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Survey and analysis of internal temperatures of Lebanese domestic refrigerators

Hussein F. Hassan ^{a,*}, Hani Dimassi ^b, Rafal El Amin ^a

^a Department of Natural Sciences, Nutrition Program, School of Arts and Sciences, Lebanese American University, Beirut, Lebanon

^b School of Pharmacy, Lebanese American University, Byblos, Lebanon

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ABSTRACT

In the light of power crisis that Lebanon is witnessing, temperatures were recorded, using data loggers, in 147 domestic refrigerators in three main cities every 5 min over 3 days. A questionnaire was administered to gather information on household characteristics, power supply and refrigerator. Temperatures were on average 8.0 °C with minimum –5.9 °C and maximum 37.0 °C. Income, number of household members, age, brand, load level and seal of the fridge, frequency of power cuts and availability of alternative power had no significant effect on the overall mean temperature, while the city and the distance to heat source had a significant effect. The number of high temperature readings ($T > 6$ °C) differed significantly between the cities, while the availability of an alternative power was borderline significant. The lowest average temperatures were recorded during the night and 70% of average temperatures were in the danger zone (above 6 °C). This study can provide input to food safety risk assessments.

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Etude et analyse des températures internes de réfrigérateurs domestiques libanais

Mots clés : Réfrigérateur ; Température ; Enregistreurs de données ; Questionnaire ; Liban

1. Introduction

The reported incidence of gastrointestinal illness in Lebanon is increasing with a significant proportion of cases thought to be foodborne (Dib, 2009). In order to minimize microbiological growth on food and prevent foodborne diseases, temperature control throughout production, transportation, storage, retail

display and domestic refrigeration is vital and information relating to temperature profiles during these stages is crucial to assess and manage pathogen-associated risks. For instance, the most commonly recommended temperature range for food refrigeration is 1–5 °C (Gilbert et al., 2007).

Foodborne illness is initiated in private homes three times more frequently than in commercial facilities (Sheard, 1986; Borneff et al., 1988; Scott, 1996; Scuderi et al., 1996). In

* Corresponding author. Tel.: +961 1 786456x1609, +961 3 191445; fax: +961 1 867098.

E-mail address: hussein.hassan@lau.edu.lb (H.F. Hassan).

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Nomenclature

ANOVA	analysis of variance
EDL	Electricite du Liban
SPSS	statistical package for social sciences

addition, up to 50% of these foodborne illness cases were linked to inappropriate food storage including ineffective chill storage and refrigerator management. Refrigerators form an important link in the wider chain of cross-contamination, and a significant factor of outbreaks of domestic foodborne disease (Ryan et al., 1996). However, the increasing importance of chilled, “ready-to-eat” products, which now make up to 60% of the average European shopping basket (Anonymous, 2003a, 2003b, 2003c), means that the refrigeration practices will continue to be major determinants in domestic food safety (Ryan et al., 1996). According to a recent report published by the Institution of Mechanical Engineers, 25% of food wastage in the developing world could be eliminated with better refrigeration (Eagle, 2014).

Despite the good hygiene and equipment advances, domestic refrigeration, which is not covered by laws and regulations in majority of countries, is still a source of concern (Laguerre et al., 2002). Lebanon is currently facing the worst electrical power supply in its history. An estimate of 90% people spend long hours in darkness (Al Amin, 2012) which is most likely affecting the internal temperature of domestic fridges and thus; putting the Lebanese population at high risk of foodborne illnesses.

Few studies have been carried out worldwide to study the refrigeration temperature in domestic settings. In China, only 2.3% of domestic refrigerators operate with a temperature <6 °C, 34.1% within 8–12 °C, 34.1% within 12–14 °C and 29.5% operate at >14 °C (Shixiong and Jing, 1990). In France, the mean temperature of >70% of refrigerators is over 6 °C and a majority of surveyed participants were unable to state the temperature at which they attempted to operate their refrigerator (Victoria, 1993). Furthermore, 15% of surveyed households in United Kingdom and 0% in Northern Ireland and New Zealand used a thermometer to control the refrigerator temperature. In addition, the refrigerator temperature was found to be influenced by a combination of factors (Flynn et al., 1992; James and Evans, 1992). In New Zealand, the majority of appliances were not operating within the recommended temperature range and a high percentage of responders were unaware of the safety zone, and did not have the means to check internal temperatures as none of the refrigerators were fitted with thermometers (O'Brien, 1997). Also, 33% of the temperature measurements in refrigerators in this country exceeded 5 °C (Anon., 2007). In addition, overall mean temperature was 5.2 °C and a significant proportion (34%) had a mean temperature >6 °C, while 55% had a mean temperature of >5 °C (Gilbert et al., 2007). In Sweden, 5–20% of the food items were stored at temperatures above 10 °C (Marklinder et al., 2004). In a Malaysian study done by Rahman et al. (2005), the temperatures of the surveyed refrigerators were: minimum –2.8 °C, average 2.0 °C, and maximum 7.5 °C. In USA, 20% of domestic refrigerators were found to operate at >10 °C (Jol et al., 2005).

No study was carried out previously in Lebanon to study the refrigerator temperature on the domestic level and to analyze the factors affecting it. The present study was done to (1) monitor the air temperature inside the refrigerator under real-use conditions and (2) to analyze the factors which have the greatest impact on refrigerator temperature. Results of our study would provide input for quantitative risk analysis models and act as a useful tool for promoting food safety.

2. Materials and methods

One hundred forty seven (147) representative refrigerators were surveyed between November 2013 and December 2013 from the three major Lebanese cities (Beirut: $n = 74$; Tripoli: $n = 37$ and Saida: $n = 36$). All refrigerators were fridge-freezer type. Selected sample size per city was calculated in a proportional way according to each city's population as per the Central Administration of Statistics in Lebanon; that is why, Beirut had the highest number of participating households, followed by Tripoli and Saida. Trained investigators interviewed a family representative and filled in a questionnaire to obtain information on the characteristics of the family (area of residence, income, gender and age of the family members), the characteristics of the power supply (frequency of power cuts, availability and frequency of the alternative power), and the characteristics of the fridge (age, seal status, brand name, volume, load level, distance to heat source and presence of a thermometer). An explanation of the study objectives, significance, and protocol, and request for the household representative to participate in the study were included on the first page of the questionnaire. Upon initial approval, informed written consent was obtained from each participant who was willing to participate in the study. The study protocol was approved by the Institutional Review Board at the Lebanese American University. A pilot study (12 households) was done to get a preliminary validation of the questionnaire. The clarity and suitability of wording, in addition to the average time needed for its completion were assessed. Then, necessary modifications were made and the results of the preliminary study were not included in the data analysis.

Data loggers (EBI 20, Ebro, Ingolstadt, Germany) with single sensors were programmed to record the temperature every 5 min over a period of 3 days. They were mounted at the middle shelf of the refrigerator near the corner furthest from the door hinges. After recovery of data loggers, temperature recordings were extracted and analyzed.

SPSS v18 Statistical computer software was used for all statistical analyses. The characteristics of the family, power supply and fridge were the independent variables. Overall mean temperature of the fridge for the three days, average of temperature recordings per day, average of temperature recordings per time slot (12:00 AM–6:00 AM; 6:00 AM–12:00 PM; 12:00 PM–6:00 PM and 6:00 PM–12:00 AM) and number of high temperature readings (temperature > 6 °C) represented the dependent variables. Analysis of Variance (ANOVA) was conducted to assess the effect of each independent variable and significance level of 0.05 was used.

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