Time Temperature Study of UK Consumers’ Domestic Refrigerators

Ellen W. Evans* and Elizabeth C. Redmond
Zero2Five® Food Industry Centre, Cardiff School of Health Sciences, Cardiff Metropolitan University, Wales, United Kingdom. *Corresponding author: elevans@cardiffmet.ac.uk

Consumer demand for convenient, fresh foods with minimal preservatives and low thermal processing has led to increased sales of refrigerated ready-to-eat RTE foods worldwide. However, such foods are commonly associated with listeriosis due to the ability of Listeria monocytogenes to survive and grow at refrigeration temperatures. Consequently, effective temperature control of RTE foods by consumers in the domestic kitchen is critical for food safety as inadequate refrigeration practices are believed to increase the risk of foodborne illness.

UK recommendations for domestic refrigeration are ≤5°C. Although data suggest that many refrigerators in home kitchens operate at temperatures exceeding recommendations, such data is often determined by means of a single one-off temperature and is not indicative of usual function or temperature fluctuation. Consequently there is a need to determine actual domestic refrigerator operating temperature over a prolonged period to gain an understanding of typical usage on function.

This study aimed to assess actual domestic refrigerator operating temperature profiles and establish self-reported food storage practices of UK consumers

Methods

Time-temperature profiles of refrigerators (n=43) in domestic kitchens were determined using three Signatrol SL52T self-contained button dataloggers (Range: -40°C – +85°C; accuracy: ±0.5°C; frequency: every minute) over 136 hours placed in a central storage area, a door storage area and outside of the refrigerator.

Households (n=43) documented self-reported refrigerator usage during profiling. Statistical analysis was conducted using IBM SPSS Statistics to determine significant differences or relationships between refrigeration temperatures and self-reported practices.

Results

Refrigerator profiles

Forty-three domestic refrigerators in consumer home kitchens were included in the study. The age of domestic refrigerators in kitchens ranged from 4 months up to 30 years, the majority (70%) of refrigerators were free-standing non-integrated. As indicated in Table 1, refrigerator operating temperatures ranged from -0.15°C to 17.9°C, an average difference of 1.94°C was determined between refrigerator doors and central storage locations operating temperatures. Statistical analysis determined:

Table 1. Domestic refrigerator temperature ranges (°C)

<table>
<thead>
<tr>
<th></th>
<th>Door operating temperature</th>
<th>Central operating temperature</th>
<th>Door/central temperature difference</th>
<th>Temperature fluctuations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>-0.15</td>
<td>1.72</td>
<td>0.02</td>
<td>1.51</td>
</tr>
<tr>
<td>Max</td>
<td>17.90</td>
<td>16.91</td>
<td>4.51</td>
<td>6.03</td>
</tr>
<tr>
<td>Mean</td>
<td>7.84</td>
<td>5.88</td>
<td>1.94</td>
<td>3.47</td>
</tr>
</tbody>
</table>

No statistical differences (p>0.05) were determined in operating temperature according to refrigerator age.

A positive correlation between the ambient temperature of the kitchen and the temperature of the refrigerator was determined (r = 0.786, n = 8192, p < 0.005).

Average temperature change of 1.92°C was noted when food shopping was reported to be placed in the refrigerator (range: 7.05°C increase - 2.01°C decrease).

A positive correlation between temperature change and door opening frequency (r = 0.29, n = 258, p< 0.005), as illustrated in Figure 3, a greater temperature change was observed when a greater number of door opening frequencies was reported.

No significant differences (p>0.05) were determined in temperature fluctuations according to reported method of putting food shopping away after returning home, ‘continuously re-opened’, ‘opened and left open’ or ‘organise all chilled items and place in refrigerator all at once’.

Figure 2 illustrates the average operating temperature of refrigerators; although 21% of refrigerators had mean operating temperatures adhering to recommended safe operating temperatures. The time-temperature profiling determined that:

• 40% central storage locations were operating at unsafe (>5°C) temperatures for the duration of the datalogger study (136 hours).

• 67% refrigerator doors storage locations were operating at unsafe (>5°C) temperatures for the duration of the datalogger study (136 hours).

• No refrigerator doors or central storage locations were discovered to operate at ≤5°C for the duration of the study.

• 9% had a door and central temperature that were ≤5°C for 75% of the study.

Figure 3. Daily door opening frequency and temperature change (n = 258)

Temperature fluctuations as indicated in Table 1, were determined to be on average 3.47°C each day. Temperature changes correlated with self-reported usage:

• A positive correlation between the ambient temperature of the kitchen and the temperature of the refrigerator was determined (r = 0.786, n = 8192, p < 0.005).

• Average temperature change of 1.92°C was noted when food shopping was reported to be placed in the refrigerator, (range: 7.05°C increase - 2.01°C decrease).

• A positive correlation between temperature change and door opening frequency (r = 0.29, n = 258, p< 0.005), as illustrated in Figure 3, a greater temperature change was observed when a greater number of door opening frequencies was reported.

• No significant differences (p>0.05) were determined in temperature fluctuations according to reported method of putting food shopping away after returning home, ‘continuously re-opened’, ‘opened and left open’ or ‘organise all chilled items and place in refrigerator all at once’.

Impact of self-reported practices and external factors on operating temperature fluctuation

Significance of the study

• Temperature profiles indicate that majority of the sample may store RTE-foods at unsafe temperatures which may increase risk of foodborne illness such as listeriosis given the pathogens ability to proliferate at increased refrigeration temperatures.

• Findings highlight the need for improvement of domestic kitchen refrigeration practices among UK consumers.

• Data may be used to inform development of targeted food-safety strategies.

References


2. Scott, E., 2004. The influence of consumer behaviour on foodborne listeriosis due to the ability of Listeria monocytogenes to survive and grow at refrigeration temperatures. Consequently, effective temperature control of RTE foods by consumers in the domestic kitchen is critical for food safety as inadequate refrigeration practices are believed to increase the risk of foodborne illness.


Figure 1. Domestic refrigerators mean operating temperatures (n = 100)