Available online at www.sciencedirect.com
SCIENCE DIRECT®
Food Control 16 (2005) 515–521
FOOD CONTROL
www.elsevier.com/locate/foodcont

Microbiological risk assessment in the beverage industry

Zoltán Syposs [a,*], Olivér Reichart [b], László Mészáros [c]

[a] The Coca-Cola Company (CERD), P.O. Box 453/174, H-1537 Budapest, Hungary
[b] Department of Food Hygiene, Faculty of Veterinary Science, Szent István University, István u. 2., H-1078 Budapest, Hungary
[c] Department of Refrigeration and Livestock Product Technology, Faculty of Food Science, Szent István University, Ménesi út 45., H-1118 Budapest, Hungary

Received 1 August 2003; accepted 22 January 2004

Abstract

This paper illustrates some of the developments and considerations in the field of quantitative microbiological risk assessment, applying a beverage industrial model based on laboratory based experiments, process exposure assessment versus finished-product microbiological quality control. In laboratory experiments, the authors investigated the effect of chlorination on *Klebsiella oxytoca* and the efficacy of industrial water treatment was estimated by applying a mathematical model based on destruction kinetics. The quantitative risk assessment model took into account the input contamination level, the chlorine concentration and the residence time distribution in the chlorination tanks with their probability distribution and the probability of *Klebsiella oxytoca* detection in the treated water as a function of the input cell concentration was calculated by using Monte Carlo simulation. The model was validated in a Pilot Plant for a six month period and the linear relationship between the predicted and observed probability of *Klebsiella*-detection was characterized with a determination coefficient of $R^2 = 0.905$.

Keywords: Microbial risk assessment; Coliform bacteria; Beverages

1. Introduction

Risk analyses in the field of food safety is a rapidly developing series of activities and during the recent years several symposiums have been addressed to the principles of the risk analysis framework (FAO/WHO, 1997) which consists of three elements: risk assessment, risk management, risk communication.

Risk assessment is the scientific evaluation of the probability of occurrence of known or potential adverse health effects resulting from exposure to biological, chemical or physical factors in the food. There are several opened questions around the terminology and methods associated with risk assessment and hazard analyses. The common and most important objective of the activities is to provide scientific and experimental based risk estimates in order to manage food safety.

One of the frequently referred questions addressed is the following: Can risk assessment—as defined by the Codex Alimentarius—be carried out at company level?

On the one hand, if the classical full type risk assessment would be carried out by different companies, most of them should present statements such as: this product at time of consumption is associated with probability of occurrence of adverse health effect to a certain extent. Also, during the risk assessment process the dose-response model should be realized at the company level. Therefore, the classical risk assessment approach is considered to be carried out at the governmental level.

On the other hand, it is well known from the relationship between the food industry, health surveillance (food safety monitoring systems) and the food inspection bodies that the barrier of risk assessment carried out at the governmental level often is the lack of data obtained from the industry. In order to provide more precise estimates, industry, governmental agencies and scientific institutes must work together to enable the required progress of risk assessment (Tompkin, 2001).

The microbiological risk assessment framework provides a structured and scientific approach for evaluating the complex issues associated with food hygiene and foodborne diseases. Food safety is the prime consideration, thus the scope of microbiological risk assessment

* Corresponding author. Tel.: +36-1-279-7054; fax: +36-1-279-7048.
E-mail address: zsyposs@eur.ko.com (Z. Syposs).

0956-7135/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodcont.2004.01.013

interprets a number of pathogen-food combinations for identifying and evaluating the likely impact of different risk management options.

The overall objective of risk assessment is to provide estimates on the probability of disease occurrence using a well-structured approach according to the four steps suggested by the Codex Alimentarius Commission: (i) hazard identification, (ii) hazard characterization (dose-response), (iii) exposure assessment, (iv) risk characterization.

The integration of quantitative risk assessment models with the related food safety issues at international/national level, might be the driving force to improve and adopt these models by addressing purely business risk in cases where the food safety parameters are not, or likely not to deteriorate, however the level of risk to the business is still high.

Based on the scope of the assessment, quantitative risk assessment (QRA) was used as a process by which the results of the hazard analyses were used to make business decisions, which might not necessarily impact the food safety parameters of beverage products.

Although the technology of beverage manufacturing has rapidly developed and progressed in the past two decades, the ultimate goal is still to operate at low cost and implement aseptic filling technologies. Despite the advanced technology, spoilage of beverages as well as detection of indicator microorganisms in the process continue to occur.

The scope of this case study addresses the frequently referred question, i.e. what is the probability of the presence and detection of hygiene indicator bacteria (e.g. Coliform group) in the final product based on the results obtained from control points (CP's) and critical control points (CCP's) in the process.

The most important raw material in the beverage industry is the water, which goes through a series of treatment process prior to syrup manufacturing and filling. The process is demonstrated in Fig. 1.

Coliform bacteria as indicator of pathogen(s) in water (Jay, 2000) are one of the most relevant biological parameters for the beverage and mineral water industry. Recent studies (Casani & Knochel, 2002) have shown that *Klebsiella* spp. strains proved to be more resistant than other coliforms and some of the species are capable of showing persistence in water or drinking water supplies (Lund, Tony, Baird-Parker, & Gould, 2000). Based on series of beverage industrial microbiological analyses from process environment, *Klebsiella* spp. occurrence is confirmed. Due to the facts described above, as test strain *Klebsiella oxytoca* was chosen to perform initial risk assessment in the pilot plant.

The QRA process was used in order to estimate the probability of *Klebsiella oxytoca* detection in the product as a function of the initial contamination level of the raw water. The QRA process based on the assumption

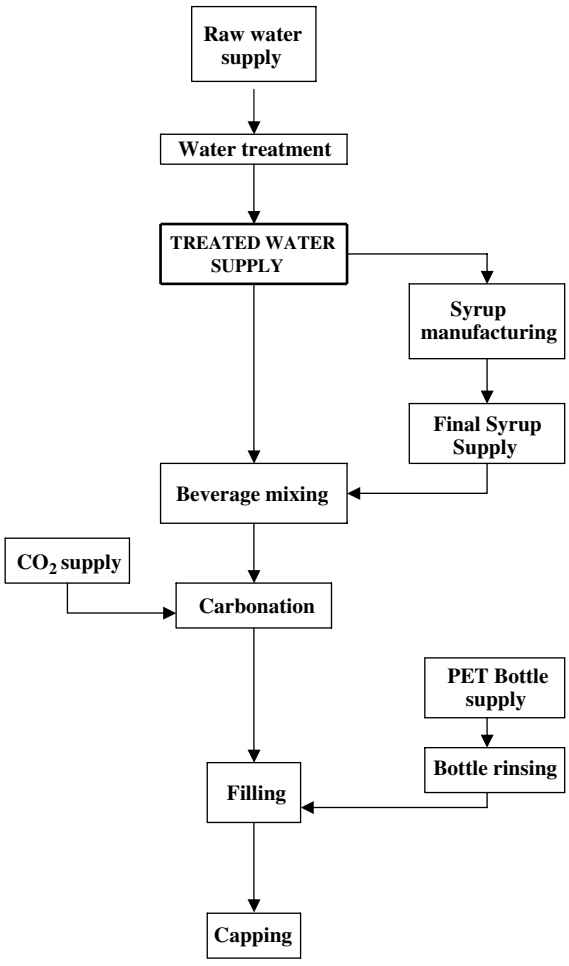

Fig. 1. Scheme of the beverage manufacturing process.

of the initial living cell concentration and the mathematical modelling of the effect of chlorine on the destruction rate, taking into account the probability distribution of the contamination, chlorine concentration and the residence time distribution during disinfection. For evaluation, the Monte Carlo simulation was applied.

Monte Carlo simulation is widely used for model calculations to estimate all the possible outcomes and their probability if the input parameters of the model are variable and/or uncertain. The model is calculated several thousand times (called iterations, scenarios or trials), all times with randomly chosen input parameter values. The random input values are calculated from the probability distribution of each input parameter by a sampling algorithm. While Monte Carlo sampling is the oldest and best-known unadulterated random sampling method, the Latin hypercube sampling is a more sophisticated method. It is a stratified sampling without replacement to reproduce the input distribution with much greater efficiency than the Monte Carlo sampling does (Vose, 2001). As summarized, in traditional mod-