
18 products were shown to display higher ($P<0.01$) APC than lower fat
19 patties. LF0 (low fat, no flame) patties and LF10 (low fat, 10
20 seconds flame) had similar ($P>0.05$) psychrotrophic-plate-counts
21 (PPC), however, were lower ($P<0.01$) than both HF0 and HF10 (high
22 fat, 10 seconds flame) patties. Moreover, HF10 patties had less
23 ($P<0.01$) PPC than did HF0 patties. Also, lower fat products
24 showed fewer ($P<0.01$) PPC than higher fat products. Evaluation of
25 pseudomonas counts (PSU) showed HF0 patties to possess more
26 ($P<0.01$) organisms than all other products. Additionally, F10 and
27 LF0, and LF10 and HF10 had similar ($P>0.05$) values.

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                        INTRODUCTION

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

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

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.

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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 $-20^{\circ}C$ for one month. Upon

experimental initiation, meat was tempered at $0^{\circ}C$ 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 $4.4^{\circ}C$ 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 $1.7^{\circ}C$.

10   <u>Microbial Analysis:</u>

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 $40^{\circ}C$ 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 $4.4^{\circ}C$ for 7 days. Pseudomonad counts

(PSU) were enumerated on heart infusion agar (Difco, Detroit, MI)

with 1% <u>Beef Trim and Surface Flaming</u>

ceporin, 1% fucidin and 1% cetrimide added (CFC agar), with plates

incubated at 30°C for 48 h. Lactobacillus-plate-counts (LPC) were

determined on MRSA broth with 2% added agar (Difco, Detroit, MI)

with plates incubated at 40°C for 48 h. After appropriate

incubation, plates were counted with a Bacteria Colony Counter

Model 500A (Spiral Systems Instruments, Bethesda, MD). All

microbial data were expressed in log$_{10}$ cfu's/g of sample.

Metmyoglobin:

Determination of metmyoglobin concentration (4) was performed

in duplicate at each storage period. Samples (5 g) were added to

50 ml of 0.04 M phosphate buffer (pH 6.8) and homogenized for 30

seconds with a Pro250 Homogenizer (Monroe, CT). The homogenate

was then centrifuged for 30 minutes at 5°C (50,000 x g) with the

supernatant filtered through Whatman No. 1 filter paper and

analyzed spectrophotometrically at 525, 572, and 730 nm using a

Perkin-Elmer model #C688-0000 Lambda 4 UV/VIS spectrophotometer

(Norwalk, CT). Measurement of metmyoglobin was calculated using

the following formula (13) which utilized a turbidity correction

(9).

Met $\% = (1.395 - ((572^{A} - (730^{A} * 1.45)) / (525^{A} - (730^{A} * 1.73))))) * 100$

pH Determination:

Determination of product pH was performed in duplicate at

each storage period using 100 ml of deionized distilled H$_2$O and 10

g of product. The water and meat were mixed for 30 seconds using

a Pro250 Homogenizer (Monroe, CT). Extech Instruments Corporation

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

<u>Hunter Color Analysis:</u>

Objective product color measurements were obtained in triplicate for patties at each storage period using Hunter Labs D25 DP9000 (Reston, VA) Color Difference Meter. The unit was standardized using a white C2-36852 standard plate. Expression of values obtained were in Hunter Color "L", "a" and "b" units (11).

<u>TBARS Analysis:</u>

Analysis of 2-thiobarbituric acid reactive substances (TBARS) was determined in duplicate (12).

<u>Product Temperature:</u>

Post-treatment temperatures were obtained from freshly ground treatments at five randomly selected sites using Koch Supplies Incorporated AT-500 Digital Thermometer (Kansas City, MO).

<u>Compositional Analysis:</u>

Moisture, fat and protein analysis were performed in triplicate (3) on randomly selected samples taken from lean beef strips immediately prior to treatment.

<u>Visual Evaluation:</u>

Pattie surface discoloration was monitored at each storage period by a four member experienced panel. Each panelist viewed patties in a retail display case, which also approximated retail lighting conditions. The panelists were asked to determine 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

1   can be a particular problem in reference to ground beef, in that,

2   it can grow at moderate temperatures, but is classified a

3   psychrotroph <u>Beef Trim and Surface Flaming</u>

4   (8, 6). As with other forms of microbial enumeration mentioned

5   previously, HF10 had lower (P<0.01) PSU when compared to HF0 and

6   was similar (P>0.05) to LF10 (Table 1). LF0 had lower (P<0.01)

7   PSU than the higher fat products but was similar (P>0.05) to LF10.

8   Over storage time, PSU counts were similar (P>0.05) for Days 0

9   and 1, but lower (P<0.01) than Days 2, 4 and 8 which increased

10   (P<0.01) chronologically (Table 3). Among fat types (Table 4),

11   higher fat products displayed greater (P<0.01) PSU counts.

12   Findings for PSU combined with those for PPC suggest that use of

13   flame on high fat beef trim might not decrease populations of

14   psychrotrophs as effectively as for overall aerobic populations.

15   As previously stated, ground beef for retail consumption is

16   usually displayed in an aerobic condition. However, even though

17   presented in this state, proliferation of organisms which are

18   basically anaerobic in nature can occur. One such facultative

19   anaerobe is lactobacillus. Lactobacillus (LPC) showed no effects

20   (P<0.05) over fat types (Table 4). This finding is of particular

21   interest since higher fat patties were shown to display higher

22   microbial populations than low fat patties. This was probably due

23   to low LPC displayed by both high and low fat products. A

24   significant (P<0.01) interaction was detected in reference to

25   analysis of storage time * treatment for LPC (Figure 1). In

26   general, values for LPC tended to be higher as storage time

27   increased. Additionally, HF10 patties tended to have lower LPC

when compared to all other patties, while HF0 patties displayed

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

1 increased <u>Beef Trim and Surface Flaming</u>

2 microbial growth when compared to lower pH lean tissue samples.

3 LF10 had greater (P<0.01) pH values than HF10 and HF0, and HF0

4 displayed a higher pH than (P<0.01) HF10 patties (Table 1).   A

5 general trend was revealed when analyzing by treatment.   LF0 and

6 HF0 products when compared to their low or high fat flamed

7 counterparts had different product pH's (Table 4).   This could be

8 due to the fact that when initially heated, lipases and

9 phospholipases, produce free fatty acids, thus, lowering product

10 pH (7).   Product pH over storage (Table 3) showed pH on Days 0 and

11 1 to be similar (P>0.05), but higher (P<0.01) than Days 2, 4 and 8

12 which were all similar (P>0.05).   Lower fat patties possessed a

13 higher (P<0.01) final product pH than the higher fat products.

14 The findings for pH reported here are confusing, in that, as beef

15 trim fat level increased, a similar increase should have been

16 noted for ground beef pattie pH.

17 <u>Color Stability</u>

18   Metmyoglobin content of beef products, particularly retail

19 ground beef patties is extremely important, since consumer

20 purchasing choices of red meats are based to a high degree upon

21 product color (17).   Analysis for metmyoglobin content was

22 conducted to determine pigment conversion in the final product.

23 Significant (P<0.01) interactions occurred for storage time *

24 treatment (Figure 2) and storage time * fat type (Figure 3).

25 These two interactions are very much related, in that both reveal

26 slight increases as storage time lengthened.   However, between

27 Days 4 and

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3 8 of storage the higher fat patties showed marked increases in

4 metmyoglobin content.

5 Visual evaluation of product surface discoloration revealed

6 significant (P<0.01) interactions for analysis of storage time *

7 treatment (Figure 4) and storage time * fat type (Figure 5). In

8 general, values for patties increased over time, however, as with

9 the significant interaction of storage time * treatment in the

10 analysis of metmyoglobin, HF0 patties displayed a marked increase

11 in product discoloration between Days 4 and 8 of storage. Also,

12 noted was that HF10 showed the lowest surface discoloration scores

13 at Day 8. On the whole, increases were noticed for low and high

14 fat patties over storage, with high fat patties initially

15 displaying higher values. However, between Days 0 and 1 of

16 storage, low fat patties showed greater increases in discoloration

17 and over the remainder of storage magnitudes of differences

18 between low and high fat products were extremely variable.

19 Hunter color "L" values (lightness) were different (P<0.01)

20 among treatment patties (Table 2) with high fat patties displaying

21 similar (P>0.05), but higher (P<0.01), "L" values than either low

22 fat product. LF10 displayed a lighter (P<0.01) colored pattie

23 than LF0. No differences (P>0.05) were revealed for product "L"

24 values over 0, 1, 2, and 4 days of storage (Table 3), however,

25 each had higher (P<0.01) "L" values than Day 8. Product "L"

26 values among fat types (Table 5) indicated higher fat patties had

27 much lighter (P<0.01) colored patties than low fat products which

1 was entirely

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4 due to fat content.

5   The use of Hunter "L", "a" and "b" values for evaluation of

6 ground beef products is important, however, the Hunter "a" value,

7 as it relates to ground beef, is the most effective of these.

8 Hunter "a" values are an objective tool to evaluate meat redness

9 properties. Hunter "a" values showed no differences (P>0.05) over

10 fat types (Table 5). A significant (P<0.01) interaction was

11 detected for Hunter "a" values for storage time * treatment

12 (Figure 6). This interaction is probably closely related to those

13 previously mentioned, in that over the first four days of cooler

14 storage HF0 patties exhibited values superior to other treatment

15 patties. However, between Days 4 and 8 the rate of degradation

16 was much more rapid than that of other treatment patties. While

17 tending to lower scores for product surface discoloration, HF10

18 patties showed trends of lowering "a" values when compared to

19 other lower fat products.

20   Hunter "b" values (yellowness) were significant (P<0.01)

21 among treatment patties (Table 2). Yellowness values were higher

22 (P<0.01) for HF0 patties than for all other patties. HF10 patties

23 displayed higher (P<0.01) values than either low fat product.

24 Over storage (Table 3) the highest (P<0.01) "b" values were

25 displayed on Days 1 and 2 while values on Days 4 and 8 were

26 similar (P>0.05). Day 0 had lower (P<0.01) "b" values than Day 4.

27 Due to fat content (Table 5), the higher fat products displayed

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

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4   While many interactions existed in reference to color

5 stability, findings indicated that fat level probably played a

6 more important role for color effects than the use of surface

7 flaming. This was shown by the lack of extreme effects for LF10

8 coupled with HF10 not showing the highest discoloration scores.

9 Fat Smearing

10   Surface fat smearing revealed differences (P<0.05) among

11 treatment patties (Table 2).   As expected, HF10 patties had

12 greater (P<0.05) amounts of surface fat smearing than all other

13 patties, which were similar (P>0.05). Among fat types, (Table 5)

14 high fat patties displayed higher (P<0.01) smearing values than

15 low fat patties.

16 Post-Treatment Temperature

17   Post-treatment temperature means were different (P<0.01)

18 among treatments (Table 2). Post-treatments temperatures of LF0

19 and HF0 while similar (P>0.05) were lower (P<0.01) than for the

20 flamed treatments, which were also similar (P>0.05).   No

21 differences (P>0.05) were noted for post-treatment temperature in

22 relation to fat type (Table 5).

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24   CONCLUSIONS

25   Higher fat products contained greater microbial growth than

26 their lower fat counterparts. However, the use of surface flaming

27 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] $\log_{10}$ cfu/g	PPC[c] $\log_{10}$ cfu/g	PSU[d] $\log_{10}$ cfu/g	TBARS[e] mg/kg	pH
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] $\log_{10}$ cfu/g	PPC[c] $\log_{10}$ cfu/g	PSU[d] $\log_{10}$ cfu/g	TBARS[e] mg/kg	pH	L[f] VALUE	B[g] VALUE
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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