Consumers may fail to ensure domestic refrigerators operate at safe temperatures.

Ellen W. Evans* and Elizabeth C. Redmond

ZERO2FIVE Food Industry Centre Food and Drink Research Unit, Cardiff Metropolitan University, Wales, UK.
*Corresponding author: elevans@cardiffmet.ac.uk

Introduction

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[1]

However, such foods are commonly associated with listeriosis due to the ability of *Listeria monocytogenes* to survive and grow at refrigeration temperatures[2].

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[3].

UK recommendations for domestic refrigeration are ≤5.0˚C[4]. 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[5].

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.

Purpose

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.

Participating 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.

Publication

The findings from this study are presented in:

Evans EW & Redmond EC. (2016) “Time-Temperature Profiling of United Kingdom Consumers’ Domestic Refrigerators”. *Journal of Food Protection.* 79(12):2119 – 2127.

References

1. Bureau of Microbial Hazards. *Listeria monocytogenes Challenge Testing of Refrigerated Ready-to-Eat Foods*. 2012; Available from: http://www.hc-sc.gc.ca/fn-an/legislation/pol/listeria_monocytogenes-test-eng.php.
2. Adams, M. and M. Moss, *Food Microbiology*. Second Edition ed. 2006, Cambridge: The Royal Society of Chemistry.
3. Scott, E., *Food safety and foodborne disease in 21st century homes.* Can. J. Infect. Dis., 2003. **14**(5): p. 277 - 280.
4. FSA and DoH. *Listeria – keeping food safe*. [Leaflet] 2008 24th October 2013]; Available from: http://www.food.gov.uk/multimedia/pdfs/publication/listeriafactsheet0708.pdf.
5. Evans, E.W. and E.C. Redmond, *Behavioural Risk Factors Associated With Listeriosis in the Home: A Review of Consumer Food Safety Studies.* J. Food Prot., 2014. **77**(3): p. 510 - 521.

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 analyses determined:

Table 1. Domestic refrigerator temperature ranges (˚C)

	Door operating temperature	Central operating temperature	Door/central temperature difference	Temperature fluctuations
Min	-0.15	-1.72	0.02	1.51
Max	17.90	16.91	4.51	6.03
Mean	7.84	5.88	1.94	3.47

- No statistical differences (p>0.05) were determined in operating temperature according to refrigerator age.
- No significant differences (p>0.05) were determined in refrigerator operating temperatures according to refrigerator type.
- Those reporting to check their refrigerator temperature *‘every day’* and *‘every week’* were significantly more likely (p<0.05) to have mean refrigerator temperatures in-line with recommendations (≤5˚C), than those *reporting ‘every three months’* and *‘less than once a year’.*

Time-temperature profiling

Figure 1 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.

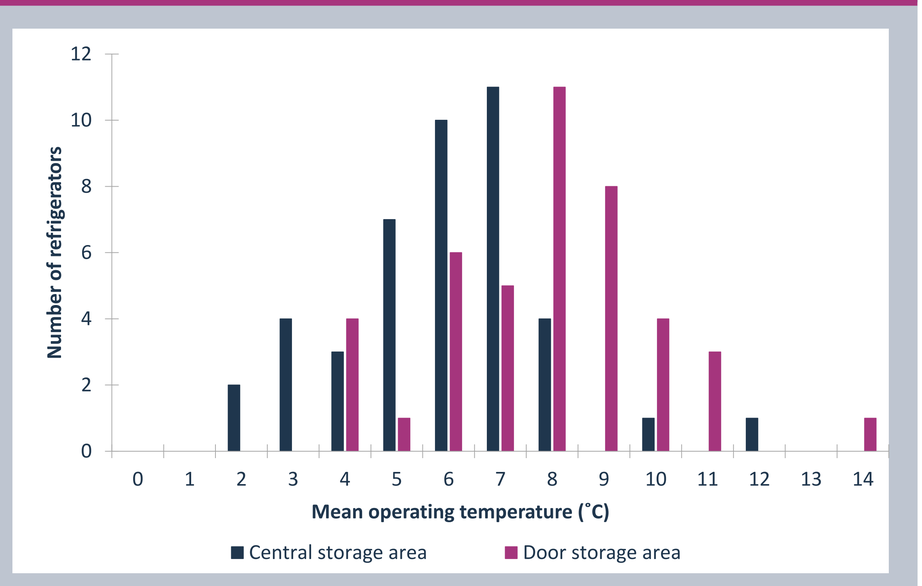

Figure 1. Domestic refrigerators mean operating temperatures (n = 43)

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

Figure 2. 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’.*

Significance of 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.