Proper Control of Retail Case Temperature Improves Beef Shelf Life

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ABSTRACT

Using laboratory-simulated retail conditions, a variety of retail case blower temperatures were selected to determine their influence upon the surface temperature of displayed rib eye steaks, bacterial growth and beef shelf life. Steak surface temperature was found to be significantly correlated with blower temperature and exceeded the temperature of the incoming blower by 9°C. Furthermore, bacterial generation time and beef shelf life were significantly and inversely related to blower temperature. Shelf life was also dependent upon the initial psychrotrophic bacterial load. Retail blower temperature could be easily adjusted to reduce steak surface temperature to 2°C, and thereby extend the visual shelf life of meats on display.

Proper temperature control is the most significant factor in limiting bacterial growth and thereby maintaining the safety and desirable appearance of retail meats (1,3,6-8). In view of this, it has recently been recommended that display cases maintain meats at internal temperatures from 2 to 4°C (1,5). However, retail surveys (1,2,5) have shown that display case thermometers are not indicative of the temperature of the displayed meat but rather reflect the temperature of the incoming blower air. Relative to this, Davidson and Bodyfelt (2) observed that the average temperature of displayed meat, poultry and seafood exceeded the temperature recorded at the retail case blower by more than 6°C. More recently, Greer and Jeremiah (3) showed the surface temperature of retail displayed steaks ranged from 7.5 to 14.2°C and was on the average about 7°C higher than that recorded within the display case.

In consideration of these findings, some workers (1,5) have contended that the design of retail cabinets is such that recommended temperatures for displayed meats cannot be achieved. However, it is doubtful that retail cases are operating at maximum efficiency, and few attempts have been made to regulate blower temperature in an effort to reduce the temperature of retail meats to a more acceptable level. Furthermore, there is a lack of data relating blower and product surface temperature to bacterial growth and beef retail case life (3). Thus the present study was undertaken to establish the influence of various retail case temperature settings on the bacterial spoilage of steaks.

MATERIALS AND METHODS

Meat samples and display conditions

A total of 35 randomly selected wholesale beef ribs were subjected to 6 days of postmortem aging followed by frozen storage at -20°C. Before each experiment 5 ribs were thawed for 72 h at 1°C and 50 rib eye steaks (1.5-cm thick) were fabricated and wrapped in an oxygen-permeable polyvinyl film (Vitafilm choice wrap). In one instance, ribs were subjected to temperature abuse by exposure to a temperature of 20°C for 24 h before fabrication. This resulted in an increased initial bacterial load on steak surfaces to be used for purposes of comparison.

At each of the five temperature treatments (described below), 50 steaks were positioned in the display case in 5 rows extending from the rear of the case (near the blower) to the front (most distant from the blower). In this manner, any temperature effects due to the proximity of samples to the blower could be determined.

To simulate commercially utilized retail conditions, the display case (Hill Refrigeration of Canada Ltd) used throughout this study was a horizontal, fan-assisted, convection type cabinet (2) illuminated with 150-watt incandescent floodlights to give a light intensity of about 800 lx at the meat surface.

Temperature measurements

To investigate the influence of display case blower temperature on steak surface temperature and shelf life, the following five display case settings were selected: -9.4, -6.7, -3.9, -1.1 and +1.7°C. These retail case settings resulted in blower temperatures of -8.6, -5.7, -3.6, -0.5 and 2.0°C, respectively. At each of these temperature treatments the surface temperature of 5 steaks was recorded over a period of 4 days of retail display, using a Honeywell multichannel recorder as described in a previous report (3).

Retail case blower temperatures were recorded manually from a thermometer located 1 cm from the incoming blower air. A total of 13 blower temperature measurements were recorded daily for 4 days and the results are expressed as an average for each temperature treatment. Blower temperature extremes were also determined, using maximum and minimum thermometers. Room temperature averaged 23°C throughout this investigation.

It is noteworthy that the display case used in the current study defrosted at regular 12-h intervals. The temperature profiles of both the retail case and displayed steaks during these defrost cycles have been...
reported previously (2). In the present study, blower and steak surface temperatures represent the average in the absence of defrosting. Temperatures recorded during defrosting are discussed separately.

Retail evaluation and bacterial analyses

At each temperature treatment steaks were evaluated by a 3-member sensory panel for discoloration and retail acceptability, using the 7-point subjective scales described previously (4). Shelf life was determined as the time, in days, for steaks to reach a retail acceptance value of 3.5 (4). Daily, from day 0 to day 10 of retail display, 5 different steaks were selected and subjected to sensory evaluation. The same samples were swabbed to determine the psychrotrophic bacterial load, as described previously (3). Psychrotrophic bacteria were enumerated following 10 days of incubation of Plate Count Agar (Difco) at 7 C (9). Bacterial generation times were determined from the logarithmic phase of growth as the time in hours for the population to double.

Statistical analyses

The relation of blower temperature to steak surface temperature, bacterial generation time and steak shelf life was determined, following linear regression analyses. The significance of differences between temperature treatments was determined using the Student's "t" test. Temperature treatment effects were compared to those obtained at a blower temperature of -0.5 C since this is the temperature which most closely approximates that recorded in retail outlets (2).

RESULTS

Effect of blower temperature on steak temperature

A direct, positive relationship ($r = 0.971, P < .01$) was observed between blower temperature and the temperature recorded at the surface of retail displayed steaks (Fig. 1). It is noteworthy that steak surface temperatures averaged about 9 C higher than that of the incoming blower air.

It should be stressed that these temperature means (Fig. 1) do not reflect temperature maximums recorded during display case defrosting. At mean blower temperatures of -8.6, -5.7, -3.6, -0.5 and 2.0 C, the maximum retail case blower temperatures recorded during the defrost cycles were 17.4, 19.9, 28.4, 29.4 and 25.9 C, respectively. In similar fashion, corresponding steak surface temperatures were 8.5, 10.9, 12.8, 15.0, and 20.5 C during defrosting.

Effect of blower temperature on bacterial growth and steak shelf life

A highly significant inverse relationship was observed between blower temperature and both bacterial generation time ($r = 0.992, P < .001$; Fig. 2), and steak shelf life ($r = -0.990, P < .005$; Fig. 2). From the slope of the regression equations (Fig. 2), a 1-C increment in blower temperature resulted in a 0.7-h reduction in the bacterial generation time and more than half a day reduction in steak shelf life.

Figure 2. Effect of retail case blower temperature on bacterial growth and steak shelf life.

The minimum permissible blower temperature which could be used with this particular display case was -8.6 C. At temperatures below this, some freezing was observed on the surface of samples displayed at the rear of the case near the blower. At a blower temperature of -8.6 C, displayed steaks remained visually acceptable for 8.2 days when compared to 3.8 days at the usual retail case operating temperature (-0.5 C).

Effect of bacterial load

Comparisons were made of the effect of the initial bacterial load upon shelf life at the usual blower temperature (-0.5 C) and the minimum permissible blower temperature (-8.6 C). When the initial bacterial load increased from log bacteria/cm$^2$ of 1.40 to 3.83, shelf life at -8.6 C decreased from 8.2 to 4.2 days. Similarly, shelf life at -0.5 C decreased from 3.8 to 1.5 days.

DISCUSSION

Some factors influencing the temperature of retail displayed meats include display case design (6), blower temperature (7), position of meats within the case (1,5), intensity of illumination (6,8) and the amount of heat absorbed and retained between the meat surface and the polyvinyl wrap (8). As a consequence of the combined effects of these parameters, retail case thermometers are indicative of the temperature of the blower air rather than that of the displayed product. Relative to this,
surveys of retail outlets have shown, that depending upon location within the display case, ground beef temperatures ranged from 4 to 25°C warmer than that of the blower air (1,2,5). These findings are supported by the results of the present study where displayed steak surface temperature averaged 9°C higher than temperatures recorded at the blower.

These excessively high temperatures allow rapid bacterial proliferation and are thereby detrimental to the shelf life and safety of displayed meats. In view of this, recommendations have been made that the internal temperature of meats on retail display be maintained at 2 to 4°C warmer than that of the surrounding air (1,2,5). However, some (1,5) have contended that the nature of display conditions are such that it may be difficult to achieve these temperatures at the meat surface. Contrarily, the present study has demonstrated that steak surface temperature could be maintained at 2°C at a blower temperature of -8.6°C. Under these conditions, psychrotrophic bacterial growth was significantly reduced, and steaks remained visually acceptable for 8.2 days. This shelf life was significantly greater than the 3.8 days observed at the usual blower temperature setting (-0.5°C) and greatly exceeds the 2 to 3 days shelf life for beef in retail outlets (3). It is noteworthy that the usual operating temperature of the retail case blower in this laboratory (-0.5°C) is in accordance with the average of -0.6°C reported following a survey of 30 retail stores (2).

The relationship between blower and steak surface temperature, established in the present investigation, is similar to results of a retail survey by the Meat Packers Council of Canada (1). These workers observed ground beef temperatures of 2-5°C in display cases operating at a blower temperature of -0.5°C. This value is close to recommended meat storage temperatures (1,5) and indicates that proper temperature control is possible under actual retail conditions.

Also, in the current study, steak surface temperatures for samples at the rear of the retail case (near the blower) were 2°C lower than those located at the front of the case (data not shown). Consequently, bacterial growth on the former steaks was comparatively slower and shelf life was extended by up to 1 day. Others (1,5) have also stressed the importance of the position of meats within the display case. In view of this, if a horizontal, fan-assisted convection type display case is used, it would be advisable for retailers to move older products closer to the blower when re-loading. In this manner of rotation, older more contaminated samples would retain their desirable sensory qualities longer.

Although steak retail case life was directly related to blower temperature, it was also influenced by the initial, psychrotrophic bacterial load. At blower temperatures of both -0.5 and -8.6°C, steak shelf life was reduced by 50% when the initial bacterial load increased from log bacteria/cm² of 1.40 to 3.83. These findings complement those of a previous investigation (3), where it was stressed that in any study of the effects of temperature on beef shelf life, the initial, bacterial load must be given careful consideration.

The results of a recent study (3) showed that steak retail shelf life could be extended by removing meat from display each evening and refrigerating at 1°C overnight. This method, however, may not be readily adopted by the industry due to increased labor and storage facilities. The results of the present study have provided a more practical alternative by demonstrating blower temperature could be easily regulated to extend retail case life. In addition, results presented herein may be the first to correlate blower temperature to bacterial growth and steak shelf life. It should be stressed that these findings are only applicable to steaks stored under the experimental conditions described. As noted previously, displayed steak surface temperature is dependent upon the nature of the retail display environment and case design. Furthermore, as reported here, shelf life is also influenced by the initial psychrotrophic bacterial load. However, it is not unreasonable to assume that retail case temperature could be manipulated to reduce temperatures of meats displayed under a variety of distinct retail conditions. In this fashion, a relatively simple adjustment by the retailer could improve meat safety, shelf life and reduce spoilage losses.

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REFERENCES