LOW TEMPERATURE AGING OF BEEF

R. B. SLEETH

UNIVERSITY OF MISSOURI

Over the years we have become more and more concerned with tenderness in beef. I think that our increasing awareness of the problem has arisen first because we have become more and more concerned with the consumer acceptance of beef, and secondly because many cuts of beef are considered convenience items (to be cooked and served with a minimum of time and effort). Therefore, there is little wonder that workers in this field of research should be interested in the factors that produce tender beef.

Since the consumer demands tenderness as well as other palatability factors in meat, improvement in the quality of beef through aging is a long-established practice in the meat industry. However, the problem of aging and tenderizing meat properly and economically with the least possible amount of shrinkage and cutting loss continues to be paramount importance to the meat packer.

It has been established that during the ripening of beef held at refrigerated temperatures, certain changes take place; among these is an increase in tenderness. Numerous investigators have shown that there is a change in the degree of tenderness as assessed by organoleptic evaluations and mechanical shear force measurements. Much work has been reported on this subject but no attempt will be made here to review the literature.

This report is a summary of some of the results obtained from a two year study involving 46 Choice and Good grade beef carcasses. The study was concerned with an investigation of (1) weight losses due to shrinkage as influenced by (a) length of aging, (b) quality of product, (c) temperature, (d) humidity, and (e) air velocity and (2) organoleptic characteristics of steaks stored at 0°F. for 0 months.

Experimental Procedure

The cattle, weighing 800-850 pounds, were slaughtered at the Missouri Station Laboratory. Hot carcass weights were recorded at time of slaughter. Carcasses were then placed in a chill room at 36°F. and chilled 24 hours to an internal temperature of 45°F. After the initial chilling period, the carcasses were weighed, quartered and/or cut into wholesale cuts, and then reweighed. Weight was recorded daily throughout the aging periods to determine shrinkage losses.

The aging room conditions for all tests in this study are shown in Table 1. The details of the aging, sampling, organoleptic, and Warner-Bratzler Shear procedures are given in an earlier report of this study (Food Technology, 1957, XI, No. 4, pages 205-208).
Results and Discussion

Shrinkage. From the physical standpoint, the over-all shrinkage picture appears to be based on the relative humidity of the aging room, the grade of cattle, and the length of the aging period. However, the majority of the moisture loss does not occur during the first two or three days as has often been suspected. The average shrinkage was 0.4 per cent per day indicating that a consistent line relationship is formulated under these cooler conditions. The data also indicate that, on the basis of days aged, the average per cent shrinkage per day for Choice and Good quarters and wholesale cuts aged in an 80 per cent relative humidity was 0.52 per cent. At 90 per cent relative humidity, the shrink was 0.32 per cent per day. This denotes that with a higher relative humidity in the aging room the moisture loss is substantially reduced.

Choice fore and hind quarters shrunk less than those of comparable weight in the Good grade. These were aged under the same relative humidity. This reveals the influence of the subcutaneous fat on the moisture losses and should be considered by the meat packer or processor when aging meat.

In addition, all Choice and Good forequarters lost more moisture than the corresponding hindquarters which were held under comparable aging conditions. This is only natural since there is a much larger exposed cut surface on the forequarters.

In order to evaluate our experimental shrinkage data with a commercial aging operation, shrinkage data for hindquarters, forequarters, ribs, and loins were collected from the warehouse facilities of a major supermarket operator. The data was collected for a one year period (February 5, 1955 to January 28, 1956) which included 16,974,450 pounds of product.

All meat aged was U. S. Choice and was aged under the same environmental conditions; namely, a temperature of 33 - 35°F, a 88-92 per cent relative humidity and an air flow of 15 to 20 lineal feet per minute at the surface of the product. The wholesale loins were aged an average of 18-21 days, wholesale ribs and hindquarters 15-18 days, and forequarters 5-7 days.

The average shrinkage for the hindquarters was 1.9 per cent as compared to 3.0 per cent shrinkage for our data. However, a valid comparison cannot be made here due to a very small number in the experimental group.

The per cent shrinkage for the forequarters was 0.5. No comparison is possible with our data since we did not age any forequarters comparable to the commercial aging period.

The average shrinkage for the Choice wholesale ribs was 2.3 per cent for the 15 to 18 day period. Our data, indicates a 4.0 per cent shrinkage was found for Good wholesale ribs aged 12 days under the same environmental conditions.

The wholesale loins had an average shrinkage of 0.3 per cent. The variation in shrinkage from week to week was much less for the loins than was shown for the fore and hindquarters and wholesale ribs. A portion of this fluctuation was due to a shortening of the aging period at certain periods of
the year. The remaining variation was possibly due to slight changes in the environmental aging conditions although that was not ascertained.

**Tenderness.** There was a pronounced, although not significant, difference in tenderness in regard to days and temperatures at which the product was aged. You will note from the slide that in each instance as the days and temperature increased, tenderness values were substantially increased. In addition, the rib steaks were always more tender than the round steaks which were aged under the same environmental conditions. However, the round steaks from the Choice hindquarters aged 3 days were more tender than the corresponding rib steaks. This would lead us to postulate that top round steaks, during short periods of aging at low temperatures may be very acceptable to the consumer.

Evaluation of the tenderness values show no apparent differences between the Choice and Good grades in this test. These results are in agreement with two earlier reports by Wierbicki from the Ohio Station.

**Flavor.** The mean panel scores for flavor show very little difference in relation to days aged. This would suggest that aging periods longer than 14 days would not materially influence the flavor constituents normally developed in meat during aging. We also know that flavor is directly related to protein degeneration; therefore, a relationship may be associated with tenderness. During the aging period, the muscle fibers and connective tissues are attacked by both enzyme systems and chemical compounds inherent with the meat. The resultant autolysis has been considered to be a flavor more desired in meat.

There was no difference in flavor as shown by the palatability committee between the Choice and Good grades of ribs and quarters. This is in agreement with Black et al. and Hedrick who found that fatness of the animal did not have any significant influences on the flavor of cooked samples.

**Aroma.** The mean scores for aroma follow almost directly with those for flavor in which there was no significance. The aroma would naturally be associated with flavor and the new chemical compounds which have been formed from the protein degradation.

Grade did not have any significant influence on aroma. This is in agreement with Marion et al. who found no apparent difference in aroma of meat from Choice grade animals as compared to those of lower grade.

**Juiciness.** The juiciness scores remained essentially the same in all experiments. Again, difference between grades did not show any appreciable influence on the panel scores.

**Flavor of Fat.** As it would be expected, there was no apparent difference in flavor of fat regardless of days aged or the environmental conditions under which the product was held.

**Thawing and Cooking Losses.** Observations by Wierbicki at the Ohio Station that aged meats release less moisture during thawing and cooking than non-aged or product that has been aged for a short duration, is substantiated...
### TABLE I

**THE EFFECT OF ENVIRONMENTAL CONDITIONS ON SHRINKAGE, THAWING AND COOKING LOSSES AND PALATABILITY FACTORS**

<table>
<thead>
<tr>
<th>Product</th>
<th>Grade No.</th>
<th>Days Aged</th>
<th>Temp. (°F.)</th>
<th>Rel. Hum. (%)</th>
<th>Air Flow (LPM)</th>
<th>MOISTURE LOSSES (%)</th>
<th>PALATABILITY FACTORS</th>
<th>Flavor of Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooler Thawing Cooking</td>
<td>Tender-ness</td>
<td>Flavor Aroma Juiciness</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ribs¹</td>
<td>Good 7</td>
<td>6</td>
<td>36 80 20-25</td>
<td>3.48 1.74 25.13</td>
<td>4.51</td>
<td>5.10</td>
<td>5.21</td>
<td>4.53</td>
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<tr>
<td>Ribs⁺¹</td>
<td>Good 16</td>
<td>12</td>
<td>34 90 15-20</td>
<td>4.06 0.91 24.84</td>
<td>4.63</td>
<td>4.74</td>
<td>4.71</td>
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</tr>
<tr>
<td>Fore¹</td>
<td>Ch. 4</td>
<td>14</td>
<td>40 80 15-20</td>
<td>3.15 0.93 25.18</td>
<td>4.70</td>
<td>4.82</td>
<td>5.28</td>
<td>4.70</td>
</tr>
<tr>
<td>Hind²</td>
<td>Ch. 4</td>
<td>14</td>
<td>40 80 15-20</td>
<td>3.05 2.35 30.06</td>
<td>4.12</td>
<td>4.91</td>
<td>4.55</td>
<td>4.71</td>
</tr>
<tr>
<td>Fore¹</td>
<td>Good 4</td>
<td>14</td>
<td>40 80 15-20</td>
<td>5.25 1.31 25.04</td>
<td>5.15</td>
<td>4.85</td>
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<td>40 80 15-20</td>
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<tr>
<td>Fore¹</td>
<td>Good 8</td>
<td>3</td>
<td>36 90 25-30</td>
<td>2.20 0.82 31.09</td>
<td>4.15</td>
<td>4.70</td>
<td>4.58</td>
<td>4.22</td>
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<tr>
<td>Hind²</td>
<td>Good 8</td>
<td>3</td>
<td>36 90 25-30</td>
<td>2.08 3.56 33.83</td>
<td>4.02</td>
<td>4.43</td>
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<td>4.15</td>
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<tr>
<td>Hind³</td>
<td>Ch. 7</td>
<td>3</td>
<td>36 90 15-20</td>
<td>0.95 0.45 25.09</td>
<td>4.30</td>
<td>5.11</td>
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<tr>
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<td>3</td>
<td>36 90 15-20</td>
<td>0.95 2.53 22.41</td>
<td>5.08</td>
<td>5.30</td>
<td>5.05</td>
<td>5.70</td>
</tr>
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</table>

¹Rib steaks used for taste panel evaluation.
⁺Top round steaks were used for taste panel evaluation.
³T-bone steaks were used for taste panel evaluation.
by this report. As an example, we see that Good wholesale beef ribs aged 6
days lost substantially more moisture during thawing and cooking than did
comparable ribs aged 12 days. A further examination of the data reveals that
the top round steaks lost more moisture than the corresponding rib steaks due
to thawing and cooking.

SUMMARY

Choice and Good hindquarters, forequarters and wholesale ribs from
46 cattle weighing 800-850 pounds were aged at 36°F. This product was aged
under relative humidities varying from 80 to 90 per cent and air velocities
of 15 to 20 lineal feet per minute.

On the basis of the results, the following findings appear most
significant.

Grade, length of the aging period, and relative humidity of the
aging room are the critical factors affecting shrinkage. Tenderness, flavor,
aroma, juiciness, and flavor of fat values were determined.

The water holding capacity of the product increased with aging
since the aged product (12-14 days) released less moisture during thawing and
cooking than the product aged at shorter duration (3-6 days).

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DR. SCHULTZ: May I ask a quick question? Were these meats
frozen?

MR. SIEBETH: Yes, these were frozen. Just as soon as the
aging period was over they were frozen so that we could get them all on
the same basis, since we could have our taste panel's evaluations only
at a given time.

DR. SCHULTZ: What do you mean by environmental conditions
temperatures of 33 to 35?

MR. SIEBETH: Those are the environmental conditions in the
aging room, humidity, air flow and temperature.

MR. HENRICKSON: Thank you for pointing out some of the factors
that need to be considered in low temperature aging.

We will go right on to the next topic, that of aging at high
temperature. George Wilson. (Applause)

MR. GEORGE WILSON: Thank you, Bob.
Dr. Wang has described in some detail part of our studies on meat tenderization, that having to do with proteolytic enzymes, and I should like to describe another phase of our research on meat tenderness, the topic of this discussing being aging at high temperatures.

Dr. Deatherage has mentioned a number of things that could be and probably are related to meat tenderization during aging. I am sure that we subscribe to many of the points that he has brought out in his talk this morning. However, I think that we still will go along with the thesis that there is a time-temperature relationship taking place during aging, and this is supported in many places. Some of Dr. Deatherage's data this morning, the Tender Ray process of Kroger, is another example of it.

Until the advent of antibiotics and irradiation, a temperature of 60 or 65 degrees was the upper limit to which we could go in establishing this time-temperature relationship.
FIGURE 3 -- COOLER SHRINKAGE (MOISTURE EVAPORATION) FROM U. S. CHOICE GRADE BEEF HINDQUARTERS. Hindquarters aged 15-18 days, 33-35° F. and 88-92% R.H. Data collected for 52 weeks (Feb. 5, 1955-Jan. 28, 1956) and included 6,671,451 total pounds aged or an average of 125,877 lbs. per week.

Data from the warehouse of a major supermarket operator.
FIGURE 4 -- COOLER SHRINKAGE (MOISTURE EVAPORATION) FROM U. S. CHOICE GRADE BEEF FOREQUARTERS. Forequarters aged 5-7 days, 33-35°F. and 88-92% R. H. Data collected for 52 weeks (Feb. 5, 1955-Jan. 28, 1956) and included 8,236,222 total pounds aged or an average of 156,532 lbs. per week.

Data from the warehouse of a major supermarket operator.
FIGURE 5 -- COOLER SHRINKAGE (MOISTURE EVAPORATION) FROM U. S. CHOICE GRADE BEEF RIBS. Ribs aged 15-18 days, 33-35°F. and 88-92% R.H.
Data collected for 52 weeks (Feb. 5, 1955-Jan. 28, 1956) and included 1,019,655 total pounds aged or an average of 20,393 lbs. per week.
Data from the warehouse of a major supermarket operator.
FIGURE 6 -- COOLER SHRINKAGE (MOISTURE EVAPORATION) FROM U. S. CHOICE GRADE BEEF LOINS. Loins aged 18-21 days, 33-35°F and 88-92% R.H. Data collected for 50 weeks (Feb. 5, 1955-Jan. 28, 1956) and included 587,122 total pounds aged or an average of 20,565 lbs. per week.

Data from the warehouse of a major supermarket operator.