The effect of early post mortem storage conditions on sensory and bacteriological quality of electrically stimulated, hot boned beef longissimus

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INTRODUCTION

Hot boning may theoretically result in a muscle shortening that adversely affects meat tenderness. Since hot boned primal cuts will chill faster than carcasses an additional shortening may occur. However, the first experiments on hot boning of beef already showed that conditioning of hot boned meat at temperatures of 15 °C followed by chilling at 2 °C will prevent toughening (Schmidt and Gilbert, 1970; Schmidt and Keman, 1974). Postponing boning until 8 hours post mortem was found equally effective in overcoming tenderness disadvantages (Kastner and Russell, 1975; Kastner et al., 1973).

Since its introduction electrical stimulation has paved the way for an increased interest in hot boning. By accelerating the onset of rigor mortis electrical stimulation may eliminate tenderness problems associated with pre-rigor excision (Davey et al, 1976; Gilbert et al, 1979; Seideman et al, 1979; Taylor et al, 1980). Superimposing high temperature conditioning on the electrical stimulation and hot boning treatment was reported to significantly improve tenderness (Chrystall, 1982).

From a bacteriological point of view, however, excessive times at elevated temperatures are disadvantageous since they allow microbial proliferation on hot boned meat (Kotula, 1981). Minimizing the initial contamination by strict hygiene and/or sanitation may restrict bacterial growth (Buchter, 1982; Smulders and Woolthuis, 1983). However it seems that particularly initial chilling will substantially restrict the level of contamination of hot boned meat (Walker, 1982). Cuthbertson (1982) reported that a rapid initial chilling resulted in bacterial numbers not exceeding those of conventionally boned meat. In spite of the application of electrical stimulation in the latter study this was achieved at the expense of some toughening.

Purpose of the present study was to monitor the effects of various conditioning temperatures on the sensory and bacteriological quality of electrically stimulated, hot boned beef.

MATERIALS AND METHODS

Six approximately 13 months old meat bulls of the Meuse Rhine Yssel (MRY-) breed were stimulated electrically within 5 min. post mortem (85V, 14Hz, 30 s). Within 1½ hours post mortem both left- and righthand longissimus muscles were hot boned and sampled for bacteriological examination.

The caudal part of each longissimus muscle up to the 3-5th rib was divided in equal "cuts" of approximately 10 cm thick. From five randomly distributed locations on the cross section of each cut samples were taken for sarcomere lenghts measurements according to Voyles procedure (1971). The cranial parts were cut into 2 cm thick "chops" which were ran through a culture of bacteria prepared from scrapings of cutting tables in an attempt to simulate a higher degree of cross contamination.

Cuts and chops of each animal were vacuum packaged and randomly distributed over water baths of 0, 10, 15, 25 and 35 °C in which they remained for 3, 5 or 7 hours. Within the framework of this presentation only the 5 hours conditioning period will be dealth with. A rough estimation of the rapidity of glycolysis was obtained by monitoring the pH and temperature fall of one single longissimus cut per bath, fully submerged in an open vacuum bag. After conditioning cuts and chops were stored in a chilling room at 3 ± 1 °C for 8 days. At day 9 cuts were unpacked and investigated sensorically and bacteriologically.

Evaluation of sensory meat quality

After samples had been mopped dry and weighed to assess dripp loss. They were exposed to air for one hour. Subsequently colour was assessed using the Hunter L, a, b equipment. After heating in a water bath to a core temperature of 70 °C cooking loss was assessed. Using a mechanically driven borer cilynders of 1 cm^2, excised from the cooked samples, were subjected to Instron Warner Bratzler shear force measurements.

Bacteriological examination

The culture of bacteria originating from the cutting tables was prepared by adding 300 g scrapings to 2700 ml peptone-saline solution. After 30 min of stirring and sieving the suspension was frozen. Yhe day before the experiment the frozen culture was allowed to thaw in the refrigerator at 4 ± 1 °C. The number of bacteria in the suspension was assessed after 2 hours of resuscitation at ambient temperatures.

Longissimus cuts were sampled by means of sterile cork borers, lancets and tweezers. Thus 2 tissue discs of approximately 4.5 cm^2 were punched out, subsequently macerated in 27 ml peptone- saline solution in a Stomacher and resuscitated for 1½-2 hours. Numbers of colony forming units (cfu) of the following micro organisms were ultimately assessed in a macerate of which 1 ml corresponds to a sample of 0.33 cm^2:

a) Aerobic colony count: in poured plates of Tryptone Glucose Beef extract Agar (Difco 0002-01); incubation 3d at 30 °C and 14 d at 4 °C. b) *Enterobacteriaceae:* in poured plates of Violet Red Bile Glucose agar (Oxoïd CM 485) with overlayer; incubation 20 h at 37 °C (Mossel et al, 1962) c) *Lactobacillaceae:* on spread plates of acid acetate agar (Merck Art. nr. 5413); anaerobic incubation 48 h at 30 °C (Gonzalez et al 1971) d) Lancefield group D streptococci: on spread plates of Kanamycin Aesculin Azide (KAA) agar (Oxoïd CM 481); incubation 18 to 20 h at 37 °C (Althaus et al, 1982).

Mathematical analysis of data

Significance of differences were assessed by Student t-tests. To determine significance of differences in bacterial colony counts, samples with less than 7 colonies in the first decimal dilution plate and therefore inappropriate for colony assessment (Mossel and Drion, 1954) were assigned counts corresponding with the limit of detection.

RESULTS AND DISCUSSION

Sensory meat quality

Figure 1 and Table 1 present the temperature- and pH decline as measured in single longissimus cuts until 7 hours post mortem.

Since heat transmission appears to be mainly dependent on physical variables such as muscle volume the graphs of Fig. 1 may be a reasonable estimation of the actual temperature decline in all samples. The graphs show that the core

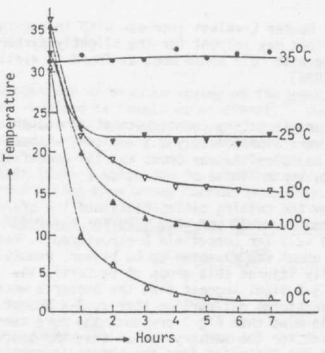

Table 1

Conditioning temperatures

	0°C	10°C	15°C	25°C	35°C
Hours post mortem					
1½▽	6.3	6.1	6.0	6.0	6.0
2½	6.1	6.0	5.9	5.8	6.0
3½	5.9	5.8	5.7	5.8	5.9
4½	5.9	5.8	5.6	5.6	5.6
5½	5.9	5.7	5.6	5.6	5.6
6½	6.0	5.7	5.5	5.6	5.6
7½	5.8	5.7	5.5	5.6	5.5
8½	5.8	5.6	5.5	5.5	5.5

▽ Before conditioning

Figure 1, Table 1. The effect of various conditioning temperatures on temperature decline (Fig. 1) and pH decline (Table 1) in beef longissimus.

of the longissimus cuts had reached the temperature of the water baths at approximately 4 hours post mortem. Table 1 should be considered a rough estimate of the mean pH decline. Inter-carcass variation may account for some of the difference in pH. Yet, lower temperatures appear to slightly hamper a fast glycolysis.

Combining pH and temperature measurements show that at 1 h post mortem cold shortening conditions (Bendall, 1972) may have been present.

Figures 2, 3, 4, 5 and 6 present the effects of various conditioning temperatures on sarcomere length, drip loss, heating loss, Instron Warner Bratzler shear force values and Hunter L, a, b, colour values.

Fig. 2 shows that sarcomere length is highest at 15° C and decreases with higher and lower temperatures. Expressed as percentage of the sarcomere length before conditioning the shortening at 0, 10, 25 and 35° C was 25.3, 7.6, 7.3, and 9.6 % ($p < .001$). At 15° C the shortening was negligible ($p > .05$). Thus, as compared with Locker and Hagyard's data derived from unstimulated meat (1963) electrical stimulation has reduced shortening by approximately 50 %. Yet, the acceleration of glycolysis by electrical stimulation was not fast enough to fully prevent muscle shortening when hot boning is conducted very early post mortem. Intensifying the stimulation treatment may reduce the shortening effect. However, this may lead to increased denaturation of sarcoplasmic proteins and consequently to increased drip losses (Eikelenboom and Smulders, 1982).

Drip loss percentages were lowest at 15° C and increased slightly ($p > .05$) with lower-, and significantly ($p < .025$) with higher temperatures. The striking coincedence of higher sarcomere lengths and lower drip losses is in agreement with earlier findings on beef longissimus (Smulders et al., 1981a, 1982).

Cooking losses were lowest at 10° C and increased slightly with lower and higher conditioning temperatures. However, none of the differences were significant ($p > .05$).

Instron Warner Bratzler shear force values reflected the "cold-" and "heat-shortening" found at 0 and 35° C: samples conditioned at these temperatures showed considerable toughening as compared with the 15° C

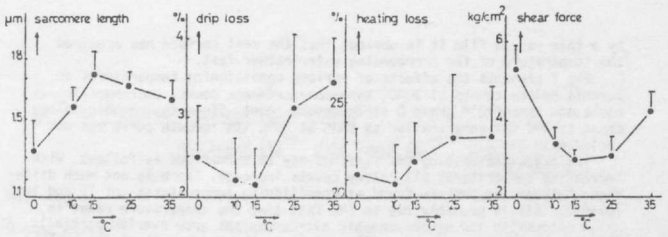

Figure 2 *Figure 3* *Figure 4* *Figure 5*

Figures 2-5. The effect of various conditioning temperatures on the sarcomere length, drip loss, heating loss and Instron Warner Bratzler shear force values of beef longissimus as assessed at 7 days post mortem.

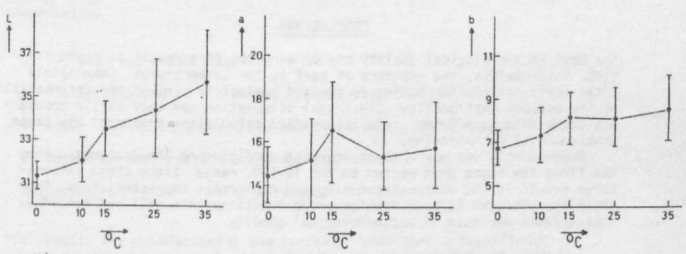

Figure 6

Figure 6. The effect of various conditioning temperatures on the Hunter L, a, b, values of beef longissimus as assessed at 7 days post mortem.

conditioned meat ($p < .025$).

Fig. 6 shows that particularly Hunter L-values increase with increasing conditioning temperatures. This effect may account for the slightly darker red colour of hot boned as compared with cold boned meat as found in earlier studies (Smulders et al., 1981b, 1982).

Bacteriological meat quality

Immediately after hot boning the aerobic colony counts both at 30 and 40C (limits of detection 1.3 log/cm^2) were approximately 2.5 log/cm^2, whereas the *Enterobacteriaceae* count, the *Lactobacillaceae* count and the Lancefield D streptococci count were all below their limits of detection (<1.3, <2.3 and <2.3 respectively).

The suspension of bacteria from the cutting tables contained log cfu/ml 5.10 and 4.91 for aerobic colony counts at 30 and 40C, 1.79 for *Enterobacteriae*, 3.22 for *Lactobacillaceae* and <2.3 for Lancefield D streptococci. Particularly the *Enterobacteriaceae* count was expected to be higher. Probably the frozen storage has substantially injured this group of bacteria. The temperature decline as shown in Fig 1 might suggest that the bacteria were subjected to the conditioning temperatures not earlier than at 3-4 h post mortem. However, one should bear in mind that Fig 1 presents the core temperatures and as such is more relevant for the sensory rather than the bacteriological quality. Since the meat was separated from the waterbath merely

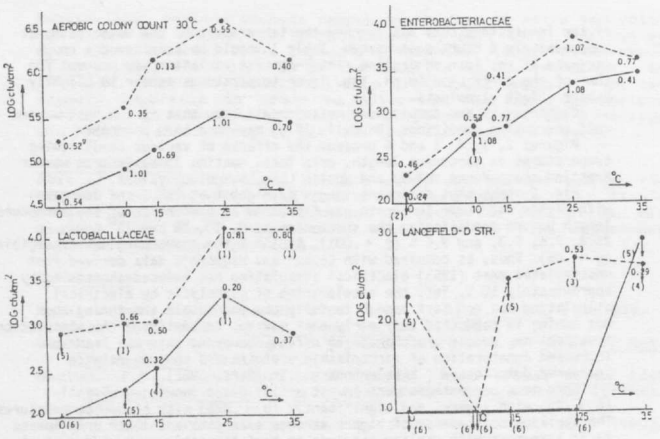

Figure 7. The effect of various conditioning temperatures on the bacteriological quality of beef longissimus.; • —— • *NOT INOCULATED* • - - - • *INOCULATED .*
∇ *standard deviation.*
(n) *= number of samples with counts under limit of detection.*

by a thin vacuum film it is obvious that the meat surface has acquired the temperature of the surrounding water rather fast.

Fig 7 presents the effects of various conditioning temperatures on aerobic colony counts at 30C, *Enterobacteriaceae* count, *Lactobacillaceae* count and Lancefield group D streptococci count. Since the aerobic colony count at 40C was very similar to that at 30C its growth curve was not included in Fig 7.

The major bacteriological findings may be summarized as follows. With increasing temperatures all colony counts increase. There is not much difference between the numbers found at conditioning temperatures of 15 and 35C ($p>.05$). This is probably due to the fact that the temperature range in which mesophilic and psychrotrophic microorganisms grow overlap partially. At 15C psychrotrophic bacteria will constitute the major part of the surface flora whereas at 35C mesophilic bacteria will dominate (Mossel 1982). However, in view of the adverse effects on sensory meat quality conditioning at 35C is undesirable. Not surprisingly,the colony counts are the lowest at 0C. The sensory meat quality is substantially deteriorated at low temperatures, however. Consequently temperatures of 10 to 15C should be considered. Dependent on the hygiene practiced (in the present study simulated by applying or omitting an inoculation of the meat surfaces) the 10-15C temperature range results in a surface contamination of 10^5 (aerobic colony count at 30C without inoculation) to 10^6 (idem,without inoculation) cfu/cm2. At none of these temperatures unacceptably high *Enterobacteriaceae* counts were found. One should realize, however, that these results may only be obtained provided one conforms to Good Manufacturing Practices.

CONCLUSIONS

The best bacteriological quality may be expected as a result of rapid chilling. Nevertheless, the exposure of beef to low temperatures immediately after early-post mortem boning is advised against in view of the deterioration of the sensory meat quality. Electrical stimulation can only partly counteract these adverse effects since intensified stimulation treatment may cause problems with waterbinding.

Consequently one may wish to increase conditioning temperatures during the first few hours post mortem to the 10-15C range since these temperatures result in the best waterbinding and tenderness characteristics. Provided one conforms to Good Manufacturing Practices this will not entail an unacceptable decrease in bacteriological quality

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