
Part 1: Insights around the domestic refrigerator

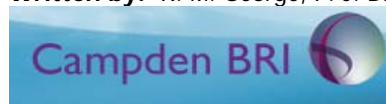
Reducing food waste through the chill chain



An extensive study of consumer refrigerated food practices in the home and experimental measurements of refrigerated food temperatures during their transit from the retail store to the domestic fridge.

WRAP helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change.

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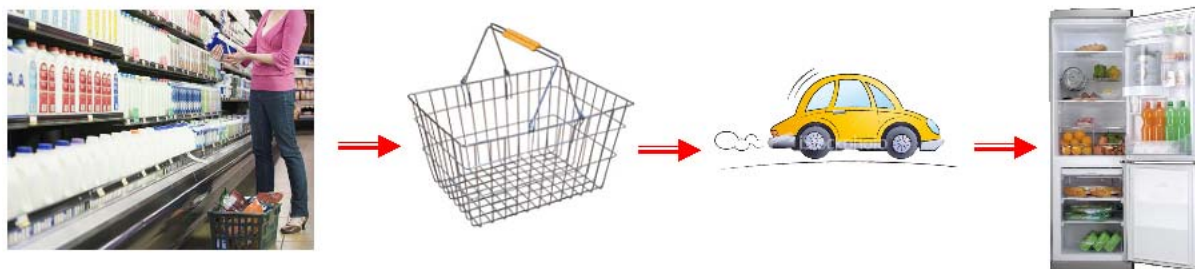
Front cover photography: Consumer fridge, taken as part of this research

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Executive summary

Keeping refrigerated food¹ cold (typically between 0°C and 5°C) is important to ensure the safety and quality of the food up to the end of its stated shelf life. From the point of manufacture, through distribution and in the display cabinets in-store, there are strict guidelines for the control of temperature. It is important that consumers take similar care from the point of purchase, through transportation home and in the domestic refrigerator. It is this latter part of the chill chain that is the focus of this study (Figure E1).

Figure E1 Summary of the domestic chill chain



Helping consumers to better understand the importance of storing food correctly could make a significant contribution to reducing the 2.9 million tonnes of food and drink that is thrown away before ever being cooked or served ("not used in time"). WRAP research² has shown that 255,000 tonnes of food is thrown away before it has even reached its 'use by' or 'best before' date, and much of this could have been avoided if the food had been stored correctly, including at the right temperature.

This project has sought to understand domestic refrigerated food storage and is comprised of four elements:

- Store to home assessment.
- Consumer survey and in-home fridge temperature experiment.
- Controlled domestic fridge temperature study.
- Domestic fridge thermometer evaluation.

The main aims of the study are:

- To generate consumer insights that will inform a behavioural change campaign, for example, through Love Food Hate Waste (www.lovefoodhatewaste.com), focusing on increasing consumer understanding of the importance of good temperature control through the domestic chill chain and how consumers can ensure they are keeping food at the right temperature e.g. using a fridge thermometer effectively. For maximum impact the messages would need to be reinforced by partners in the grocery and white goods sector.
- To provide evidence to the refrigerator manufacturing industry that will enable them to consider new design features to make their temperature control features more evident to their consumers and easy for them to use.

Fridge air temperatures, rather than product temperatures, were recorded throughout this research. This reflects how consumers would measure fridge temperatures using most domestic thermometers.

The key insights from this work are summarised below.

Store to home assessment

The 'store to home' assessment was conducted to quantify the changes in temperature within a range of refrigerated foods, that might occur after they had been purchased by the consumer from the retailer and during the transit home to the consumer's own fridge. The temperature change in six different food products was monitored through three controlled tests and in three different bag types (an insulated bag (cool bag), woven bag and standard bag).

¹ 'Refrigerated food' is used in this report to refer to all foods that are designed to be kept refrigerated for reasons related to safety or quality, plus any foods that benefit from being kept refrigerated (for example, fresh fruit that retains its quality for longer if kept refrigerated).

² Household Food and Drink Waste in the UK, WRAP, 2009

The results from this work suggest that using insulated bags to bring refrigerated food home from the shops, particularly during warmer months, will help reduce the degree to which product temperatures may increase. The number of consumers now using 'bags for life' would suggest that this might not be a particularly difficult behaviour to adopt. In addition, consumers should be alerted to the magnitude of the food temperature rises that can occur during shopping and transport. Given the particularly good results for all bag types during the test designed to simulate shopping during colder months (when the period at the higher temperature was the shortest), it may be beneficial to remind all consumers, when in-store, to pack refrigerated and frozen items together where possible and transport chilled and frozen foods as quickly as possible to minimise the risk of food spoilage.

Depending on the type of food, the bag used and the temperature regime employed to mimic different 'store to home' journeys, temperature rises of up to 11°C were observed. Following the temperature change phase of the test, the products were returned to the controlled temperature room and removed from the carrier bag, to simulate being stored in a domestic refrigerator. Data was logged during this cooling period, and it showed that some of the products took up to 15 hours to return to below 5°C with the chiller operating at 4.3°C. It is likely that this 'recovery' time would be longer in a domestic refrigerator due to the lower airflow and space limitations that mean that products are often stacked up or pushed close together. This finding underlines the importance of not allowing products to warm up significantly during shopping and transport.

Consumer survey and in-home fridge experiment

Several key insights were gained through the research which may contribute to food waste:

- A substantial number of respondents stated that they did not check the contents of the refrigerator before a major shop (either thoroughly (32%) or briefly (39%)) with the implication that this may lead to unnecessary food purchases.
- Only 13% of all respondents used a cool bag/box to bring refrigerated foods home. Overall, 45% of respondents stated that the usual time between completing the main grocery shop and unpacking was up to 30 minutes, with a further 23% stating this was between 30 minutes to one hour.
- Many people are not storing foods in the fridge that will last much longer there, for example 78% do not store apples in the fridge and 36% don't store carrots in the fridge. WRAP research³ has shown that storing apples and carrots in the fridge can maintain their quality and extend their in-home life, making it easier for consumers to eat the whole pack and avoid wasting any. In addition 29% don't store eggs in the fridge, as recommended.
- The storage of opened cheese was variable with just over a third of buyers (34%) storing the product in its original packaging in the fridge, and a further 40% in the fridge but in an alternative wrapping. Nearly a fifth (19%) stated that they decanted this item into an airtight container. The storage of cooked meats was similar to that of cheese in that 42% of buyers stored the product in its original packaging in the fridge, and a further 37% in the fridge but in an alternative wrapping. Just over 11% decanted opened/cooked meat into an airtight container.
- 42% disposed of unopened cooked meats occasionally while 38% occasionally disposed of unopened chilled ready meals. When it came to opened and partly consumed food the figures were unsurprisingly higher; cooked meats rose to 59% and cheese, chilled ready meals, apples and carrots were all disposed of occasionally by 40% of the survey population. A lack of knowledge about shelf life of certain foods or their optimum storage conditions may well be contributing to this (in addition to pack size for example).
- It is encouraging that, unprompted, 79% of respondents correctly stated that the fridge should be run at between 0°C to 5°C⁴, although just over 10% of respondents did not provide a response, 4% said either -2°C or -1°C and 5% said 6°C. However, just a fifth had some way of measuring their fridge temperature (e.g. an integral temperature display or fridge thermometer).
- Notably a significant proportion of the survey population (16%) agreed with the comment that fridge temperatures do not make much difference to how long food lasts.

The in-home temperature survey completed as part of this research shows that the majority of domestic refrigerators operate at a mean air temperature of around 7°C. It was apparent that a proportion of the fridges tested (14 fridges, 29% of the sample) were operating at mean air temperatures of 9°C or above. Only 14 of the 48 fridges (29% of the sample) were found to be at mean air temperatures of 5°C or less. With 34 fridges (70%) operating below 8°C.

³ *Helping consumers reduce fruit and vegetable waste, WRAP, April 2008*

⁴ <http://www.eatwell.gov.uk/keepingfoodsafestoring/#cat301168>.
Advice relates to air temperature.

The average air temperature reading across the whole survey population, as recorded by the interviewers, using the thermometers provided was 5.9°C. This would suggest that the majority of fridges in the UK are operating in a manner which should allow food to be stored at a safe temperature (assuming particularly sensitive foods are stored in the coldest part of the fridges). However, up to 30% of households may improve their fridge performance by reducing their fridge temperatures.

Controlled domestic fridge temperature study

The air temperature and humidity levels within six fridges were tested under laboratory controlled conditions (e.g. air temperature and humidity measurements, fridge loading, door opening and environmental conditions)⁵. The six fridges chosen for this test encompassed, as far as practicable, a range of makes, models and designs.

Almost all fridges work on a vapour compression cycle. The cooling effect is generally controlled by a simple 'on-off' thermostat that switches on the compressor when the temperature is too high and then off when the temperature has reached a pre-determined level. As such, fridge air temperatures fluctuate and 'cycle'.

During the experiment, the six fridges were set to provide a nominal fridge air temperature of 5°C and maintained an average (across a range of locations within each fridge) temperature distribution below 5°C. A wide variation of air temperatures were measured at different points in the cabinet. The fridges with glass shelves were better able to maintain a more consistent air temperature within the fridge and to minimise any rapid rise in air temperature than those with wire shelves. It is important to note that depending on the temperature of food going into the fridge, its residency time, its density and its packaging the fridge air temperature will not necessarily directly correlate to product temperature. Nor will product temperature fluctuate at the same speed or to the same extent as air temperature. This study was not designed to quantify product temperature changes and cannot suggest the extent to which product temperatures are affected by air temperatures and cycles. However, it is assumed that, at equilibrium, the temperature of the food cannot be lower than the air temperature.

For all but one of the models tested the temperature dial was not designed to correlate with the actual temperature nor was it clear whether turning the dial up would raise temperatures or visa versa.

Ideally, given that temperatures are not consistent within fridges and the temperature fluctuations, consumers should monitor their fridge temperatures, using a fridge thermometer, on a regular basis and at a range of locations within the fridge. This will enable them to keep temperature sensitive foods in the coldest part of the fridge. In addition, awareness of such temperature variations, and advice on where to store specific foods (for maximum quality and safety) should be graphically represented inside the fridge cabinet.

Fridges that clearly indicate their temperature to the consumer, for example, through an integral thermometer (where the reading is visible without opening the door) and alert them when the temperature rises beyond an acceptable level e.g. 8°C would help consumers ensure their fridge is operating at the right temperature.

The humidity levels measured within the fridges showed that in general the interior of a fridge is quite a dry environment. In a fridge, humidity levels are generally lower than the surrounding environment as the moisture in the air condenses on the cooled surfaces within the fridge and then is drained away. These results re-emphasise the importance of wrapping food such as cheese and sliced meats in an air-tight container to prevent them drying out.

Domestic fridge thermometer evaluation

A separate study (undertaken for WRAP by Campden BRI) evaluated a wide range of domestic fridge thermometers available to the UK consumer. The results of this work are presented in a separate report⁶ with an overview of the results included in this report given the recommendation from this work to use a fridge thermometer in the home.

⁵ *The experiments were not designed to align with ISO standards, which set out test methods for household refrigerating appliances, but to simulate a real life environment. Hence, the controlled domestic fridge study tests air temperature rather than product temperature as this is what the consumer will measure using most domestic thermometers.*

⁶ *A performance assessment of domestic fridge thermometers, WRAP, 2009.*

The 18 different fridge thermometers tested were generally accurate, even the cheapest variants, though the development of a design specifically for fridge use (where the scale is at a suitable range) would minimise reader error.

In conclusion, it would seem that there is scope to improve temperature control in the domestic chill chain. Key is improving consumer understanding of the importance of good temperature control and ensuring tools such as fridge thermometers are used effectively. Regularly monitoring fridge temperature in a range of locations and storing the most temperature sensitive foods in the coldest part of the fridge could deliver significant benefits.

Recommendations

This study has generated a number of key observations regarding the consumer use of fridges and a series of recommendations across the supply chain that could be explored to help consumers keep what they buy at its best in the fridge and prevent food waste. These are summarised below:

Food manufacturers

- Simplify the labelling of products with respect to storage conditions on-pack aiming for a common approach whereby manufacturers should choose to label with a choice of two phrases relating to temperature, i.e. either “Keep Refrigerated”⁷ or “Store at 5°C maximum”. This is in line with CFA guidance⁸ and would help reiterate the correct fridge temperature (of below 5°C) and highlight which are temperature sensitive products.
- Extend the use of reclosable packaging, particularly for products like cheese and cooked meat and, where possible, make it clear that the packaging is helping to keep the food fresh because the fridge is a dry environment.

Food retailers

- Increase the availability and visibility of tools such as fridge thermometers and ‘cool-bags’ in-store, for example, by selling them in the refrigerated food aisles.
- Include tips and guidance, for example, at point of sale or incorporated into recipe card materials, highlighting the importance of good temperature control. Increase consumers’ knowledge of the link between optimal storage, particularly in regard to keeping refrigerated food at the right temperature, and keeping food fresh. Such materials could also make consumers aware of humidity levels within the fridge and the importance of wrapping/reclosing opened packs or storing them in air-tight containers.

White goods manufacturers

- Investigate developing an industry standard for whether turning the dial up or down reduces or raises the temperature or as a minimum make it clearer for any given fridge which direction produces a cooler or warmer temperature. It would be helpful if the industry could take steps to start producing fridges where the numbers on the dial reflect the temperature. In moving towards this objective it is recommended that higher numbers reflect higher temperatures.
- Reinforce the importance of keeping the fridge at the right temperature, with tips on using a fridge thermometer and regularly measuring the temperature, for example, graphically within the fridge or within the manufacturer’s handbook.
- Include illustrations, for example, graphically within the fridge or within the manufacturer’s handbook, of where the coldest part is likely to be together with guidance on which temperature sensitive foods should be stored there. Continue to increase the proportion of manufacturer handbooks available online and include a simple “one page” summary \ pull-out on-line and in hard copy of the relevant use and storage advice.
- Develop point of sale material to highlight the importance of good temperature control, fridge humidity and using a fridge thermometer.
- Increase the number of new fridges (even basic designs) that have an integral thermometer. The temperature indicator should ideally be visible to the consumer even when the door is closed. The suitability of integral alarms, that sound when the temperature rises above a certain level, could also be investigated.

⁷ From a manufacturing perspective, chilled food labelling of ‘keep refrigerated’ is taken to mean an 8°C maximum, targeting 5°C. In reality, most commercial chill chains will operate well towards the lower end of this regime. The larger temperature range reflects the fact that residency time in the supply chain is relatively short. Consumer facing messages should, however, only refer to a temperature range of 0-5°C.

⁸ Labelling of storage requirements on pack, CFA, 1996
(<http://www.chilledfood.org/MEDIA/POSITION+STATEMENTS/temperature>)

Fridge thermometer manufacturers

- Ensure all thermometers are sold with clear instructions for use e.g. what temperature the fridge should be run at, good practice on how regularly the temperature should be measured and at how many locations in the fridge.
- Develop thermometers that are specifically for fridge use and have a scale that is appropriate to the temperature range likely to be found in a domestic fridge; and is therefore easy to read.

White goods retailers

- Stock tools such as fridge thermometers and fridge door alarms alongside fridges.
- Include tips and guidance, for example, at point of sale, highlighting the importance of good temperature control.

WRAP / FSA

- Update the survey of domestic refrigerator temperatures in the UK (e.g. as proposed under the FSA's 'Forward Evidence Plan'⁹).
- Use the Love Food Hate Waste (www.lovefoodhatewaste.com) campaign and Eatwell (www.eatwell.gov.uk) to reinforce messages about:
 - The importance of good temperature control in-home and between leaving the supermarket and home for refrigerated foods e.g. minimising the time the food is outside a refrigerated environment and the fridge door is kept open etc.
 - The fact that fridges are not designed to have a consistent temperature throughout, providing good practice guidance for measuring fridge temperatures (how often and at what locations).
 - The likely humidity levels within refrigerators and the effect on food products e.g. the importance to wrap/seal food after opening, using packaging in the right way.
 - What should be kept in the fridge and which are temperature sensitive and should be stored in the coldest part of the fridge.

WRAP will work with the food and white goods sectors through the Courtauld Commitment¹⁰ and Home Improvement Sector Commitment¹¹ to take forward these recommendations. Success would help both improve food safety in the home and could reduce food spoilage associated with poor storage that could lead to waste.

⁹ <http://www.food.gov.uk/multimedia/pdfs/evidenceplan10.pdf>

¹⁰ http://www.wrap.org.uk/retail/courtauld_commitment/index.html

¹¹ http://www.wrap.org.uk/retail/home_improvement/index.html

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