TIME/TEMPERATURE RECORDING WITH DATA-LOGGERS AND DEVELOPMENT OF A SPECIFIC SOFTWARE FOR CUMULATIVE ABUSE MEASUREMENT

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Background - Among the most interesting topics of modern food control aspects, prevention and management of diffusion of biological entities are the most important. While demanding completely safe food is unrealistic, it is possible to have food in which potential hazards have been reduced (Adams and Moss, 2000). Even today, despite our increased knowledge, 'Food-borne disease is perhaps the most widespread health problem in the contemporary world and an important cause of reduced economic productivity' (WHO, 1992). The *intervention* approach, instead of the old-fashioned *repressive* one, extended all along the food production, distribution and storage lines, leads to adequate consumer protection. The European Union Directive 93/43, commonly known as 'the food hygiene directive' (Council Directive 93/43/EEC) and the more recent Proposal for a Regulation of the European Parliament and of the Council laying down detailed rules for the organisation of official controls on products of animal origin intended for human consumption (COM (2000) 438(03) indicate the stages to be applied for. They include the design of ways for the elimination of all identified critical sites and practices, relying on holistic quantitative risk analysis; the implementation of the required intervention steps all along the production, distribution and culinary preparation lines; and the meticulous codification of procedures to be followed throughout. Adequate control of storage temperature all along the food chain is one of the most important points in code of good manufacturing and distributing practices but not always achieved as supported by surveys of retail display cases (FDA, 1996). Temperature abuse (TA) occurs when product is allowed to remain at temperatures favourable to pathogen growth for sufficient time to result in unsafe levels of pathogens or their toxins in the product. It is of the utmost importance that processors manage the amount of time that food is exposed to temperatures that are favourable for pathogen growth and toxin production (FDA, 1996). During food processing, transportation and distribution microbial growth can be limited or enhanced in according to temperature variation. Pathogen growth and toxin formation as a result of time/temperature abuse (TTA) of food products can cause consumer illness. Current regulation gives several indications and provides with minimum legal requirements for fresh meat (Council Directive 91/497/EEC), meat products (Council Directive 92/5/EEC) or fresh poultry meat (Council Directive 92/116/EEC), although future regulation should mainly focus on the cumulative time/temperature abuse (CTTA).

Objectives - It is of the utmost importance that processors manage the amount of time that food is exposed to temperatures that are favourable for pathogen growth and toxin production (FDA, 1996). In an attempt to explore the relationship between refrigeration and microbial growth, the objective of this work is to test retail display cases and home refrigerators for time/temperature abuse and to develop software for measurement of CTTA during production, storage and distribution. One of the main problems is still related to the precise determination of the CTTA; in fact, whilst several data-logger are able to download data to any PC, very few software are currently available to calculate the CTTA when several thousands measurements have been recorded. Using Microsoft Visual Basic (Microsoft Corporation, US) we developed specific software to easily calculate the CTTA from within Microsoft Excel spreadsheet files of any size.

Methods - Towards control of the time/temperature recording, several data logger were used. These are two-channels portable units (temperature and relative humidity) type Testostor 175-2 (Testo, Lenzkirch, Germany). A serial connection was used to transfer data to a PC. Data were saved as .WKS files which have been then edited with spreadsheet software. Each data-logger can hold up to 4000 measurements and the rate frequency (RF) can be set from 30 seconds to 12 hours intervals. The Testo software was used to calibrate the loggers and to download data. System requirements for this software are very low: an IBM PC or compatible computer with at least a 386 microprocessor with Windows 3.1 or better and 4 MB of main memory are sufficient. During this first trial we have checked 12 retail display cases and 10 home refrigerators for CTTA using a RF of 5 min, thus recording 12 measurements per hour, 288 per day, for up to 2000 measurements per week per each device checked. The large spreadsheets files generated by the Testo software during the download of data have been then processed with the software developed. The CTTA has been calculated with software, developed using Microsoft Visual Basic to generate routines and a specific "macro" that runs within Microsoft Excel spreadsheets. This macro, using a clear-cut algorithm, is able to calculate the area off all the peaks falling above the chosen control temperature (CT) and then to determine the length of the base (i.e. the time abuse). This first version of the macro runs on the Italian versions of Microsoft Excel 97 for Windows and of Microsoft Excel 98 for Macintosh. Future versions will run on any Microsoft Excel version regardless the software localization and the operative system.

Results and discussion - We have generated several charts to accurately analyse the temperature trends. Unfortunately, for space reasons, we can include in the text only three examples (Figures 1, 2 and 3) along with the detailed CTTA for several control temperature. We grouped the refrigerators in diverse categories. Since no commonly acknowledged data are available, we arbitrary generated the following categories for retail display cases, according to the CTTA: excellent (temperature lower than the minimum legal requirement for 90% of the storage period), good (70%), fair (50%), poor (30%), dangerous (>20%). For home refrigerators we arbitrary generated the following categories, according to the CTTA: excellent (temperature < 6°C – 42.8 F -, for more than 90% of the storage period), good (temperature <6°C for >70%), fair (>50%), poor (>30%), dangerous (>20%). Two retail display cases were put into the excellent category, whilst almost all the remainders were in the fair one: only one was judged poor. The situation was worse in the home sector: only one refrigerator was included among the excellent, and only two in the good one, while the remainder were in the fair (6) or the poor (1) category. We this work we demonstrated that at some point during storage, distribution, display or consumer handling of refrigerated foods, proper refrigeration temperatures was not maintained. Surveys of retail display cases indicated that temperatures of 45-50°F (7-10°C) were not uncommon. Surveys of home refrigerators indicated that temperatures exceeded 50°F (10°C). The first version of our software was able to calculate the CTTA for all the tested devices at several control temperature (Figures 1, 2 and 3): its user-friendly interface and the ease of use allow even the least experienced user to master all the parameters and to generate detailed charts and reports.

Pertinent literature - **Adams**, M. R. and M. O. Moss (2000), Food Microbiology, The Royal Society of Chemistry, Cambridge, UK. - **FDA**. 1996. Fish and Fishery Products Hazards and Controls Guide, 1st ed. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Center for Food Safety and Applied Nutrition, Office of Seafood, Washington, DC. - **WHO**. 1992. 'WHO Commission on Health and Environment. Report of the Panel on Food and Agriculture'. WHO/EHE/92.2, 191pp.

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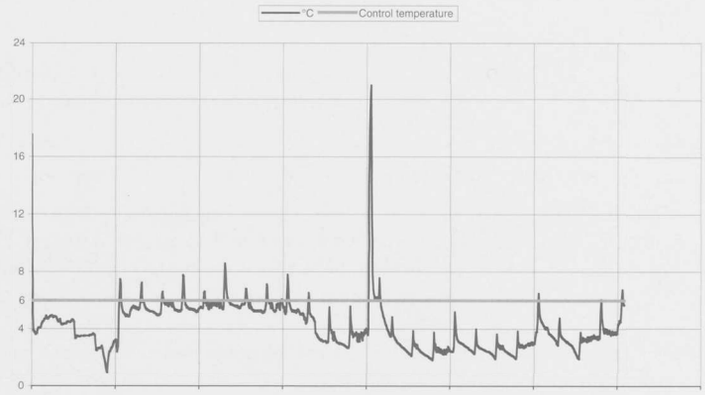
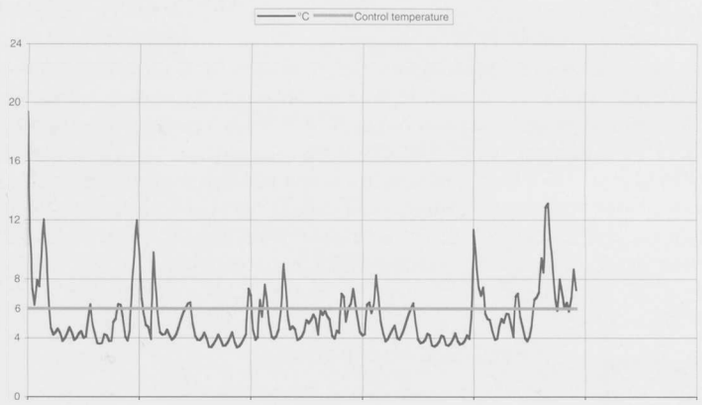


Time/temperature abuse:

- >4°C: 81 hrs, 24 min
- >6°C: 10 hrs, 58 min
- > 8°C: 1 hrs, 33 min
- >10°C: 1 hrs, 03 min

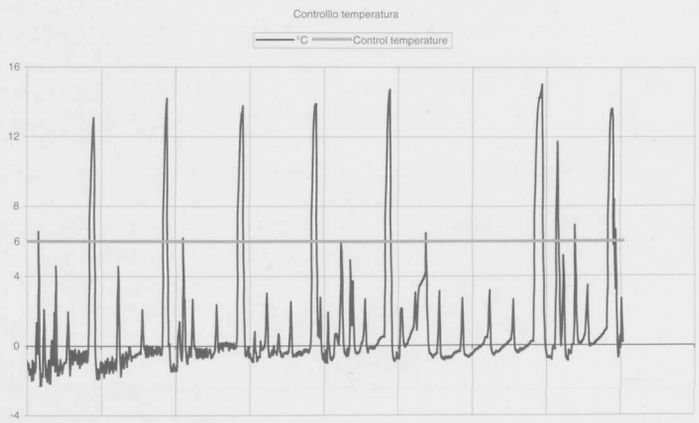
Figure 1. Example #1: time/temperature measurements from 19/10 to 26/10/2001.



Time/temperature abuse:

- >4°C: 47 hrs, 25 min
- >6°C: 17 hrs, 17 min
- > 8°C: 5 hrs, 26 min
- >10°C: 2 hrs, 16 min

Figure 2. Example #2:time/temperature measurements from 28/02 to 02/03/2002.



Time/temperature abuse:

- >4°C: 19 hrs, 02 min
- >6°C: 14 hrs, 44 min
- > 8°C: 12 hrs, 29 min
- >10°C: 10 hrs, 16 min

Figure 3. Example #3: time/temperature measurements from 04/03 to 12/03/2002.