Microbiological Condition of Restructured Steaks Prepared From Pre- and Postrigor Beef

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ABSTRACT

In two experiments the microbiological quality of restructured steaks prepared from hot and cold boned beef was investigated. Half of each electrically stimulated carcass was hot boned (ca. 45 min postmortem), and the other side was deboned after 20-24 h chilling. For both experiments, defatted desinewed neck and flank muscles were flaked, and 1% NaCl was added to half of the meat batches. In experiment 1, meat batches were stored at -40°C for ca. 1 month, then tempered, restructured into steaks and refrozen. In experiment 2, restructuring of the hot boned meat followed the flaking process, then steaks were stored at -40°C. After thawing, steaks were stored at 1±1°C until sampled. Sampling occurred after 1, 4, 8, 11 and 15 d in experiment 1 and after 1 and 7 d in experiment 2, and included assays for aerobic mesophilic and psychrotrophic colony counts and Enterobacteriaceae. Results of experiment 1 indicated that deboning treatment did not affect bacterial numbers significantly. Initially, contamination levels were low (ca. 4 log CFU/g) and spoilage occurred after ≥8 d of storage. In experiment 2, deboning treatment had a significant effect on bacterial growth. Initial (mesophilic and psychrotrophic) contamination was lower on hot processed steaks, yet after 7 d of refrigerated storage, bacterial numbers were higher (p<0.95) on hot vs. cold boned steaks.

Experiments 1 and 2 showed that salt did not affect bacterial growth.

Restructuring of raw meats allows the upgrading of low-valued primals or trimmings into desirable meat products of uniform size, shape, and texture. Furthermore, the uniform portion control, consistent tenderness, and flavor comply with the requirements of the hotel, restaurant, and institutional trade.

Electrical stimulation, hot boning and vacuum packaging, singly or collectively, offer many advantages to the meat industry. Hot boning reportedly results in improved energy conservation and efficiency, higher meat yields, shorter processing times and substantial financial savings (3, 9, 20, 23). Also, several studies have demonstrated that the use of prerigor meat might be advantageous with respect to processing characteristics such as water-holding capacity (3,22,26), higher emulsifying capacity (25), and lower cooking losses (17). Limited practical experience with restructuring of hot boned meat indicates that hot processing may indeed have advantages (2, 19).

Published data on the microbiological condition of restructured products prepared from prerigor meats are scarce. Hence, reports on comminuted, but not restructured, prerigor processed products are often used as a reference, although these do not offer conclusive evidence. Emswiler and Kotula (4) and McMillan et al. (12) suggest that only minor differences exist in the microbiological condition of ground beef processed from hot and cold deboned beef carcasses. However, Lin et al. (11) found higher bacterial counts in prerigor processed pork sausage. Similarly, Newsome et al. (15) observed significantly higher contamination levels in restructured steaks prepared from prerigor meat.

Before the introduction of a new food processing technology, the impact of that process on product shelf life and potential health hazards must be assessed. Further research on microbiological quality is needed before restructuring of hot processed beef may be unconditionally endorsed. The present study was designed to establish the shelf life of restructured beef steaks prepared from electrically stimulated hot and cold boned beef.

MATERIALS AND METHODS

Experimental

A total of twelve 4- to 6-year-old cows was used in this study. Immediately after exsanguination, carcasses were electrically stimulated (85 V, 14 Hz, 30 s).

Flank and neck muscles were excised from the right carcass sides at approximately 45 min postmortem (hot processing treatment). Left sides were chilled for 1 1/2 h at -3 to -5°C at an air velocity of 3 m/s and subsequently stored at 1±1°C for 20-24 h, whereas the counterpart muscles were excised from the chilled carcass side.

After excision the meat was defatted, desinewed and cut into smaller pieces (ca. 2 cm³).

Experiment 1. The process of flaking was done with the Comitrol® 1700 (Urschel, Wijk bij Duurstede, The Netherlands) equipped with a 6-mm flaking head, at a rotational speed of 3600 rpm. The flaked meat was either mixed with 1% sodium chloride in a Hobart® blender (Model AE 120) for 5 min, or remained unsalted.

Meat batches were packed in plastic bags, handpressed to an approximate thickness of 4 cm, quickly frozen, and stored at -40°C.
One day before forming, the meat packs were placed at 4±1°C, and restructuring was carried out with meat having a temperature of ca. -2°C. The VM 400 HD restructuring equipment (Koppens Machinefabriek B.V., Bakel, The Netherlands) was used at a pressure of 70 or 140 atm to press steaks with 0 or 1% salt, respectively. The forming plate was 10 mm thick and had three circular holes of 110 mm diameter.

Restructured steaks were wrapped with an oxygen-permeable film, put in cardboard boxes, and frozen and stored at -40°C. One day before sampling, frozen steaks were placed on a plastic tray, wrapped with an oxygen-permeable film, and stored at 1±1°C. The next day, and after 4, 8, 11, and 15 d of refrigerated storage, steaks (n=6 for each group) were sampled to determine the bacterial load.

**Experiment 2.** Meat was divided into two portions, then half was flaked with the 6-mm head and the remainder was processed using a 19-mm head of the Comitrol® 1700, both at a rotational speed of 5400 rpm. The flaked meat was mixed for 2 min in a Hobart® blender, then 0 or 1% sodium chloride was added, and the meat was mixed for an additional 3 min.

The meat was restructured using the equipment and pressure described for experiment 1. Hot boned meat was restructured immediately and cold boned meat was restructured after frozen storage (as in experiment 1). The hot and cold processed steaks were frozen and stored at -40°C. One day before sampling steaks were thawed as in experiment 1. Steaks were sampled the next day and after 7 d of storage at 1±1°C.

**Microbiological examination**

Sampling was done by a destructive method (24). From each treatment group, six steaks were sampled. After maceration of 10 g meat in 90 ml of peptone saline solution (0.9% NaCl) in a Stomacher, numbers of colony forming units (CFU) of the following microorganisms were assessed in the macerate (of which 1 ml represented 0.1 g meat; 5):

a. Aerobic mesophilic colony count: in poured plates of tryptone glucose beef extract agar (Difco 0002, Detroit, MI); incubation 3 d at 30°C.

b. Aerobic psychrotrophic colony count: on spread plates of tryptone glucose beef extract agar (Difco 0002); incubation 14 d at 4°C.

c. Enterobacteriaceae: in poured plates of violet red bile glucose agar (Oxoid CM484, Basingstoke, UK) with overlayer; incubation 20 h at 30°C.

**Results and discussion**

Figure 1 presents results of the bacteriological examination of the steaks prepared from flank muscles in experiment 1. The results on the steaks prepared from the neck muscles were similar and are not presented. As expected, bacterial loads increased considerably during storage. However, the initial contamination was relatively low, with aerobic mesophilic colony counts of 4.4-6.6-log units (13,16). Noticeable microbial spoilage, as evidenced by sliminess and off-odors, occurred not earlier than after 8-11 d. Neither time of processing (pre- vs. postrigor) nor addition of salt significantly affected bacterial numbers at any time.

Numbers of Enterobacteriaceae were very low, nearly always below the limit of detection, and therefore these data are not presented.

Hot processing might be expected to affect the bacterial quality of meat products for various reasons. The higher temperature and sticky surface of the meat may increase the risk of contamination and enhance the growth rate resulting in higher bacterial loads. Therefore, special procedures, such as boning ‘on the rail’ and intensified cleaning and disinfection of boning utensils, have been proposed to reduce the initial level of contamination (21). Although in our experiment the hot meat was boned without any of these special precautions, the initial contamination of both the hot and cold processed products was fairly low. This is probably due to the fact that the primals used in our experiment (i.e., the flank and neck) generally have little contact with cutting tables during boning, and consequently, the risk of cross-contamination is relatively small. Also, the restructuring was performed while the meat was still frozen.

The growth rate of bacteria appeared to be similar on hot and cold processed steaks. In our study the temperature of the hot deboned meat remained high for only a short period (<1 h). We hypothesized that hot processing according to this procedure would not significantly affect bacterial numbers since for ground meat (prepared from cold boned meat), it has been established that such a short exposure to high temperatures (25-35°C) immediately after comminution has no effect on the bacterial growth during subsequent refrigerated storage (Dr. Karl Dijkmann, personal communication).
The effect of salt addition was not consistent and observed differences were never significant. Salt can act as a bacteriostatic agent; some bacteria are inhibited by salt concentrations as low as 1%. However, the majority is not affected by concentrations up to 7.5% (1). In contrast to direct inhibition, the addition of salt to prerigor meat may affect bacteriological growth indirectly by maintaining the high pH of prerigor meat for some time (7) which possibly stimulates bacterial growth. However, this would result in pH differences that are generally small (ranging from 0.2 to 0.5 pH units (7)), and it seems unlikely that this would seriously affect bacterial growth (6).

TABLE 1. The effects of time of processing and salt addition on the aerobic mesophilic (AM) and aerobic psychrotrophic (AP) colony counts of restructured steaks prepared from hot and cold boned beef flank after 1 and 7 d of storage at 1+1°C (means expressed as log\textsubscript{10} CFU/g, n=6; experiment 2.)

<table>
<thead>
<tr>
<th>Storage time (days)</th>
<th>Hot processed</th>
<th>Cold processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Salt</td>
<td>1% Salt</td>
</tr>
<tr>
<td>1</td>
<td>AM 4.65\textsuperscript{a1}</td>
<td>4.63\textsuperscript{a}</td>
</tr>
<tr>
<td></td>
<td>AP 3.94\textsuperscript{a}</td>
<td>3.90\textsuperscript{a}</td>
</tr>
<tr>
<td>7</td>
<td>AM 6.02\textsuperscript{a}</td>
<td>5.77\textsuperscript{a}</td>
</tr>
<tr>
<td></td>
<td>AP 6.25\textsuperscript{a}</td>
<td>6.06\textsuperscript{a}</td>
</tr>
</tbody>
</table>

(1) In a horizontal row, numbers with same superscript letter are not different (p>0.05).

The procedure followed in the first experiment (hot or cold boning, freezing, thawing and restructuring) did not appreciably affect the physical-chemical characteristics of the restructured products (18). Therefore, the second experiment was performed, in which steaks were restructured immediately after flaking (c.q. before freezing). Results of the bacteriological examination are presented in Table 1. Numbers of Enterobacteriaceae were below the limit of detection (<7 CFU/g meat) and are therefore not presented. Again, as in experiment 1, salt addition did not affect bacterial numbers. However, time of processing (pre- or post rigor) had a significant effect on bacterial growth, the level of contamination of hot processed steaks being slightly lower initially but significantly higher after 7 d of refrigerated storage. This is in contrast to experiment 1 in which the time of processing did not appear to affect bacterial growth. It is unlikely that this contrast resulted from differences in pH and/or temperature of hot and cold processed meat. Possibly bacterial injury due to the freezing/thawing/freezing cycle (10) (occurring in cold but not in hot processing!) or other factors related to the restructuring of hot meat are involved. The observed differences between results of experiments 1 and 2 stress the importance of microbiological monitoring whenever procedures are changed. Apparently even minor changes in processing procedures such as freezing after, rather than before, restructuring, may have serious microbiological implications.

The slightly higher colony counts of the hot processed restructured steaks (5.8 to 6.0 log\textsubscript{10} after 7 d storage, in experiment 2) are still well below any reference value for comminuted meat products (10,13). Furthermore, the refrigerated storage period (7 d) was relatively long for this type of product. It is not common practice to store a previously-frozen product for such a long time. With products having shorter storage times, differences in bacterial growth between hot and cold processed products will likely be less noticeable.

It may be concluded that, in products made from frozen meat, the time of deboning has little effect on the microbiological quality of restructured steaks. In products made from frozen meat and then refrozen after restructuring, the freeze-thaw cycle may be a more important determinant of bacterial growth than previous handling treatments, such as hot processing.

REFERENCES

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