INVESTIGATING FOOD SAFETY IMPLICATIONS OF MEAL-KIT DELIVERY SUBSCRIPTION SERVICES IN TORONTO

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Abstract

Meal-kit delivery subscription services are gaining popularity as a convenient option to have pre-proportioned ingredients and recipes delivered to consumers' homes, providing a new alternative to "fast food." As this is a relatively new food service, there has been minimal research investigating the food safety implications. This study provides a time-temperature analysis of high-risk ingredients such as meat, poultry and fish products that are included in meal-kit delivery subscription boxes available in Toronto, Ontario, Canada. Temperatures were measured (in triplicate) over an 8-hour period after delivery, which may be typical to the average consumer working a "9-5" job. The average surface temperature was calculated for 42 high risk ingredients provided in the meal-kit and analyzed using descriptive statistics. At the 8-hour mark, 76% (n=32) of the average surface temperatures for each product were above 4°C, with a mean temperature of 5.9°C and a standard deviation of 2.1°C. A website review was also completed for the identified 8 companies that were able to provide these services in Toronto, to examine relevant food safety information provided to consumers. Food safety information was minimal, only 12.5% (n=1) recommended checking the internal temperatures of high-risk products upon receiving the delivery. A little more than one third (n=3) of the companies provided information recommending that the temperatures of high-risk food products should be received at temperatures below 4°C or recommend visually inspecting the food products upon receival. None (n=0) of the websites reviewed disclosed a risk of foodborne illness due to microbial growth or temperature abuse, recommended disposing of food products if they appeared to be spoiled, or recommended disposal of high-risk food products if their temperature was within the danger zone prior to refrigeration by the consumer. The results from this study

have shown that current temperature control methods being used by meal-kit delivery subscription services are inadequate, and companies fail to provide sufficient information regarding food safety.

Introduction

Meal kit delivery services are gaining popularity as a convenient and time-saving option to have fresh and pre-proportioned ingredients delivered to the consumers front door, allowing a healthier alternative to traditional "fast food" (Hertz & Halker, 2017). Meal kits contain premeasured raw ingredients as well as an accompanying recipe and are delivered to consumers' home doorsteps after being pre-ordered from the suppliers' websites (Hertz & Halker, 2017). These services provide convenience by saving time on grocery shopping and meal planning. (Hertz & Halkier, 2017). In the Greater Toronto Area, various companies offer this service, including HelloFresh, Chef's Plate, Cook It, Good Food, MissFresh, Fresh City Farms, Yumm, and Dinnerlicious. HelloFresh claims to deliver over 6.8 million meals per quarter to their 2.4 million active customers (HelloFreshGroup, 2020).

Meal kits often include various raw meat and dairy products which can be considered high risk in terms of food safety as they require refrigeration to prevent microbial growth and toxin formation (Randazzo-barnes, 2013). Meal kits are typically delivered in insulated cardboard boxes, with ice packs for temperature control (Hertz & Halker, 2017). Delivery times vary, with most companies specifying a broad 12-hour delivery window. For the consumer that works a typical "9-5" job, boxes can be left out of refrigeration for hours. This creates a risk for consumers, as the meal-kit delivery industry is unable to ensure proper refrigeration throughout

delivery (Randazzo-barnes, 2013). Additionally, the extent that these companies provide consumers with food safety information and recommendations is unclear.

With busy and changing lifestyles, consumers now have less time for in-home meal preparation (Allard, 2002). Combined with improper food handling practices, this contributes to a greater risk of foodborne illness, and the complexity of prevention (Allard, 2002). Although foodborne illness is preventable, it still affects 1 in 8 Canadians every year, with symptoms ranging from vomiting and diarrhea to severe neurological conditions (Thomas et al, 2013). This high burden of illness results in decreased quality of life, loss of productivity, and economic losses (Byrd-Bredbenner et al, 2013).

Many cases of foodborne illness are caused in the home, through unsafe food handling and preparation by the consumer themselves. In a study of *E. coli* outbreaks in the US, 80% of suspect hamburgers had been prepared and eaten at home (Scott, 2003). In Canada, previous data has also shown that the home is the most common setting for exposure to *Salmonella*, *E. coli*, and *Campylobacter* (Scott, 2003). One of the most common mistakes in food handling at home is inappropriate food storage, such as poor refrigeration (Scott, 2003). The US Centers for Disease Control (CDC) states that leaving food out too long before refrigeration is one of the top ten dangerous mistakes regarding food hygiene, as harmful pathogens can grow in perishable food when left out of refrigeration for over two hours. It is recommended to store perishable foods in the refrigerator within 2 hours (CDC, 2019).

As the popularity of meal-kit delivery services increases, the CDC also has dedicated a page to tips for meal-kit delivery safety. Before placing an order, the CDC suggests doing appropriate research on the company's food safety practices (CDC, 2019). The CDC recommends making sure the company is using insulated packaging during delivery, as well as

dry ice or gel packs to keep food cold (CDC, 2019). They also recommend refrigerating or freezing delivered ingredients as soon as possible, and checking that foods arrive frozen, partially frozen with visible ice crystals, or <4°C. To ensure food is safe to eat, it is suggested to verify temperatures using a food thermometer (CDC, 2019).

There is minimal literature specifically investigating the food safety of meal-kit delivery services, as this is a relatively new food service venue. In a study by Hertz & Halkier, meal boxes were considered as a new form of convenience food, as they reduce time needed for meal planning and grocery shopping and are considered a more nutritious alternative to other forms of convenience food (Hertz & Halkier, 2017). The food safety implications of these boxes were not discussed. A review completed by Mercier et al (2017) specifies recent developments in maintaining the cold chain for the transportation of perishable foods. It was determined that the weakest link in the cold chain occurs within transportation by the consumer (Mercier et al, 2017). This is a concern for meal-kit delivery boxes, which are delivered by couriers such as Canada Post who do not use refrigerated vehicles.

Li et al performed a time-temperature study evaluating the ability of insulated packaging with or without icepacks to keep perishable food items out of the temperature danger zone throughout delivery in non-refrigerated delivery vehicles. Temperatures in storage bags as well as surface and internal temperatures of the food were measured in 15-minute intervals over a 4-hour period. It was found that food held in mylar foil bags with frozen gel packs for four hours at an environmental temperature of 21.1°C exhibited a temperature increase of 4-11°C (Li et al, 2014). However, some meal-kit delivery boxes use alternative lining and not mylar foil, as they aim to have 100% recyclable packaging. (HelloFresh, 2019). Additionally, these boxes are often left out of refrigeration for much longer than a 4-hour time period.

As the popularity of these subscription services increases, food safety implications need to be further researched. The aim of this study was to investigate the temperature change in high-risk food products delivered in meal-kit subscription boxes when left out of refrigeration for a time period similar to that which is to be expected by the typical consumer. Websites of each meal-kit delivery service were also reviewed for information pertaining to food safety and the prevention of foodborne illness.

Methods

Temperature assessment

Eight meal-kit delivery subscription services were identified as available to be delivered to consumers in Toronto, Ontario. Each meal-kit was ordered for delivery, corresponding to the dates in Table 1. Recipes in each meal-kit were preselected from those which contained temperature sensitive meat, poultry or fish products. The most basic meal kit subscription was selected, containing either two or three recipes, and the ingredients to make those recipes. Delivery dates were staggered from November 11th, 2019 to January 11th, 2020, as seen in Table 1.

Upon delivery, the packages were collected and stored at room temperature of 22.8°C. The internal air temperature of each box was taken by placement of an electronic cooking probe thermometer (Cooper-Atkins DDT361, Middlefield CT) in the centre of the box. The probe thermometer was placed inside of the box with the probe positioned in the centre, the box was resealed, and the internal air temperature was recorded after 10 minutes. This was performed hourly for 8 hours following delivery of each box.

For each meat, poultry or fish food item, the surface temperature was collected in three different areas using an infrared thermometer (Thermor PS200, Newmarket ON). This was completed upon delivery, and hourly for an 8-hour period following delivery. After each hourly measurement was recorded, the products were repositioned to their original state, and the box was re-sealed until the next measurement was taken.

For each meal-kit company, two rounds of meal-kit boxes were obtained on different dates. During the data collection phase, one food company (MissFresh) was merged with a different company (CookIt).

Table 1. Delivery dates for meal-kit delivery subscription services, and selected products.

Company ID #	**Delivery Date 1**	**Product Type**	**Delivery Date 2**	**Product Type**
1	11-Nov-19	Ground pork Steak	27-Jan-20	Italian sausage Chicken
2	11-Nov-19	Ground pork Steak Chicken	27-Jan-20	Pork strips Pork chops Chicken
3	11-Nov-19	Salmon Chicken Ground pork	03-Feb-20	Shrimp Chicken Ground pork
4	22-Nov-19	Italian Sausage Shrimp Ground Beef	N/A	N/A
5	22-Nov-19	Chicken Italian sausage	11-Feb-20	Chicken Italian sausage

6	22-Nov-19	Italian sausage Beef strips Ground lamb	03-Feb-20	Pork Strips Beef Strips Ground Beef
7	21-Jan-20	Prosciutto Ground turkey Chicken	11-Feb-20	Chicken Ground beef Steak
8	27-Jan-20	Ground beef Pork chops Italian Sausage	07-Feb-20	Italian sausage Ground beef Pork chops

Data analysis

Microsoft Excel for Mac was used to complete data analysis. For each hourly data point, the three surface temperatures collected for each product were averaged to show the average surface temperature of each product per hour (beef, chicken etc.). The average surface temperature recorded on delivery was subtracted from the average surface temperature at the 8-hour mark to calculate the average change in temperature for each product after 8 hours. Descriptive statistics were produced through the calculation of means and standard deviations for each hourly surface temperature average, the overall change in temperature for each product, and the internal air temperature of the box on delivery and at the end of the 8-hour period.

Website review

A website review was conducted for each meal kit delivery subscription company. The websites were reviewed in whole for information pertaining to food safety, foodborne illness, and temperature requirements. Websites were evaluated based on presence of the following food safety information: disclosed a possible risk of foodborne illness due to microbial growth on food products or from temperature-abused foods, recommended checking temperature of ingredients on receival, recommended temperatures of perishable items should be kept at or below 4°C after delivery, recommended visual inspection of food products, recommended disposal of items if visibly spoiled or if product temperatures were >4°C for more than 2 hours prior to refrigeration by the consumer, and if the website stated that use of products is at the consumer's own risk. For each criterion, information was either classified as present or absent.

Packaging

The packaging and cooling methods for each meal-kit were reviewed on delivery. Notable characteristics were recorded, including the quantity and type of ice packs used, and the type of packaging used to contain the meal-kit.

Results

Temperature assessment

Over the entire study period, a total of 42 recipes were ordered, each containing one high-risk food product (meat, poultry or fish). The average surface temperatures for each product over the 8-hour period were plotted in Figure 1. On delivery, the average surface temperature for each individual product ranged from -2.4°C to 7.6°C. Five of the food items had average surface temperatures of 0°C or below. Overall, the mean change in temperature over 8 hours for all

products was an increase of 3.7°C, with a standard deviation of 1.6°C. The greatest change in average surface temperature after 8 hours was an increase of 7.4°C in a chicken product. The average change in temperature for each product over the 8-hour period is shown plotted in Figure 2.

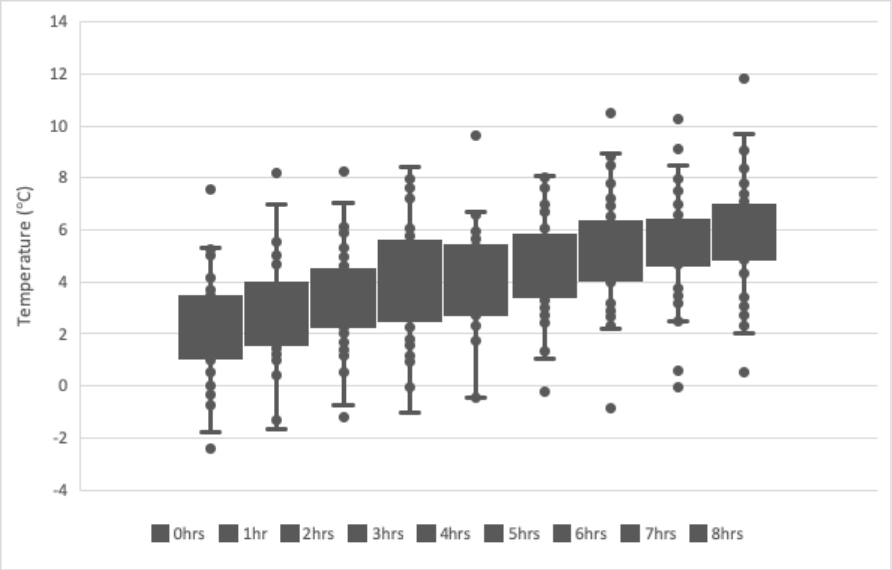

Figure 1. Average surface temperatures of 42 delivered meal-kit food products over 8 hours. The average surface temperature for each product was plotted hourly for up to 8 hours after delivery.

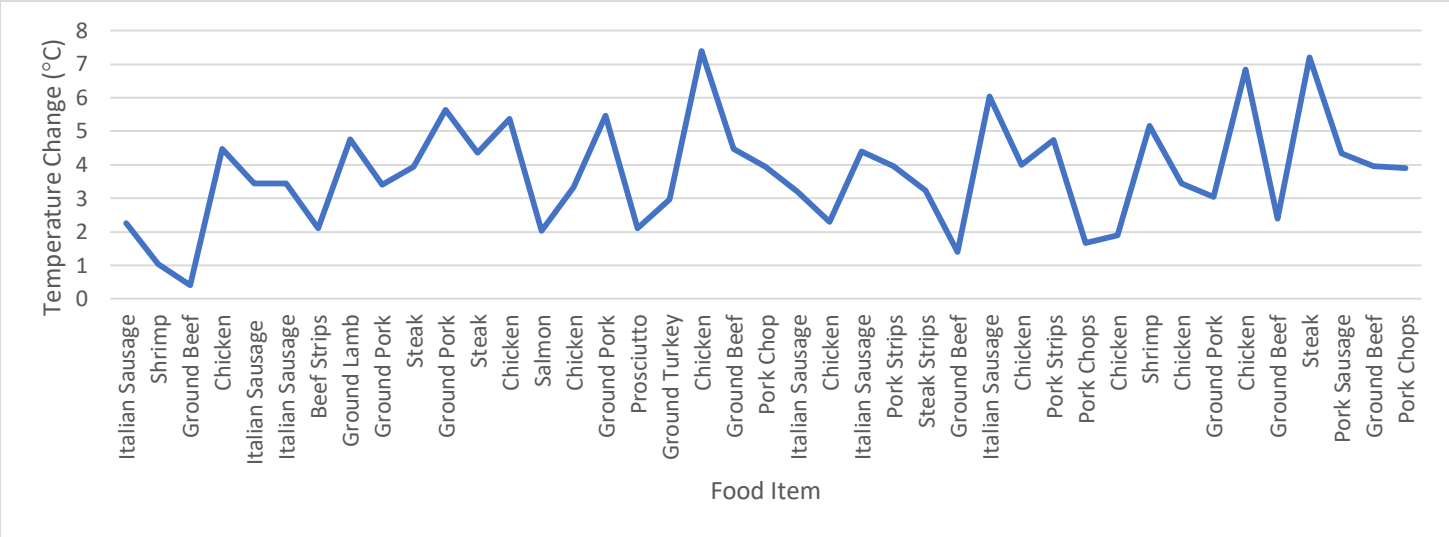

Figure 2. Average change in surface temperature of 42 delivered meal-kit food products over 8 hours.

On delivery about 12% (n=5) of products had average surface temperatures >4°C. The average surface temperature of each product at 0 hours (at delivery) was plotted in Figure 3. Upon delivery, the mean surface temperature for all products was 2.1°C with a standard deviation of 1.9°C. The highest surface temperature was recorded as 7.6°C. By the third hour, over half (n=22, 52%) of the products had an average surface temperature greater than 4°C. At the 8-hour mark, 76% (n=32) of the average surface temperatures for each product were above 4°C. The final average surface temperatures (8 hours) for each product can be seen in Figure 4. The mean surface temperature for all products at 8 hours was 5.9°C with a standard deviation of 2.1°C. The highest average surface temperature calculated at 8 hours was 11.8°C.

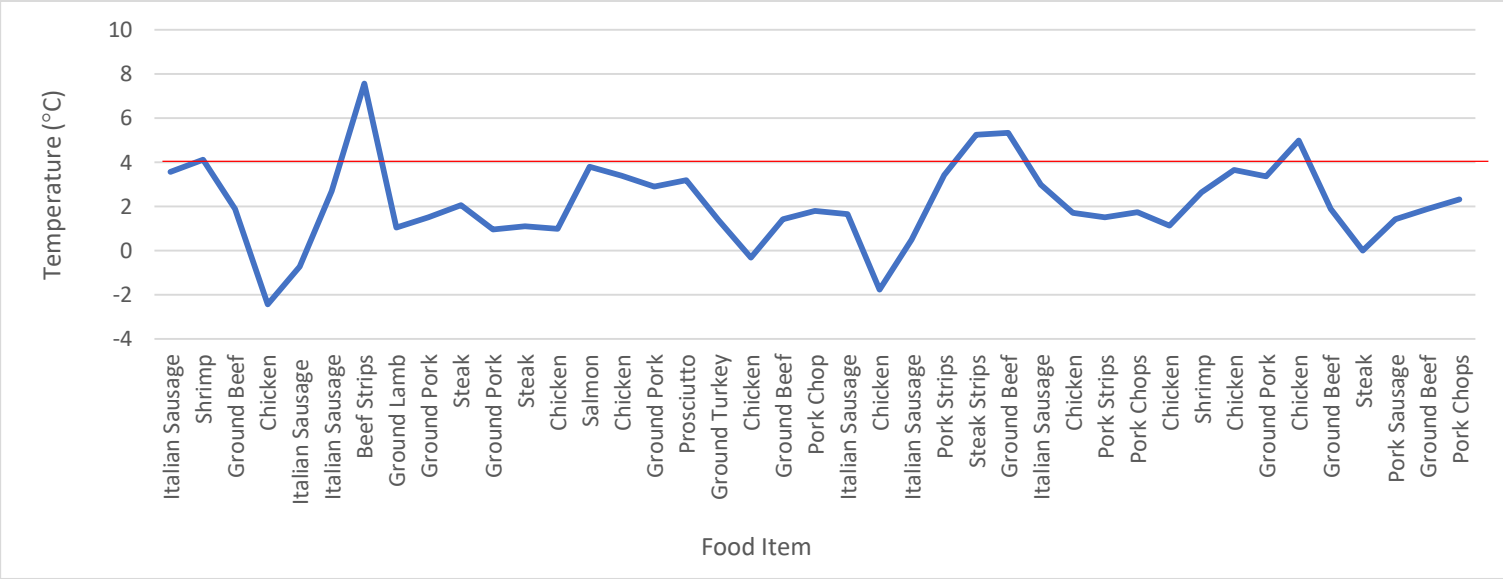

Figure 3. Average surface temperature of 42 delivered meal-kit food products on delivery (0 hours)

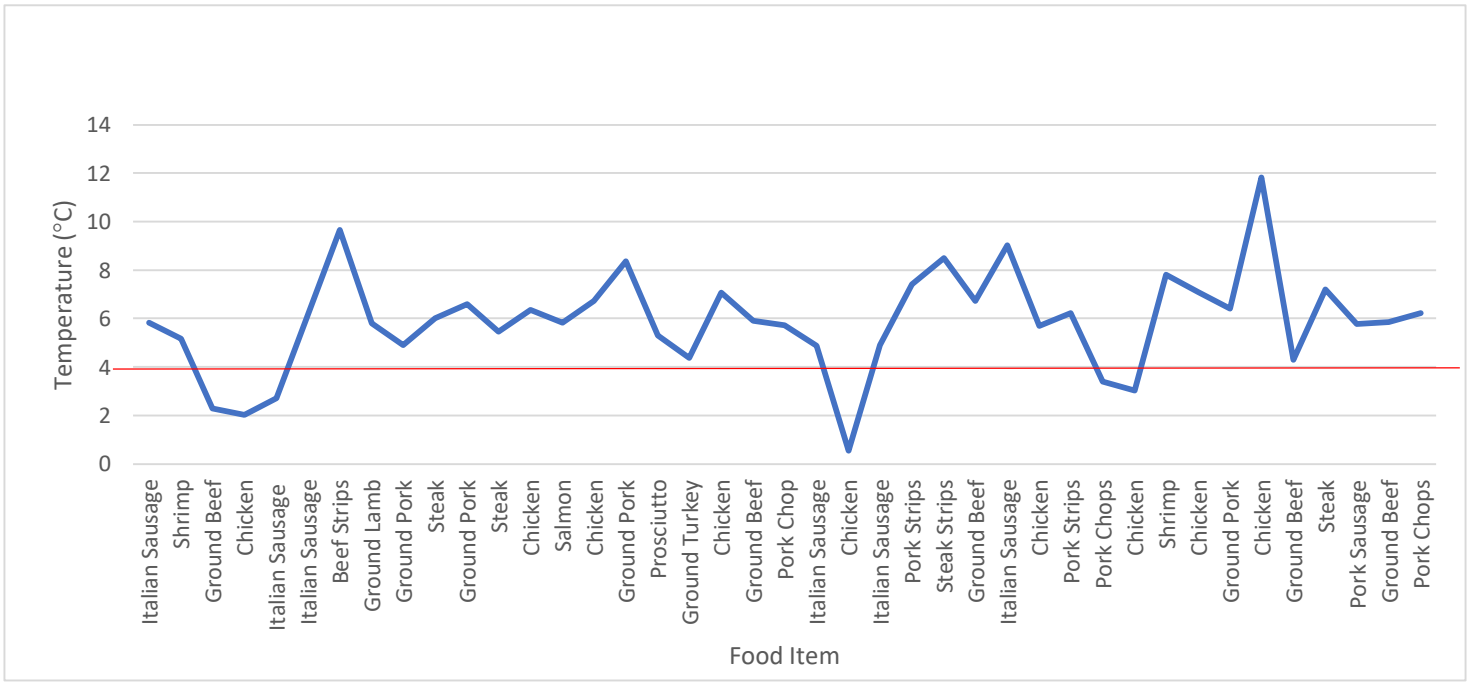

Figure 4. Final average surface temperature of 42 delivered meal-kit food products (8 hours)

The internal air temperature of each meal-kit box recorded at delivery can be seen plotted in Figure 5. The average air temperature was calculated to be 8.4°C, with a standard deviation of 2.5°C. The internal air temperature for every box was above 4°C on delivery.

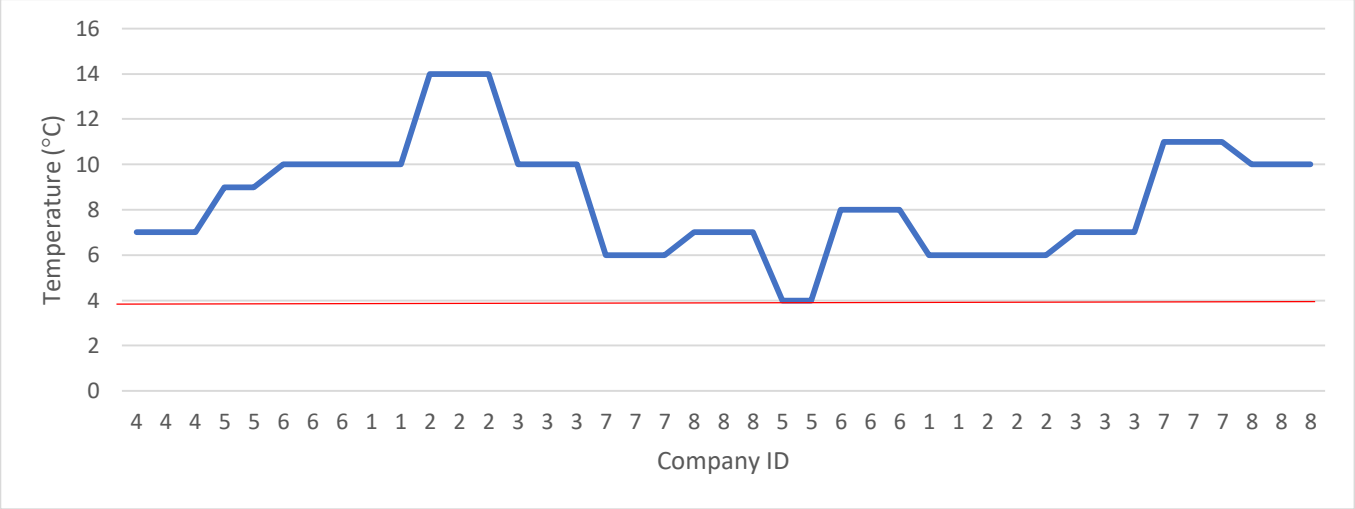

Figure 5. Internal air temperature of 42 meal-kit boxes on delivery (0 hours).

Website review

Eight meal-kit subscription delivery companies were identified as available to delivery to Toronto, Ontario. Of the 8 websites reviewed, 12.5% (n=1) recommended checking the temperatures of high-risk products upon receiving the delivery. A little more than one third (37.5%, n=3) of the companies provided information recommending that the temperatures of high-risk food products should be received at temperatures ≤4°C or recommend visually inspecting the food products upon receival. None (n=0) of the websites reviewed disclosed a possible risk of foodborne illness due to microbial growth or temperature abuse, recommended disposing of food products if they appeared to be spoiled, or recommended disposal of high-risk food products if their temperature was >4°C for more than 2 hours prior to refrigeration by the consumer. The majority (n=6) of companies disclosed that the health risk of products is passed to

the consumer upon delivery, and consumption of products is at own their risk. For each of these websites, all of the above information was only provided in fine print on the "Terms and Conditions" page.

Packaging

Each meal-kit was supplied with one or two water or saline gel ice packs and was stored in a carboard box with a plastic lining. The packaging of all meal-kit delivery boxes ordered was nearly identical, the packaging details can be found in Table 3. The exception being the packaging of one company (ID 5), which also resulted in some of the lowest surface temperatures. Uniquely, this company opted to deliver their meal kits in a reusable cooler bag, with a foil cooling bag inside, containing the high-risk products.

Table 2. Characteristics of meal-kit packaging and cooling methods.

Sampling Date	Company ID	# Products Sampled	Cooling Materials Used	Packaging	# of Icepacks
11-Nov-19	1	2	Gel	Cardboard box, white plastic lining	2
11-Nov-19	2	3	Gel	Cardboard box, silver lining	1
11-Nov-19	3	3	Gel	Cardboard box, no lining	2
22-Nov-19	4	3	Gel	Cardboard box, silver lining	1
22-Nov-19	5	2	Gel	Thermal foil bag & icepacks, inside of cooler bag	1
22-Nov-19	6	3	Water	Cardboard box, white plastic insulator	2
21-Jan-20	7	3	Gel	Cardboard box, silver lining	3
22-Jan-20	8	3	Gel	Cardboard box, silver lining	1
27-Jan-20	1	2	Gel	Cardboard box, white plastic lining	2
27-Jan-20	2	3	Gel	Cardboard box, silver lining	1
03-Feb-20	6	3	Water	Cardboard box, white plastic lining	2
03-Feb-20	3	3	Gel	Cardboard box, no lining	2

07-Feb-20	8	3	Gel	Cardboard box, silver lining	1
11-Feb-20	7	3	Gel	Cardboard box, silver lining	2
11-Feb-20	5	2	Gel	Thermal foil bag inside of cooler bag	1

Discussion

At temperatures above 4°C, many bacteria can grow to dangerous levels that result in foodborne illness, including *S. aureus, E. coli O157:H7, Campylobacter* and *Salmonella*. (USDA, 2017). It was determined that at the end of the 8-hour study period, most (72%) meat, poultry and fish food items had an average surface temperature of greater than 4°C. Only five of the food items had average surface temperatures of 0°C or below, suggesting that they were frozen. Even at the 3-hour mark, over 50% of the products had average surface temperatures greater than 4°C. As per the Government of Canada, cold foods should be kept at temperatures ≤4°C in order to slow down the growth of bacteria and prevent food poisoning (Government of Canada, 2014). Keeping temperatures at or below 4°C is critical to prevent foodborne illness, as higher temperatures can result in the growth of microorganisms and production of heat-stable toxins (Almasour et al, 2011). The high temperatures found among delivered foods could be caused by various factors, such as the temperature of the product when leaving the facility for delivery, use of unrefrigerated delivery vehicles, packaging used for the meal delivery box, and the improper placement of icepacks to meat products. When collecting surface temperatures of each food item, it was observed that usually if the meat item was in contact with the icepack, the temperatures were kept lower and out of the danger zone. However, often the icepacks were only in contact with one side of the meat product, leaving the other side completely exposed to temperatures well above that required for sufficient refrigeration.

Results of this study suggest that the packaging and cooling methods currently used by most meal-kit delivery companies are insufficient in keeping temperatures out of the danger zone. As the average internal air temperature of the meal-kit box storing the ingredients was always above 4°C, it can be concluded that the packaging used does not provide adequate refrigeration temperatures for the food products, resulting in the reliance of ice packs to keep items chilled. In a study completed my Almansour et al, it was found that in school lunches, the presence of ice packs was not sufficient in keeping temperatures of food items outside of the danger zone (Almansour et al, 2011). These results can be extrapolated to this study as well, however the results of this study could be considered potentially at a higher risk, as we are investigating high-risk raw meat products. Almansour et al recommended that further education was needed to inform the public on proper packing methods to ensure food items remained out of the temperature danger zone (Almansour et al, 2011). It was also suggested that further research should be completed on the development of ice packs and other tools that could be used to maintain safe food temperatures (Almansour et, 2011).

Only one company recommended checking the temperature of high-risk food products upon receival. Overall, food safety information was scarce and difficult to locate on the website for each company, with some companies lacking any information regarding food safety. Those that did have minimal information only presented this on the fine print "Terms and Conditions" page. All but two of the companies had a use at your own risk disclaimer, stating that the responsibility was transferred to consumer upon delivery of the product. In a study completed by Redmond, it was found that consumers generally believe there is a low personal risk of foodborne illness from food cooked at home, and in comparison to "other people," they are at a lower risk from food-related illnesses or hazards (Redmond, 2004). Given that risk of foodborne

illness is typically under-estimated by consumers at home, this may result in a lack of appropriate steps taken to reduce the hazards of foodborne illness (Redmond, 2004). Although most companies transfer the risk of foodborne illness due to temperature-abuse to the customer, it can be suggested that meal-kit delivery subscription services should have a dedicated page to food safety on their websites, to ensure consumers are educated on possible risks and steps that can be taken to reduce these. Alternative options could include a food safety pamphlet inside of the delivery boxes or sending a follow up email to the customer after an order is placed which includes recommendations to ensure proper food safety. Some of these companies also have smartphone apps, and a notification system could be set up in order to inform customers once their box has been delivered and provide additional food safety information on preventing temperature abuse.

A limitation of this study was that in order to record the internal air temperature of the box, as well as the surface temperature of the products, the box had to be unsealed on an hourly basis, which would have resulted in a loss of cold air inside of the box itself. This was attempted to be controlled by resealing the box using duct tape after each temperature measurement was recorded. Another limitation is that the study was performed during the winter months, when outdoor temperatures averaged below 0°C, resulting in potential additional cooling of the boxes. This study should be repeated in the summer, when outdoor temperatures average above 20°C, to see if more extreme results are obtained, given that the cooling methods used were already deemed ineffective at low outdoor temperatures.

Several recommendations can be made based on the findings of this study. As temperature control of high-risk items is reliant on the use of icepacks, meal-kit delivery subscription services should strategically place icepacks in boxes to cover the maximum amount

of surface area possible for these items. For example, two icepacks could be taped around the products to ensure that meat, poultry and fish products are in constant contact with the icepacks. Additionally, the use of reusable cooler bags should be considered as an alternative means of packaging. The company with the lowest recorded internal air temperatures and surface temperatures used reusable cooler bags to store items, instead of the cardboard boxes used by all other companies. More research should be completed to investigate the effectiveness of cooler bags in comparison to plastic-lined cardboard boxes in regard to temperature control. Finally, companies should ensure that when products are leaving their facility for delivery to consumers, they are at frozen temperatures. This will prevent the temperatures of food products from reaching the danger zone from delivery to storage or cooking by consumers.

In summary, this study is the first to conduct a time-temperature analysis of surface temperatures of high-risk products delivered in meal-kit delivery subscription services and to evaluate company websites for relevant food safety information. Results of this study have shown that meal-kit delivery companies need to re-evaluate temperature control methods used to minimize the risk of foodborne illness among consumers due to temperature abuse, as some products were already >4°C upon delivery and nearly three-quarters of products reached potentially unsafe temperatures at the end of the 8-hour study period. Currently, most companies transfer the risk of foodborne illness to the consumer and few provide useful food safety information to consumers. Additional efforts are needed by these companies, with a focus on educating the consumer to decrease the burden of foodborne illness. This could include the use of smartphone apps to provide additional food safety information, a follow up email sent to customers once their order is placed or shipped, informing them on required refrigeration temperatures, or simply additional information provided throughout company websites. To

ensure companies are minimizing the risk of temperature abuse, it is suggested that they used strategic icepack placement for high risk items. For example, securing icepacks with tape or elastic bands around the food items would ensure that a larger surface area is being chilled. Additionally, the use of packaging alternatives such as insulated cooler bags should be investigated.

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