PREDICITING *E. COLI* GROWTH ON PORK DURING RETAIL DISPLAY

G.G. GREER, C.O. GILL AND B.D. DILTS

Agriculture and Agri-Food Canada
Lacombe Research Centre
6000 C & E Trail
Lacombe, Alberta, Canada T4L 1W1

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BACKGROUND

In examining a commercial process for ground beef production it was concluded that temperature abuse at retail was sufficient to allow the proliferation of *E. coli* to unacceptable levels (Gill and McGinnis, 1993). This was confirmed during an evaluation of supermarket retail cases where beef steak temperatures ranged from 0 to 12°C (Greer *et al.*, 1994). Meat temperature history data were used to calculate the proliferations of *E. coli* and good correlations were observed between 4 and 8°C.

The validity of such models has been established in a variety of foods including meats (Sutherland *et al.*, 1995) but there are few reports of the impact of fluctuating storage temperatures. Throughout retail display in commercial cabinets meats experience transitory and often extreme variations in temperature. The response of pathogens to these fluctuating temperatures is a relevant safety consideration and has been evaluated in Brain Heart Infusion broth using *E. coli* 0157:H7 (Rajkowski and Marmer, 1995). There are no known reports on the validity of such models for the prediction of *E. coli* growth on meat surfaces. Thus, the present study was undertaken to determine the aerobic growth of *E. coli* on pork muscle and fat tissue under the fluctuating temperature conditions experienced during retail display and to compare experimental values to those predicted using temperature function integration.

METHODS

Bacteria. *E. coli* biotype I was isolated from commercially prepared beef trim and positively identified. Inocula were prepared from log phase cells grown in Tryptic Soy Broth (Difco) at 25°C, washed and diluted in 0.1% peptone water to give the required concentration of cells.

Pork Tissue. Sterile lean (pH = 5.6) and fat (pH = 6.3) muscle discs (10 cm^2) were prepared from pork *Longissimus thoracis* muscle as previously described (Greer *et al.*, 1995). Tissue discs were inoculated by immersion for 15 s in a suspension of *E. coli* to give an initial bacterial level of about 10^3 *E. coli*/cm^2 of tissue. Inoculated discs were placed in meat trays and overwrapped with an oxygen-permeable polyvinyl chloride film (8000 cc/m^2/24 h/atm).

Retail Display. Overwrapped tissue discs were placed in predetermined positions in a commercial, single deck retail case illuminated by 750 lux of incandescent lighting. Positions within the case were selected to reflect temperature fluctuations encountered in the commercial, retail environment (Greer *et al.*, 1994). Throughout seven days of retail display, tissue surface temperature was measured using MIRINZ-Delphi temperature data loggers with external thermistor probes.

Bacteriology. At daily intervals, fat and lean tissue disks were removed from each location within the case for bacterial enumeration. Each disk was homogenized using a Colworth Stomacher following suspension in 90 ml peptone water. After appropriate dilution, 0.1 ml quantities were surface plated on Tryptic Soy Agar (Difco). Bacterial colonies were counted following 48 h of incubation at 25°C.

Temperature Function Integration. Surface temperature histories were integrated with respect to a model describing the dependency of the aerobic growth of *E. coli* on temperature. This model has been used to assess the hygienic adequacy of retail display (Greer *et al.*, 1994). Calculated values were determined during the logarithmic phase of growth with the assumption that there was no lag phase.

RESULTS AND DISCUSSION

Predictive models for *E. coli* growth have been developed from growth rates determined in laboratory media and there has been some validation in foods including meat (Smith, 1987; Sutherland *et al.*, 1995). To examine the consequences of temperature fluctuations during meat storage, Gill (1996) developed and applied the temperature function integration technique to a variety of meat chilling processes including the retail display environment (Greer *et al.*, 1994). Good correlations were reported between observed and predicted proliferations of *E. coli* on beef.

A more detailed investigation of the growth of *E. coli* 0157:H7 in Brain Heart Infusion broth at fluctuating temperatures was published by Rajkowski and Marmer (1995). These researchers concluded that when this organism was subjected to fluctuating temperatures the growth rate approximated that at the highest temperature, and that *E. coli* could grow at 8°C.

In the current study, pork muscle and fat tissues were found to experience fluctuations in surface temperatures, which ranged from 1.5 to 24.3°C during periods of up to 7 d of simulated display in a commercial retail cabinet. These temperature extremes were

similar to those observed in commercial practice (Greer, *et al.*, 1994). During periods of logarithmic growth and in the absence of a lag phase, predicted *E. coli* proliferations were good estimates of observed values at mean surface temperatures ranging from 8.4 to 13.0°C on lean (Table 1) and 6.9 to 13.0°C on fat (Table 2). *E. coli* did not grow below 6.9°C on fat or 8.4°C on lean and at temperatures below these limits, predicted values overestimated *E. coli* growth. Improved growth on fat as compared to muscle supports earlier findings of Grau (1983) who found that both the lag phase and growth rate of *E. coli* on beef were affected by tissue type and pH.

CONCLUSIONS

Published models based upon broth cultures could be applied to predict *E. coli* growth under fluctuating retail display temperatures. Under current temperature regimes for the storage of meat in commercial display cabinets, *E. coli* growth would be expected.

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Fig. 1. Comparison between observed and predicted values for *E. coli* proliferations on pork muscle

Temperature (°C)[2]	Generations[1]	
	Observed	Predicted
3.9 (1.5-13.3)	No Growth	1.6
6.0 (3.0-21.0)	No Growth	7.8
6.9 (4.3-21.5)	No Growth	7.3
8.4 (5.5-21.5)	7.7	7.9
9.4 (5.8-24.3)	5.9	11.7
11.2 (8.8-19.5)	8.3	11.6
13.0 (11.3-16.0)	12.3	12.1

[1]Data are means of 3 determinations.
[2]Numbers in brackets refer to the range over the monitoring period.

Fig. 2. Comparison between observed and predicted values for *E. coli* proliferations on pork fat

Temperature (°C)[2]	Generations[1]	
	Observed	Predicted
3.9 (1.5-13.3)	No Growth	1.6
6.0 (3.0-21.0)	No Growth	7.8
6.9 (4.3-21.5)	5.5	3.6
8.4 (5.5-21.5)	13.4	16.2
9.4 (5.8-24.3)	13.0	12.1
11.3 (8.8-20.3)	11.4	16.2
13.0 (11.3-16.0)	12.5	12.1

[1]Data are means of 3 determinations.
[2]Numbers in brackets refer to the range over the monitoring period.