Introduction

Convenient, fresh foods with minimal preservatives and low thermal processing has led to increased sales of ready-to-eat (RTE) foods worldwide. 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. This study aims to explore consumer cognitive influences associated with food safety, domestic refrigerator use and profile domestic refrigerator operating temperatures/reported practices.

Methodology

Review of consumer food safety studies:

- Systematic literature review was conducted to obtain consumer food safety data; primary research papers were reviewed and analysed using a content analysis approach.

Domestic time-temperature profiling:

- Time-temperature profiles of refrigerators [i.e.43] in domestic kitchens were determined using three Sensor2SL2T self-contained battery dataloggers (range: -40°C to +85°C; accuracy: ±0.5°C; frequency: every minute) over 136 hours, positioned in the centre & door areas, and outside of the refrigerator.

- Households (n=43) documented refrigerator usage during profiling.

Cognitive analysis of consumer refrigeration behaviors:

- Consumers (n=100) completed quantitative self-complete questionnaires to determine knowledge, self-reported practices and attitudes towards domestic refrigeration practices.

All components of this research received ethical approval from the Cardiff Metropolitan University Healthcare and Food Ethics Panel.

Results

Review of consumer food safety studies: focus on refrigeration

- A comparison of knowledge, attitude, self-reported practice and actual behavioural data relating to domestic refrigeration is found in Table 1.

- Review analyses determined that in the UK, 35% of consumers claimed to know what temperature the refrigerator should be operating at, however only 18% were correct.

- Self-reported data determined that ownership of a refrigerator thermometer was low in countries including European nations and USA.

- In total, 26% of studies presented data on measured operating temperatures of domestic refrigerators; between 9% and 100% were found to be operating above recommended temperatures to ensure food safety.

Table 1. Consumer knowledge, attitudes, self-reported practice and actual behaviour associated with domestic refrigeration practices (n=43 reviewed studies).

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Attitudes</th>
<th>Self-reported practice</th>
<th>Actual behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it important to keep food cool?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Temperature too low, too high or just right?</td>
<td>Occasionally</td>
<td>Mostly</td>
<td>Mostly</td>
</tr>
<tr>
<td>Is it important to take precautions when putting food in the refrigerator?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Temperature fluctuates</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>refrigerator operates efficiently</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Time-temperature profiling and self-reported refrigerator

- The age of domestic refrigerators [i.e.43] ranged from 4 months to 30 years.

- Refrigerator operating temperatures can be seen below. Key findings indicate that operation temperatures ranged from 0.15°C to 19°C, an average difference of 1.94°C was determined between refrigerator doors and child storage locations.

- 21% of domestic refrigerators had mean operating temperatures adhering to recommended safe operating temperatures.

- Findings indicated that 40% central storage and 67% refrigerator door storage exceeded the ideal (5°C) temperatures for the duration of the data logger (136 hours).

- No refrigerator doors were central storage locations operated at 7°C or for child storage locations.

- 9% had a door and central temperature that was 7°C for 75% of the study.

- Temperature trends correlated with self-reported use (Figure 1).

- A positive correlation between the ambient temperature of the kitchen and the temperature of the refrigerator was determined (r=0.26, p<0.05, n=30).

- After putting food shopping away into refrigerators, it took up to 18 minutes to reach a maximum increase of temperature and 6.78 minutes to return to original temperatures.

- Findings illustrate that consumer refrigeration practices influence operating temperatures.

Discussion

Positive consumer attitudes towards the need for correct refrigerated temperature storage have been identified; however large proportions of consumers did not know what recommended operating refrigeration temperatures were.

- Previous consumer food safety research suggests that knowledge does not translate to self-reported or actual behaviour. However, in this study, significant difference (p=0.05) was determined between safe/unsafe average operating temperatures of domestic refrigerators according to consumers’ recommendation max operating temperature.

- 57% of consumers that knew the safe temperature had refrigerators with an average operating temperature of <5°C; whilst 89% of those that did not know the maximum recommended temperature having refrigerators with an average operating temperature of >5°C.

- Temperatures of older adults refrigerators were found to be higher / worse (9% operated 0.5°C for 75% of time) than in the kitchens of general consumers (10% operated 0.5°C for 90% of the time).

- Temperature changes were found to be significantly correlated with door opening frequency resulting from heat gains during door openings.

Conclusions

- Although consumers were aware of the importance of refrigeration to ensure food safety, knowledge of safe refrigeration practices was lacking; attitudes towards checking temperatures were negative and the majority reported to never check the temperature.

- Temperature profiles indicate that majority of consumers store RTE foods at suboptimal temperatures with little increase risk of listeriosis.

- Findings highlight the need for consumers to improve domestic kitchen refrigeration practices and data from this study may be used to inform development of targeted food-safety strategies.

References