Effect of Different Packaging Treatments on Microbiological and Sensory Evaluation of Precooked Beef Roasts

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ABSTRACT

Thirty boneless top round roasts were used in each of two trials to determine the effects of various packaging treatments on precooked roast beef acceptability. Roasts were dry roasted to an internal temperature of 60°C, cooled for 1 h and packaged by one of three methods: (a) vacuum packaging, (b) packaging in 100% CO₂ atmosphere or (c) packaging in 15% CO₂:30% O₂:55% N₂ atmosphere. Roasts were held at 4°C for up to 21 d. Enumeration of mesophiles and psychrotrophs, sensory evaluations and shrinkage percentages were determined at 0, 7, 14 and 21 d of storage to evaluate acceptability. Counts of mesophiles and psychrotrophs from 100% CO₂-treated roasts were significantly lower (P<0.05) than counts from vacuum-packaged roasts after 14 and 21 d of storage, whereas counts from gas mixture-treated roasts were not (P>0.05) different. After 7 d of storage, microbial numbers were similar, regardless of treatment. Sensory evaluation analyses showed that vacuum-packaged roasts exhibited little deterioration of quality characteristics at 21 d of storage, whereas both gas-treated roasts demonstrated quality deterioration by 14 and 21 d of storage. Vacuum-packaged roasts were preferred by panelists at 14 and 21 d, but CO₂-treated roasts were preferred at 7 d. No treatment effects were evident upon shrinkage until 21 storage days. At 21 d, vacuum-packaged roasts exhibited the lowest moisture loss.

The market for whole, precooked roast beef currently consists of fast-food restaurants and delicatessens, where it is sliced for sandwiches. With the increased demand for table-ready meals, however, it is feasible to assume that whole, precooked roast beef may soon be sold on the grocery shelf. Product shelf-life must first be investigated to maximize storage time and maintain acceptability.

Much research has been conducted to study the shelf-life of fresh beef cuts that have been vacuum packaged or stored in various gas atmospheres (2,3,10,15). Numerous reports are available on the inhibitory effect of vacuum packaging and high levels of carbon dioxide on common spoilage organisms (4,6,9,13). With fresh beef, color is negatively affected by the absence of oxygen. Therefore, many studies have been done using mixtures of carbon dioxide and oxygen for the purpose of inhibiting microbial growth as well as retaining the desirable color of fresh beef.

The effect of gas atmosphere usage for precooked roast beef has not been reported. Whether the effects of gas atmospheres on precooked beef would be similar to those seen on fresh beef is questionable. The objective of this study was to determine the effects of packaging procedure on both microbial and sensory qualities of precooked roast beef.

MATERIALS AND METHODS

Preparation of samples

Boneless top round roasts obtained from a local meat wholesaler were used in two separate trials. Top rounds were removed 7 d postmortem from carcasses that graded high good to low choice. In the first trial, fifteen roasts were cut by the wholesaler to weigh approx. 3 kg, vacuum packaged and transported to the Meats Laboratory. The roasts were dry roasted (uncovered) on aluminum racks in a 107°C convection oven to an internal temperature of 60°C measured with YSI model 42SC meat thermometers. After cooking, roasts were cooled (uncovered) at room temperature for 1 h, then cut in half to yield thirty 1- to 1.5-kg roasts. The roasts were weighted, placed on styrofoam trays and randomly assigned to one of three packaging treatments.

The second trial differed only in that thirty 1- to 1.5-kg roasts were initially cut by the wholesaler. Weights were recorded before cooking and after the 1-h cooling period. Cooking losses were calculated only in the second trial and not the first because of an error in gathering data.

Of the thirty roasts in each trial, nine were assigned to each packaging treatment. Three roasts served as controls. Since all thirty roasts were treated the same before cooking and since time limitations existed on sampling procedures, it was determined only three roasts were needed to adequately represent the group. The packaging treatments used were: (a) vacuum packaging; (b) packaging in 100% CO₂ gas atmosphere sealed; and (c) packaging in 15% CO₂:30% O₂:55% N₂ gas atmosphere and sealed. Cryovac type B620SP barrier bags were used for all treatments. The roasts were placed in open top meat display cases and held at 4°C up to 21 d.

The roasts were sampled on days 0, 7, 14 and 21. Control roasts on day 0 were sampled for microbial numbers, both before cooking and after the 1-h cooling period. On the other sampling days, pre-selected roasts were removed from the meat cases, unwrapped, weighed and sampled for enumeration of mesophiles and psychrotrophs. Roasts were then sliced into 0.3-cm slices the day before the taste panel for convenience. Slices were refrigerated overnight in laminated meat wrapping paper and examined the following day for sensory characteristics.
Enumeration of mesophilic and psychrotrophic organisms

Each roast was sampled by taking ten core samples, (2.2 cm diam., 0.5 cm thick). This was accomplished using an alcohol-sterilized coring tool and then slicing the desired thickness with an alcohol-sterilized knife. The ten core samples were weighed and homogenized with sterile phosphate buffered water for 2 min. Serial dilutions were made and aerobic pour plates prepared in duplicate using plate count agar (Difco). Mesophilic plates were incubated at 35°C for 2 d. Psychrotrophic plates were incubated at 6°C for 9 d. Results are reported as log10 numbers of mesophiles or psychrotrophs per gram of roast.

Sensory evaluation

Selection and training of the descriptive panel was conducted according to procedures described by Cross et al. (5). Panelists received three samples from the three control roasts. Six total samples, two from each of the three treatments, were presented on days 7, 14 and 21. Rectangular pieces (approx. 4 cm by 6 cm) were cut from each slice and placed in a small glass bowl, each bowl containing all rectangular pieces from the same roast. Samples were heated by placing the glass bowl in a Litton microwave oven (Model 418) for 1 min on reheat setting, then kept warm under a heat lamp until served. Panelists received one sample at a time. Each sample was coded with a three digit number and presented on a disposable plate. Testing was done in partitioned, white testing booths under combined fluorescent lighting and sunlight. Booths were set with disposable plasticware, evaluation sheet, pencil and glass of ambient water.

The same panelists were used throughout each trial with a minimum of ten judges for each testing day. The panel members consisted of university students and employees, 53% male and 47% female. Judges were asked to evaluate samples for appearance, color, aroma, juiciness, tenderness and overall acceptability. Samples were scored on a sliding hedonic scale (12), with endpoints labeled ‘dislike very much’ or ‘extremely undesirable’ to ‘like very much’ or ‘highly desirable’. Flavor was scored for intensity ranging from ‘extremely bland’ to ‘extremely intense’. Analysis was done by breaking the scale into nine increments on the basis that 0 = ‘dislike very much’ or ‘extremely undesirable’ and 8 = ‘like very much’ or ‘high desirable’. In addition, panelists were asked to complete a Food Action Rating Scale (14) by checking one of nine statements that would most closely represent their action. For analysis, statements were given numerical values of 1 = ‘I would eat this if I were forced to’ to 9 = ‘I would eat this every opportunity I had’.

Shrinkage

Shrinkage due to cooking losses was determined only in the second trial by the difference of raw roast weight and cooked, cooled roast weight. This difference, expressed as a percentage of the raw roast weight, was the shrinkage percent.

Shrinkage due to gas treatment was determined in both trials by the initial weight of the cooked, cooled roast and its weight on sampling day. Percentages were then calculated.

Statistical analysis

Data were analyzed by analysis of variance according to Nie et al. (11). Because numerous significant (P<0.05) interactions were observed between the main effects tested (days and treatments), a hierarchical statistical design was used by nesting the experimental units. A one-way Duncan’s multiple range test was done to compare days within treatments and treatments within days.

RESULTS AND DISCUSSION

Mesophilic and psychrotrophs

Packaging treatment effects upon mesophilic and psychrotrophic organisms for the 21-d storage period at 4°C are presented in Table 1. Data were evaluated before analysis to check for experimental error. Separate data from Trials I and II were similar, therefore facilitating pooled data from both trials. All data are reported as pooled data.

<table>
<thead>
<tr>
<th>Day</th>
<th>Microorganism</th>
<th>Vacuum</th>
<th>CO₂</th>
<th>Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Mesophile</td>
<td>3.42&lt;sup&gt;e&lt;/sup&gt;</td>
<td>4.18</td>
<td>3.70</td>
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<td>14</td>
<td>Mesophile</td>
<td>3.07</td>
<td>3.63</td>
<td>1.97</td>
</tr>
<tr>
<td>21</td>
<td>Mesophile</td>
<td>6.87&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.78</td>
<td>5.12&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Psychrotroph</td>
<td>6.78&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.45</td>
<td>5.13&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>Psychrotroph</td>
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<td>6.48&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>Psychrotroph</td>
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<td>5.23&lt;sup&gt;e&lt;/sup&gt;</td>
<td>6.40&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Day 0 cooked roasts after cooling, mesophiles = log<sub>10</sub> 4.98/g and psychrotrophs log<sub>10</sub> 0/g.

<sup>b</sup>Vacuum, vacuum-packaged roasts; CO₂, roasts packaged in 100% CO₂; mixture, roasts packaged in 15% CO₂:30% O₂:55% N₂.

<sup>c</sup>Means of log<sub>10</sub> per g.

<sup>d</sup>Means in the same row bearing unlike superscripts differ significantly (P<0.05).

Mesophilic and psychrotrophic counts were similar for all treatments after 7 d of storage. However, after 14 and 21 d of storage, vacuum-packed roasts had significantly (P<0.05) greater numbers of mesophiles and psychrotrophs than roasts packaged in 100% CO₂. Roasts packaged in 15% CO₂:30% O₂:55% N₂ were not (P>0.05) different from the other two treatments in organism numbers, but mesophilic and psychrotrophic numbers were consistently lower than the vacuum-packaged roasts and higher than the 100% CO₂-treated roasts. These results concur with reports in the literature (4,16,17) that demonstrate the inhibitory effects of increasing amounts of carbon dioxide on aerobic microorganisms.

Microorganism enumeration on roasts removed immediately from the oven was not done because preliminary investigation showed all psychrotrophs and at least 99.9% of all mesophiles were killed during the cooking process. Mesophilic and psychrotrophic counts of cooked roasts after the 1-h cooling period (control roasts) are shown by a footnote in Table 1. Mesophiles were higher in number on day 0 than mesophiles from any of the treatments after 7 d of storage. This lag in microbial growth has been observed in other studies (7,8) and may be explained as an adjustment period required by the microorganisms for adaptation to the new environment. After the 7-d period, however, treatment effects began to show. It became evident that the growth of mesophiles and psychrotrophs on precooked roast beef was most greatly hindered by packaging in 100% CO₂ and least affected by vacuum packaging of the three treatments used.

Sensory evaluation

Results of sensory panel testing are shown in Tables 2 and 3. Similar results from Trials I and II permitted pooled data from both trials.

Deterioration of roast quality occurred as storage time increased, as shown by decreased sensory scores (Table 2). Sensory scores for food action ratings for vacuum-pack-
aged roasts were not different (P>0.05) throughout the 21-d storage period. The roasts packaged in the atmospheres possessed lower (P<0.05) sensory scores at 14 and 21 d of storage as compared to the values after 7 d of storage. The only exception was that tenderness of the mixture-treated roasts was rated higher on day 14 than on day 7, although not significantly. The 100% CO₂-treated roasts were significantly lower in all quality characteristics, except tenderness after 14 d of storage. Furthermore, by 14 d the food action rating was rated higher on day 14 than on day 7, although only the exception was that tenderness of the mixture-treated roasts was rated slightly higher in quality after 14 and 21 d of storage. After 7 storage days, the 100% CO₂-treated roasts appeared more preferable, although only appearance and tenderness were rated significantly (P<0.05) different throughout the 21-d storage period.

These results were fairly consistent with observations made by the authors. As each roast was removed from its package on the testing days, notes were made on overall appearance of the whole cooked roasts. The vacuum-packaged roasts consistently retained the healthy bloom appearance that they had acquired immediately after cooking. The roasts stored in the two gases lost this bloom by 7 d of storage in Trial II and by 14 d of storage in Trial I. They appeared as a pale, gray-brown color with dull gray patches of fat covering the surface.

Data in Table 3 consist of treatment effects within days. No clear trends exist, except that vacuum-treated roasts were rated slightly higher in quality after 14 and 21 d of storage. After 7 storage days, the 100% CO₂-treated roasts appeared most favorable. Appearance, color, juiciness, and the food action rating were all rated significantly (P<0.05) higher for the 100% CO₂-treated roasts as compared to the other two treatments. By day 14, however, vacuum-treated roasts appeared more preferable, although only appearance and tenderness were rated significantly (P<0.05) higher. The vacuum treatment was also more favorable after 21 d, although only juiciness was rated significantly (P<0.05) higher.

### TABLE 2. Sensory panel ratings of precooked roasts given different packaging treatments presented as days within treatment.

<table>
<thead>
<tr>
<th>Sensory characteristics</th>
<th>Vacuum</th>
<th>CO₂</th>
<th>Mixture</th>
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</thead>
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<tr>
<td>Day 7</td>
<td>Day 14</td>
<td>Day 21</td>
<td>Day 7</td>
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<tr>
<td>Appearance</td>
<td>3.90</td>
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<td>Color</td>
<td>3.81</td>
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<td>Aroma</td>
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<td>3.93</td>
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<td>Juiciness</td>
<td>3.62</td>
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<td>3.43</td>
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<tr>
<td>Tenderness</td>
<td>4.17</td>
<td>4.03</td>
<td>4.22</td>
</tr>
<tr>
<td>Flavor</td>
<td>4.01</td>
<td>4.05</td>
<td>3.98</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>3.76</td>
<td>4.00</td>
<td>3.94</td>
</tr>
<tr>
<td>Food action rating</td>
<td>5.64</td>
<td>5.83</td>
<td>5.20</td>
</tr>
</tbody>
</table>

aVacuum, vacuum-packaged roasts; CO₂, roasts packaged in 100% CO₂; mixture, roasts packaged in 15% CO₂:30% O₂:55% N₂.
bHigher numbers indicate more desirable appearance, color, aroma, acceptability; higher juiciness or tenderness; or more intense flavor.
c9, “I would eat this every opportunity I had” and 1, “I would eat this if I were forced to”.
dMeans in same row within treatment bearing unlike superscripts differ significantly (P<0.05).

### TABLE 3. Sensory panel ratings of precooked roasts given different packaging treatments presented as treatments within days.

<table>
<thead>
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<th>Mixture</th>
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<tr>
<td>Day 7</td>
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<td>Day 21</td>
<td>Day 7</td>
<td>Day 14</td>
<td>Day 21</td>
<td>Day 7</td>
<td>Day 14</td>
<td>Day 21</td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td>3.90</td>
<td>4.88</td>
<td>4.26</td>
<td>4.39</td>
<td>3.72</td>
<td>4.10</td>
<td>3.76</td>
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<td>Color</td>
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<td>Aroma</td>
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<td>Juiciness</td>
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<td>Tenderness</td>
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<td>Flavor</td>
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<td>3.87</td>
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<tr>
<td>Overall acceptability</td>
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<td>3.83</td>
<td>4.00</td>
<td>3.76</td>
<td>3.81</td>
<td>3.94</td>
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<td>Food action rating</td>
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<td>5.16</td>
<td>5.55</td>
<td>5.20</td>
<td>5.10</td>
<td>4.78</td>
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</table>

aVacuum, vacuum-packaged roasts; CO₂, roasts packaged in 100% CO₂; mixture, roasts packaged in 15% CO₂:30% O₂:55% N₂.
bHigher numbers indicate more desirable appearance, color, aroma, acceptability; higher juiciness or tenderness; or more intense flavor.
c9, “I would eat this every opportunity I had” and 1, “I would eat this if I were forced to”.
dMeans in same row within treatment bearing unlike superscripts differ significantly (P<0.05).
One noteworthy observation was that the use of microwave oven to reheat the roast samples for the taste panel may have concealed some treatment effects. After heating in the microwave, samples appeared unevenly cooked, evidenced by dried, turned up edges on some slices, but not all. This observation concurs with Voris and van Duyne (18) who noted uneven microwave cooking of top round beef roasts.

Shrinkage

Shrinkage of roasts within treatments are presented as pooled data in Table 4. Shrinkage was similar for roasts after 7 and 14 d of storage, regardless of treatment. By 21 d of storage, vacuum-packaged roasts were significantly (P<0.05) lower in moisture loss compared to roasts packaged in the gas mixture. And, vacuum-packaged roasts exhibited considerably lower shrinkage than CO2-treated roasts, although not significant (P>0.05). Roasts from both gas treatments exhibited large amounts of brown purge, whereas the vacuum-packaged roasts did not.

Total cooking losses ranged from 15.8 to 25.2%, with an average of 20.4%. Cooking loss values in this study were considerably higher than those reported by Buck et al. (1) of 10.1 to 17.5%.

Although the use of carbon dioxide, oxygen and nitrogen mixed gases has color quality benefits for fresh beef, these same benefits were not apparent for cooked beef. The 100% CO2 atmosphere was most desirable from a microbiological standpoint by inhibiting mesophiles and psychrotrophs most effectively. However, vacuum-packaged roasts had a slight advantage from a sensory standpoint and in moisture loss. More research in this area is needed for a better understanding of the sensory quality advantages of vacuum-packaged cooked beef as compared to 100% CO2-packaged cooked beef. Also, the optimum packaging treatment for cooked roast beef may involve a combination of treatments such as flushing roasts with 100% CO2 for its bacteriostatic effects, then vacuum packaging for the actual storage period.

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REFERENCES