Inspection Systems and Mechanical Removal Systems for Bone and Cartilage Particles in Ground Beef Patties

B. W. BERRY* and E. C. GREEN

Meat Science Research Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland 20705 and Food Quality Assurance Branch, MRDD, AMS, USDA, Washington, D.C.

(Received for publication September 21, 1987)

ABSTRACT

Ground beef patties were processed from boneless beef which was subjected to two different inspection systems for bone and cartilage defects. One system permitted a higher ("high") level of defects (USDA Food Safety and Inspection Service, Meat and Poultry Inspection Requirements), while the other system (USDA PP-B-2120 Federal Purchasing Specification) permitted only a lower ("low") level of defects. Before formation into patties, the ground beef was subjected to three processing systems for defect removal (none, Weiler Bone Collector System, Speco Spiral Groove Plate System). A sensory approach (teeth and tongue) for detecting defects with cooked patty samples revealed more bone and cartilage defects in the "high" than the "low" formulation regardless of defect removal system. While the defect removal systems reduced the levels of detected defects in the "high" formulation, neither system produced patties with defect levels achieved through inspection procedures required to produce "low" levels of these defects. However, it appears that much of the bone remaining as a defect in boneless beef is reduced in size during grinding so as to be undetectable by sensory approaches.

Presence of bone and cartilage particles in ground beef is objectionable not only from an aesthetic aspect, but also from the consideration of consumer health and safety. There have been circumstances where dental injury has resulted from chewing ground beef containing bone and/or cartilage particles. The Agricultural Marketing Service of USDA has developed and used Federal Specifications for ground beef purchased by the U.S. government. These specifications include visual defect examination procedures for purposes of excluding bone and cartilage of sufficient size to be objectionable in ground beef and thus provide a safer product for end-users. Meat and Poultry Inspection (MPI) requirements performed by Food Safety and Inspection Service, USDA also include visual examination for bone and cartilage defects for all ground beef processed in USDA inspected establishments. However, these requirements are not as rigid as those detailed in Federal Specification PP-B-2120 (1). In both inspection systems, the visual examination for defects is performed on boneless trimmings just before grinding.

In 1984, the U.S. General Accounting Office (GAO) published a report (7) stating that the Federal Government could save about $20 million/year by eliminating the Federal Specifications on the ground beef it purchased and instead procuring commercial product. Certainly, not all of this $20 million savings would occur from just reducing the amount of examination for bone and cartilage in boneless beef. However, as a result of that GAO report and industry pressure, USDA amended its Purchaser's Specifications (2) by reducing the minimum number and size of bone and cartilage defects required for the product to be unacceptable. These amended Specifications were put into practice in 1984. Later amendments in 1984 (3) to the Federal Specifications stipulated that the degree of inspection for bone and cartilage would only be that required under USDA Meat and Poultry Inspection procedures (4).

The purpose of this study was to compare the level of bone and cartilage defects permitted under the Federal Specification (1) against those allowed in Meat and Poultry Inspection procedures (4) in terms of the amount of defects detected in cooked ground beef patties. This study also included a comparison of two defect removal systems. These systems are being used on a regular basis by ground beef processors (6).

MATERIALS AND METHODS

Product formulation

Three separate formulations of ground beef were processed in a commercial establishment that was processing ground beef for the School Lunch Program. Each formulation consisted of approximately 4545 kg of boneless beef trimming (triangles, rib caps, knuckles) from 80 U.S.D.A., Utility grade beef sides. A part of each formulation was comprised of approximately 250 U.S.D.A. Choice boneless plates which were used to adjust the fat content to 20 ± 1%.

The three separate formulations were made utilizing either "high" or "low" levels of bone and cartilage defects in the beef trimmings. The specific levels of bone and cartilage defects used in the formulations are illustrated in Table 1. "High" levels of

---

1Meat Science Research Laboratory.
2Food Quality Assurance Branch.
Defects in the trimmings were the result of application of MPI (4) inspection procedures, while "low" levels of defects arose from the use of Federal Purchase Specification inspection procedures (1). The use of the term "high" to identify MPI (4) regulations does not imply that high levels of bone and cartilage defects are permitted in beef trimmings under those regulations but rather is used in this paper to identify formulations. All defects were either left attached to the beef cuts during trimming or added directly to the trimmings during a 10-min pre-grind mixing (Rietz Mixer - Model RS - 28K5406). Trimmings were then ground through a 1.91-cm grinding plate using a Boldt meat grinder (Model SH 5778). The ground meat was then further mixed for 5 min before sampling for fat level using an Anyl Ray fat tester. Adjustments to insure 20 ± 1% fat were then made.

At this point each of the 4545 kg formulations were subdivided into thirds. One third of each formulation was ground through a 0.32-cm plate using a Weiler grinder (Model AG868). Another third of each formulation was ground through a 0.32-cm plate equipped with a Weiler Model BCA Bone Collector System (Weiler). The last third of each formulation was ground through a 0.32-cm plate which contained the Speco Spiral Groove Plate System (Speco) for removal of defects.

After this grinding step, the ground beef was formed into 85-g patties using a Formax 26 patty machine. Patties were stacked in boxes (16.3 kg/box) and frozen to -23°C in 72 h. The last eight boxes from each formulation-defect removal system combination were selected for testing. It was theorized that ground beef near the end of grinding for a given formulation-defect removal system might contain more bone and cartilage particles due to build-up during grinding behind the cutting blade and plate. The frozen patties were shipped to the USDA Meat Science Research Laboratory, Beltsville, MD for evaluation.

Cooking procedures

Patties were cooked from the frozen state on Farberware electric griddles (Model 101) using a griddle surface temperature of 177°C. Patties were cooked 2 min on one side and 3 min on the opposite side, followed by turning every 30 s for the remaining 3 min of the 8-min cooking cycle. Cooked patties were gently blotted with paper napkins before cutting and serving to panelists.

Sensory detection of defects

A 13-member panel was selected and trained to detect, isolate, identify and quantify particles of bone and cartilage in cooked ground beef. The procedure outlined in Table 2 was the result of a 3-month intensive effort by this panel using a wide array of experimentally and commercially prepared samples of ground beef. For a given formulation-defect removal system combination, samples (of the size identified in Table 2) were cut from patties immediately following cooking and served to each panelist. Each panelist received 20 samples for each formulation-defect removal system combination in a given day. After each panelist completed his/her evaluation of the 20 samples, trained laboratory personnel examined and validated the bone

TABLE 1. Levels of bone and cartilage permitted in beef trimmings for the three ground beef formulations.

<table>
<thead>
<tr>
<th>Level of bone or cartilage in beef trimmings</th>
<th>Bone</th>
<th>Cartilage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low for both bone and cartilage</td>
<td>Trimming performed so that for 252 kg examined out of 4545 kg, less than four pieces of bone were detected measuring 7.6 mm or more in any dimension. Also, less than five pieces of bone were found measuring 2.5 mm or more, but less than 7.6 mm in any dimension. Amounts do not exceed USDA Federal Specification PP-B-2120 inspection requirements (1).</td>
<td>Trimming performed so that for 252 kg examined out of 4545 kg, less than four pieces of cartilage were detected measuring 12.7 mm or more in any dimension. Also, less than five pieces of cartilage were found measuring 7.6 mm or more, but less than 12.7 mm in any dimension. Amounts do not exceed USDA Federal Specification PP-B-2120 inspection requirements (1).</td>
</tr>
<tr>
<td>High for bone and low for cartilage</td>
<td>For 4545 kg of trimmings, 300 bone pieces measuring 12.7 x 25.4 x &lt;76.0 mm were added directly. Six hundred bone slivers (500 of which attached to beef plate meat) measuring 3.0 x 12.7 x &lt;76.0 mm were added. Amounts do not exceed levels permitted in USDA Meat and Poultry inspection requirements (4).</td>
<td>Trimming performed so that for 252 kg examined out of 4545 kg, less than four pieces of cartilage were detected measuring 12.7 mm or more in any dimension. Also, less than five pieces of cartilage were found measuring 7.6 mm or more, but less than 12.7 mm in any dimension. Amounts do not exceed USDA Federal Specification PP-B-2120 inspection requirements (1).</td>
</tr>
<tr>
<td>High for cartilage and low for bone</td>
<td>Trimming performed so that for 252 kg examined out of 4545 kg, less than four pieces of bone were detected measuring 7.6 mm or more in any dimension. Also, less than five pieces of bone were found measuring 2.5 mm or more, but less than 7.6 mm in any dimension. Amounts do not exceed USDA Federal Specification PP-B-2120 inspection requirements (1).</td>
<td>For 4545 kg of trimmings, 80 pieces of scapula (one/chuck) having approximately a surface area of 25.8 cm² each, were left on beef chuck meat. Eighty pieces of scapula (one/chuck) having approximately a surface area of 12.9 cm² each, were left on beef chuck meat. Amounts do not exceed levels permitted in USDA Meat and Poultry inspection requirements (4).</td>
</tr>
</tbody>
</table>
TABLE 2. Procedure for sensory determination of bone and cartilage in ground beef patties.

Place 0.62 x 1.25 cm sample into mouth. Position the sample in mouth so that the long axis of the sample runs in a direction parallel to the length of the tongue. The crusty sides of the sample should be in a position perpendicular to the flat surface of the tongue.

Use the tongue to maneuver the sample through the incisors at a rate which permits complete examination of the sample in approximately 25 chews. Do not exceed the 25 chew limit. Use fewer than 25 chews only if the detected defect is extremely large in comparison to the overall sample size.

Use the incisors in a gently cutting and rolling action to separate the defect from the sample. The tongue and edges of incisors may be used as "feelers" to confirm the presence of a defect.

Once the defect has been detected, separate it from the meat fibers as completely as possible while the sample remains in your mouth.

Remove the isolated defect from your mouth and place on the paper plate. Avoid use of your hands except to remove isolated defects from your mouth.

Any defects remaining after you have swallowed the sample should be counted as detected on the final chew.

Rinse with water and use Melba Toast, as necessary, to eliminate carryover from one sample to the next one.

TABLE 3. Bone and cartilage particles detected in ground beef patties.

<table>
<thead>
<tr>
<th>Level of bone and cartilage in beef trimmings</th>
<th>Defect removal system</th>
<th>Number of pieces of bone detected</th>
<th>Number of pieces of cartilage detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low for both bone and cartilage*</td>
<td>None</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Weiler bone collector assembly</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Speco spiral groove plate</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>High for bone and cartilage</td>
<td>None</td>
<td>9c</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Weiler bone collector assembly</td>
<td>3d</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Speco spiral groove plate</td>
<td>3d</td>
<td>0</td>
</tr>
<tr>
<td>High for cartilage and low for bone</td>
<td>None</td>
<td>0</td>
<td>14c</td>
</tr>
<tr>
<td></td>
<td>Weiler bone collector assembly</td>
<td>0</td>
<td>12cd</td>
</tr>
<tr>
<td></td>
<td>Speco spiral groove plate</td>
<td>0</td>
<td>8d</td>
</tr>
</tbody>
</table>

*See Table 1 for definition of low and high levels.
*Number of pieces determined for the equivalent of 48 patties/bone or cartilage level-defect removal system combination.
*Differences significant (P<0.05) between low and high defect levels using Chi-square statistics. Values in the same column with different superscripts were different (P<0.05). For all other bone or cartilage level-defect removal system combinations, insufficient numbers exist for statistical comparisons.

and cartilage defects. The laboratory personnel used magnifying glasses and dissecting needles for this procedure.

The panel evaluated three sets of the 20 samples/day. Each set represented one of the three different defect removal systems for a given formulation. Approximately 3 h (including recesses) were required each day for the evaluations. Each formulation-defect removal system combination was evaluated eight different times and thus 24 d were required to complete the evaluations. The equivalent of 48 patties/formulation-defect removal system were evaluated.

Statistical analysis

Chi-Square statistics were used to test differences in the occurrence of bone and cartilage particles according to bone or cartilage level and defect removal system combinations. In some instances, insufficient numbers of defects were detected for statistical comparisons.

RESULTS

The values given in Table 3 clearly indicate that the "high" level of bone and cartilage left during trimming did indeed result in more bone and cartilage pieces being detected in the cooked patties compared to the "low" usage level of bone and cartilage. In fact, for the "low" level formulation, only one cartilage defect was found (when no defect removal system was used).

There is evidence for the formulations containing "high" (MPI inspection procedures) levels of bone and cartilage that the defect removal systems were effective in reducing the number of defects detected by the panelists. However, these systems did not reduce the numbers of detected bone and cartilage pieces to the levels found for product manufactured using the USDA PP-B-2120 ("low") Federal Specification (1). Also, there were no differences in the number of cartilage pieces found between no defect removal system and the Weiler system for the formulation containing the "high" level of cartilage in the boneless beef. The two defect removal systems were slightly more effective in removing bone than cartilage particles.

DISCUSSION

A sensory procedure for bone and cartilage detection in cooked ground beef was developed for this study and shown to be useful in separating formulations manufactured to
possess differences in these defect particles. For the formulation processed to have "high" bone defects and ground without a defect removal system, the number of bone particles found on a per patty basis was approximately 0.19. However, if one attempts to divide out all the bone added into the size of the bone particles detected (generally 0.12 cm maximum width) and assumes all the bone went into the product (basically true for the no defect removal system), then approximately 4.2 bone pieces/patty should have been found. It appears that a considerable amount of bone, and probably cartilage too, becomes reduced during grinding to such a small size as to be undetectable.

It is obvious from these data that application of the Federal Specification PP-B-2120 (1) inspection procedures was quite effective in reducing the amount of bone and cartilage particles in ground beef compared to commercial ground beef prepared under MPI (4) inspection regulations. GAO (7) states that 95% of U.S. ground beef production is manufactured under commercial (MPI) regulations. The question becomes whether the added cost of inspection for bone and cartilage under the Federal Specifications PP-B-2120 (1) for such a low proportion of all U.S. ground beef is worth the safety of preventing possible dental damage. For the individuals and ground beef processors (5) involved in law suits originating from dental damage from ground beef, one bone particle may be one too many. Since the defect removal systems evaluated in this study showed some promise of reducing bone and cartilage in the final product, greater effort should be directed toward improving their defect removal efficiency, while still being economical.

ACKNOWLEDGMENTS

Use of company or product names by the U.S. Department of Agriculture does not imply approval or recommendation of the product to the exclusion of others which may also be suitable. The authors gratefully acknowledge the support of the U.S. Army Natick Research and Development Center, the U.S. Defense Personnel Support Center, the Food Quality Assurance Branch, MRDD, AMS, USDA, and H and H Packing Co. This is a contributing project to Western Regional Research Project W-145.

REFERENCES