# Sustento del uso justo de Materiales Protegidos

## derechos de autor para fines educativos

UCI
Universidad para la
Cooperación Internacional

**UCI**

**Sustento del uso justo de materiales protegidos por derechosde autor para fines educativos**

El siguiente material ha sido reproducido, con fines estríctamente didácticos e ilustrativos de los temas en cuestion, se utilizan en el campus virtual de la Universidad para la Cooperación Internacional – UCI - para ser usados exclusivamente para la función docente y el estudio privado de los estudiantes en el curso Tecnología y Manejo de información perteneciente al programa académico Maestría en Inocuidad de Alimentos.

La UCI desea dejar constancia de su estricto respeto a las legislaciones relacionadas con la propiedad intelectual. Todo material digital disponible para un curso y sus estudiantes tiene fines educativos y de investigación. No media en el uso de estos materiales fines de lucro, se entiende como casos especiales para fines educativos a distancia y en lugares donde no atenta contra la normal explotación de la obra y no afecta los intereses legítimos de ningún actor .

La UCI hace un USO JUSTO del material, sustentado en las excepciones a las leyes de derechos de autor establecidas en las siguientes normativas:

a- Legislación costarricense: Ley sobre Derechos de Autor y Derechos Conexos, No.6683 de 14 de octubre de 1982 - artículo 73, la Ley sobre Procedimientos de Observancia de los Derechos de Propiedad Intelectual, No. 8039 – artículo 58, permiten el copiado parcial de obras para la ilustración educativa.

b- Legislación Mexicana; Ley Federal de Derechos de Autor; artículo 147.

c- Legislación de Estados Unidos de América: En referencia al uso justo, menciona: "está consagrado en el artículo 106 de la ley de derecho de autor de los Estados Unidos (U.S,Copyright - Act) y establece un uso libre y gratuito de las obras para fines de crítica, comentarios y noticias, reportajes y docencia (lo que incluye la realización de copias para su uso en clase)."

d- Legislación Canadiense: Ley de derechos de autor C-11– Referidos a Excepciones para Educación a Distancia.

e- OMPI: En el marco de la legislación internacional, según la Organización Mundial de Propiedad Intelectual lo previsto por los tratados internacionales sobre esta materia. El artículo 10(2) del Convenio de Berna, permite a los países miembros establecer limitaciones o excepciones respecto a la posibilidad de utilizar lícitamente las obras literarias o artísticas a título de ilustración de la enseñanza, por medio de publicaciones, emisiones de radio o grabaciones sonoras o visuales.

Además y por indicación de la UCI, los estudiantes del campus virtual tienen el deber de cumplir con lo que establezca la legislación correspondiente en materia de derechos de autor, en su país de residencia.

Finalmente, reiteramos que en UCI no lucramos con las obras de terceros, somos estrictos con respecto al plagio, y no restringimos de ninguna manera el que nuestros estudiantes, académicos e investigadores accedan comercialmente o adquieran los documentos disponibles en el mercado editorial. sea directamente los documentos, o por medio de bases de datos científicas, pagando ellos mismos los costos asociados a dichos accesos.

# Application of knowledge management for hazard analysis in the Australian dairy industry

*Fawzy Soliman*

The author

**Fawzy Soliman** is the Course Director at the School of Management, University of Technology, Sydney, Australia.

Keywords

Knowledge management, Knowledge-based systems

Abstract

Generic performance measures have emerged as appropriate tools for assessing the performance of the Hazard Analysis Critical Control Point (HACCP). These measures provide information for staffing decisions and budgetary development in the food manufacturing industry. They are also used to configure variations for costing, pricing, packaging and other functions. The HACCP performance measures have become powerful tools in the management of modern food manufacturers, in particular the dairy industry. The majority of decisions and rules used for assessing the performance of the HACCP method are too complex to capture in the form of a traditional programming language. Conventional information systems automate simple and rigid bookkeeping functions but knowledge management tools automate complex decision making and processes requiring judgement, and therefore are appropriate for automating the people-based knowledge of the HACCP performance assessment method. A new technique is presented to automate the HACCP performance assessment method using knowledge processing.

Electronic access

The current issue and full text archive of this journal is available at
**http://www.emerald-library.com**

Journal of Knowledge Management
Volume 4 · Number 4 · 2000 · pp. 287–294


## Introduction

The Hazard Analysis Critical Control Point (HACCP) was first developed in the 1960s by the Pillsbury company, the US Army Natick Laboratories and the National Aeronautics and Space Administration to ensure the safety of foods used in the space program. The original system was concerned only with microbiological hazards. During the 1970s and early 1980s, few food processors world wide embraced the HACCP approach. Although it was seen as an exciting initiative, the work involved in correctly implementing the requirements could not be justified.

In Australia the HACCP principles were not fully understood, the process was considered too complicated and too many critical control points (CCPs) needed to be identified. However, recent food poisoning outbreaks highlight the lack of enforcement of food standards by the states and territories.

## Importance of HACCP for the Australian food industry

The Australian food industry is one of the largest industries in Australia, employing over 700,000 people, with an annual turnover of $80 billion and accounting for 20 percent of Australia's total production. Accordingly, the system which has emerged for protecting the Australian food industry is the HACCP. This system has been widely implemented within the Australian food industry during the last decade to ensure the control and safety of products and processes. It is a systematic means of controlling microbiological, chemical or physical hazards which may arise in any food processing or handling operations and aims to identify and prevent problems before they occur (Notermans *et al.*, 1994). The system as explained by Bryan *et al.* (1993) is rational because it is based on historical data about causes of illness and spoilage; it is comprehensive because it takes into consideration ingredients, processes and subsequent uses of products and is applicable at all links in the food chain; it is continuous because problems are detected when they occur and action is then taken for correction; and it is systematic because it is a through plan covering step-by-step operations and procedures. At the present moment HACCP

Journal of Knowledge Management
Volume 4 · Number 4 · 2000 · 287–294

provides state-of-the-art science for food safety.

Like most quality systems today, HACCP is based on being proactive rather than reactive, doing it right the first time and so forth. With this type of approach, HACCP has gained strong awareness in the food industry, with strong interest generated in Australia through the first two Australian HACCP conferences held in Sydney (September, 1995 and April, 1996) and the third in Perth (May, 1997).

## Dimensions of HACCP's knowledge in the dairy industry

Although the HACCP system is quite new in the food industry, the dairy industry has made major in-roads in this area for many years. This may explain why there have been very few major outbreaks of food poisoning within this industry, and prompts three important questions:

(1) What are the appropriate performance measures for improving the effectiveness and/or performance of the HACCP system?
(2) What factors comprise the key determinants of the HACCP assessment?
(3) How may the HACCP's knowledge base be utilised to determine these factors?

Knowledge is deeply implicated in the HACCP performance assessment view, due to the factors upon which the method is based. Such factors are increasingly likely to be intellectual capabilities rather than physical resources. That is, HACCP performance knowledge is quickly becoming a competitive advantage (Davenport and Prusak, 1998), with the dairy industry paying more attention to knowledge management and its role in the HACCP performance assessment method.

Knowledge may be explicit or tacit (Nonaka and Takeuchi, 1995). Explicit knowledge is suitable for communication and use in various forms. However, tacit knowledge may be resident in the HACCP performance assessor's mind and may not have been expressed in other forms. According to Davenport and Pruzak (1998), tacit knowledge may be made explicit if it becomes embedded in products or processes. Thus, some of the tacit knowledge of the HACCP performance method may be transformed from individual knowledge to organisational knowledge by means of knowledge bases. Such transformation of knowledge is an important component of knowledge management.

Research indicates that there are six primary areas of knowledge in the HACCP performance method:

(1) performance measures;
(2) HACCP method;
(3) verification;
(4) internal performance measures;
(5) external performance measures; and
(6) relationships among ISO9000, HACCP and the NSW dairy industry and its regulation.

### 1. Performance measures

According to Sellenhein (1991), the performance measure is an indicator that provides feedback on how a specific task is functioning compared with the rest of the dairy industry. The purpose of this measure is to guide and improve performance measurement systems, providing feedback to individuals on performance. Management needs to know how effective its plants are by identifying which activities are operating successfully and which activities are operating poorly. Information can enhance performance by providing motivation, with information about the correctness and adequacy of work behaviour, in turn providing workers with a sense of accomplishment, competence and control.

The main goal of the HACCP performance measure is to monitor food production and assure that food is safe. Therefore specific measures need to be established to gain feedback about the effectiveness of HACCP which will ultimately result in safer food products.

### 2. HACCP method

According to Bryan *et al.* (1993), a successfully implemented and maintained HACCP system offers *High Assurance Of Food Safety*. This is what all food industries should strive for. Studies have shown that to be truly successful, the following prerequisites should be followed (Kirby, 1994):

- The HACCP system must have the full support from top management, with implementation driven from within the company.
- The whole process from raw materials, preferably including supplier

Journal of Knowledge Management
Volume 4 · Number 4 · 2000 · 287–294

accreditation, should be considered; and the staff made aware of the importance of quality.

- The importance of safety should be considered as a component of quality.

## Principles of HACCP

A brief summary of the seven principles of the HACCP system is provided by Kirby (1994) as shown in Table I.

**3. Verification**

Verification is a key part of correctly implementing the HACCP system (Pierson, 1995). Much of this verification has been derived from the ISO9000 series. Verification is also the least understood part of the HACCP system – Pierson (1995) states that "verification activities are still in their infancy relative to other HACCP activities". Peters (1995) agrees: "This is the least understood and implemented principle of the HACCP discipline".

According to Pierson (1995), the principle of verification provides three basic outcomes. It:

(1) demonstrates that the HACCP system is operating correctly;
(2) confirms that safe food is being produced; and
(3) provides feedback to the HACCP team and to management.

Verification evaluates this by providing limits for each crucial step in the process, called a CCP. At each CCP, parameters are set to measure these steps, such as temperature, time, pH, water activity, microbial levels and so forth. The CCPs are monitored and adjusted constantly so as not to allow any deviation from the set limits. This principle thereby allows identification of whether the system is working, using the CCPs as performance measures of the internal workings of HACCP.

**Table I** The principles of HACCP (modified from Codex, 1993)

| Principle | Subject | Action |
|---|---|---|
| 1 | Hazard analysis | Construct a flow chart of the process stages. Identify and list all potential hazards |
| 2 | Identification of critical control points (CCPs) | Identify CCPs using a decision tree. Specify the systems of control |
| 3 | Establishing critical limits | Target values and critical limits must be set for each CCP |
| 4 | Monitoring | Continual or regular registering at each CCP to verify maintenance of control |
| 5 | Correction | Establish protocols for: (i) when CCPs are moving towards loss of control; and (ii) when CCPs are out of control |
| 6 | Verification | Establish systems to confirm the correct functioning of HACCP |
| 7 | Documentation | Establish documentation for all of the procedures and records necessary for the implementation and operation of the above procedures |

**Source:** Kirby (1994)

**4. Internal performance measures**

Internal performance measures are mainly measures used during the verification stage. Examples of the internal performance measures are levels of housekeeping, personal hygiene, foreign objects, percentage of rejects, percentage of rework, time onhold, finished product quality and number of washings.

**5. External performance measures**

The external environment consists of many elements outside the food manufacturer's boundaries. Food manufacturers need information and knowledge from their environment (internal and external) to make decisions and plans for the future. Before decisions concerning the future are made, external measurements are necessary, with the most common external measure used in the dairy industry being consumers' complaints and customers' satisfaction. Since the common external measures are based on customer feedback, the question to ask is: what knowledge from customer feedback may be used to assess the success of the HACCP method?

**6. HACCP, total quality management (TQM), international standards organisation (ISO)/Australian standards (AS)**

Since most food manufacturing companies use HACCP as a foundation for their quality system, it is appropriate to incorporate the relationship between HACCP, TQM and the requirements for ISO/AS certification in the knowledge base for the HACCP performance method.

Journal of Knowledge Management
Volume 4 · Number 4 · 2000 · 287–294

It has been reported that the ISO 9000 /AS 3900 series of standards focus on the contracts and relationships between customers and suppliers, and conformity to customer specifications, rather than on internal operations of a quality management system (Harrigan, 1993). This is because certification for ISO has often been judged on the basis of the quality of an organisation's documentation management, rather than on the efficacy of the quality management system in achieving assured quality and safety of products.

As a result it may be possible, although unlikely, for an ISO certified organisation to produce unsafe food. Current food legislation in New South Wales (NSW) will frequently provide for the possibility of a defence of due diligence by a food manufacturer, supplier, retailer or caterer. The adoption of HACCP or certification to ISO 9001/2 /AS 3901/2 is seen by many organisations as a responsible step providing the due diligence defence. That is why factors influencing the use of TQM, ISO and AS in the dairy industry are also included in the HACCP performance knowledge base.

## The HACCP and the NSW Dairy Corporation

In the past the NSW Dairy Corporation monitored all dairy companies on a routine basis to ensure compliance with the NSW Dairy Corporation's specifications. This was done by taking random samples from each product line on a daily basis and testing them for microbiological and chemical composition. This occurred with all dairy manufacturers, ranging from small, single person companies to large multi-site manufacturers. Any companies that did not comply with the set specifications were subjected to further in-depth audits and hence a hefty cost to the manufacturer.

At present the NSW Dairy Corporation no longer monitors dairy companies by testing their products; instead they encourage manufacturers to develop and implement their own quality management systems whereby the responsibility falls on the owners or managers. The Corporation recognises the following four types of quality systems:

(1) ISO 9000 and AS 3900 Quality Management Series Certification.
(2) HACCP.
(3) Food Processing Accreditation (FPA) for factories with export licences in accordance with the Australian Quarantine Inspection Services (AQIS) regime.
(4) The HACCP9000 Quality Systems.

For companies with HACCP, the NSW Dairy Corporation audits the plant based on a rating system which reflects the level of advancement in the HACCP program. The ratings scales are as follows:

- A rated once per four months;
- B rated once per two months;
- C rated once per month;
- D rated once per two weeks.

Where a factory has a Corporation HACCP or an FPA program in place and is a rated "A" under the AQIS regime, there is no charge for three required inspections/audits. Where a factory is "B" rated or less under the AQIS regime, then each inspection/audit in excess of three is charged at a rate of $72.00 per hour (as of 1996). Where a factory does not have a quality system in place, the factory will be rated as "B", "C", or "D" and charged for all inspections (New South Wales Dairy Corporation, 1995/6).

## Automation of HACCP performance functions

There are many functions in the manual HACCP performance system that are potential candidates for computerisation. However, the most important functions in the automation of HACCP performance systems are the calculation of:

- Performance points used on a continuous basis to identify the need for changing the limits of monitoring. These indicators are reviewed and updated continuously as the situation requires.
- "HACCP Monitoring Levels" used to convert the standards into operational limits. This process is continuously calculated and updated according to the changes in testing and the unit's needs.
- Allocation of current and projected staff time and duties based on production needs.

At the heart of the automated HACCP performance system is the evaluator module.

This module uses a computational model to evaluate the various HACCP parameters required to perform the analysis (Soliman, 1998a). The five main functions performed by the evaluator module are as follows:

(1) *Standard level of monitoring*. Each time the system is used, the calculation of frequency of occurrence, average time and standard deviation takes place. This calculation is performed for every case and for all activities during every shift. The evaluator module then calculates the weighted average times (WAT) and stores the results in the HACCP database.
(2) *Performance scores*. A performance score for each HACCP is calculated by the normalisation of the standard levels of monitoring using a suitable interval of time.
(3) *HACCP levels*. A safety level exists for every HACCP. The automated HACCP system employs HACCP safety levels, which are used to group HACCP into categories that reflect the magnitude of testing. The selection of the HACCP level defines the HACCP in relation to performance scores.
(4) *Production staff time*. The production staff time required to provide testing to a sample is based on the degree of testing and the HACCP levels in place.
(5) *Number of production staff required*. The automated HACCP system calculates (to the nearest whole number) the number of production staff required to ensure the level of HACCP desired in every shift.

One important function of the HACCP performance system is forecasting the number of staff required for each shift. However, production staff rosters are usually prepared ahead, i.e. it is necessary to predict the production needs a few days ahead. In most cases this requires some input from experienced staff. The expert advice is usually based on historical decisions previously made in similar situations.

## The HACCP knowledge-based system

The HACCP knowledge resides in a sophisticated knowledge base, which is distinct from the conventional processing mechanisms. Traditional information systems seek to create information reports by accumulating, organising and processing data. In the HACCP knowledge-based system, decisions made on the basis of HACCP performance are so complex that they need to be made efficient and regulated by means of a *knowledge regulator*.

## Regulators of HACCP performance knowledge

The knowledge regulator is a control concept which is closely associated with the movement of decisions and information within the HACCP knowledge-based system (Soliman, 1998b). The regulator concept permits decisions on HACCP performance to be made in response to any small variations between HACCP performance, production needs and the availability of production staff.

At the initial stages the HACCP knowledge-based system uses these results to group the critical HACCP performance indicators under three categories: *direct indicators*, *indirect indicators* and *production needs indicators*. The system then formulates a group of major categories of activities which become the critical HACCP performance indicators and make up the basic module in the HACCP knowledge-based system.

## HACCP performance database

Data are entered and stored in the HACCP performance database. The on-line facility enables production staff to enter as frequently as necessary all HACCP performance activities related to the same production batch. Two types of entries can be made, yes or no, to confirm or otherwise that the activities took place. The frequency of the activity is also entered for each of the critical indicators of HACCP performance. The system also displays default information such as product name, date and staff name. The user with the appropriate authorisation level can edit this information.

## HACCP knowledge base

At the beginning of the learning stage, all decisions made regarding HACCP performance and the allocation of staff duties are stored for later reuse. The knowledge-

Journal of Knowledge Management
Volume 4 · Number 4 · 2000 · 287–294

based system presents the experts with a number of scenarios requiring decisions.

Once product data and HACCP performance decisions are entered, the system automatically calculates the HACCP levels and displays the staffing levels required to provide performance testing and other duties.

## Knowledge representation

Soliman (1998b) demonstrated that knowledge could be represented in the system through four models: elicitation model; structure model; model of expertise; and design model. These models are interrelated explicitly within the system to give the full benefits for problem solving, documentation, maintenance and explanation as described briefly below.

- *The elicitation model*. The knowledge (in the form of decisions, protocols, policies, etc.) gained from the expert in the elicitation phase is described and used to define the elicitation model, which is the basis of the structure model.
- *The structure model*. The structure model consists of the four contexts – concept, activity, data flow and ordering contexts – which are used for capturing the functional aspects of the system. In addition, the activities in the HACCP performance are defined in a process context. The contexts of the structure model are represented in the inference layers of the model of expertise.
- *The model of expertise*. The model of expertise includes all functional requirements of the HACCP performance system. The non-functional requirements, such as efficiency of the problem-solving method, maintainability of the system or persistency of data are also considered. The function of the HACCP performance system is described in the model of expertise using first-order logic and dynamic logic for each layer of the model of expertise.
- *The design model*. Decisions are captured within the design model, which interacts with the model of expertise. The design model allows description of data structures, algorithms and mathematical models. Transposing the HACCP performance functions (data and rules) in a concept context enhances the problem-solving capabilities of the knowledge-based system (Soliman, 1998b). This close relationship with the concept context allows the experts to reason about real HACCP performance needs. In other words, the HACCP performance functions are represented in the knowledge-based system by foue views, namely: *data view*, *function view*, *staff view* and the *control view*.

The most important entities here are the HACCP performance functions and events which are linked together to form the so-called *event-driven HACCP performance functions*.

The knowledge-based system models the control flow of the HACCP performance functions and links the relevant entities generated by all the views. Accordingly, HACCP performance functions are easily connected to their input and output data which are located in the data view to model the data flow. Figure 1 illustrates the conceptual components of the HACCP knowledge-based system.

## Computational results

The HACCP performance knowledge-based system was used in a medium size dairy manufacturer. Data collected after six months of operation indicate that considerable improvement has resulted from using the system. Table II compares the results obtained from the dairy manufacturer before and after the implementation of the system.

The above measures do not include percentage recalls, percentage Salmonella detection, percentage Listeria detection or percentage downtime.

## Conclusions

The application of knowledge management tools in the dairy industry enables monitoring of all dairy activities to ensure that consistent food safety is assured. For those companies with a HACCP system in place, maintaining the system is one of the main difficulties. The NSW Dairy Corporation grading system assesses the level of advancement in a HACCP system and this affects the number of audits. The better the grade the fewer the

**Figure 1** The conceptual components of HACCP knowledge-based system

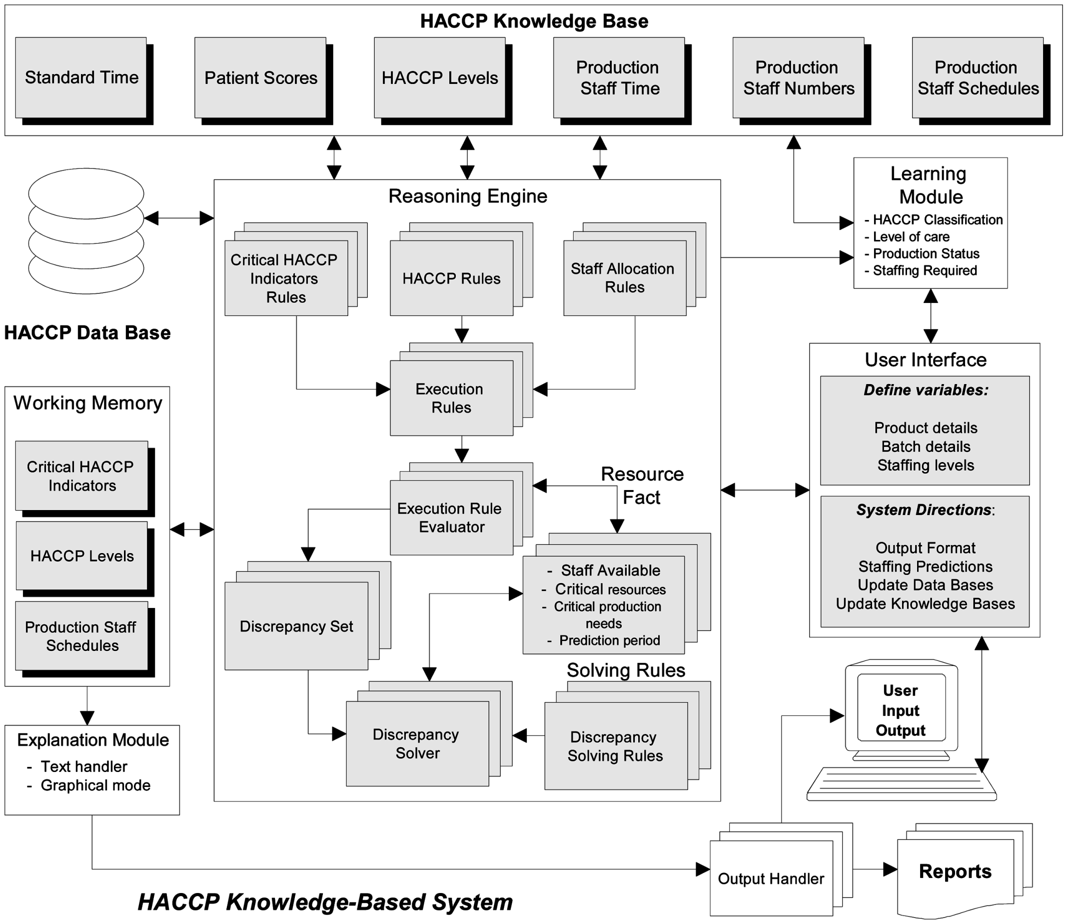


**Table II** Results from dairy manufacturer

| Performance measure | Improvement % | Numbers | |
|---|---|---|---|
| Level of housekeeping accomplishment | +125 | 4 | 9 |
| Level of hygiene | +100 | 4 | 8 |
| Level of microbial count | +25 | 8 | 10 |
| % Rejects | +25 | 4 | 3 |
| % Rework | +50 | 2 | 1 |
| % Foreign objects found | +33 | 3 | 2 |
| Customer complaints | +20 | 10 | 8 |
| Customer satisfaction | +100 | 1 | 2 |
| % Non-conformance | +33 | 9 | 6 |
| Approval by external auditing body | +16 | 12 | 14 |

audits and therefore a useful performance measure is the number of audits. This is only compulsory in the dairy industry and hence would not be a common measure in any other food industry until a regulated law is enforced.

Experience has shown that the manual HACCP method is expensive to maintain, as it requires time and effort to support. Considerable savings and benefits may be obtained if some of the HACCP functions are computerised using knowledge management tools such as knowledge-based systems. The HACCP knowledge-based system is a computer software application which seeks to replicate the problem-solving and decision-making approaches of the HACCP experts. The HACCP knowledge-based system which is best suited for procedure-intensive tasks which involve the processing of large volumes of HACCP data manipulates facts, relationships between those facts, and heuristics (or rules of thumb) within a narrow and bounded HACCP area. During its development, a vast body of task-specific knowledge from a human is transferred into a computing environment.

Although many of the benefits of knowledge management tools are difficult to quantify, empirical support linking these tools with cost savings and improved quality has been reported. In addition to delivering higher quality outputs which leads to increased customer satisfaction, knowledge

Journal of Knowledge Management
Volume 4 · Number 4 · 2000 · 287–294

management technology enables human resource scarcities to be overcome through "smarter" work.

In conclusion, the use of knowledge management tools in HACCP will make major advances into redefining food safety and care away from physically driven processes and towards an knowledge-intensive system. The extent to which food manufacturers are cognisant of the knowledge management multi-mission capabilities in itself does not guarantee the successful implementation of a flexible strategy; rather, strategy, organisational design and incentives must match the new opportunities offered by the multidimensional and complex offerings of knowledge management systems.

## References

Bryan, F.L., Guzewich, J.J. and Todd, E.C.D. (1993), "Use of the hazard analysis critical control point approach by state, provincial and local food protection agencies: results of a survey and discussion", *Dairy, Food and Environmental Sanitation*, Vol. 13 No. 6, pp. 323-31.

Davenport, T.H. and Prusak, L.P. (1998), *Working Knowledge: How Organizations Manage What they Know*, Harvard Business School Press, Boston, MA.

Harrigan, W.F. (1993), "The ISO 9000 series and its implication for HACCP", *Food Control*, Vol. 4 No. 2, pp. 105-11.

Kirby, K. (1994), "HACCP in practice", *Food Control*, Vol. 5 No. 4, pp. 230-36.

New South Wales Dairy Corporation (1995/6), *Annual Report*, Chippendale.

Nonaka I. and Takeuchi, H. (1995), *The Knowledge Creating Company*, Oxford University Press, New York, NY.

Notermans, S., Zweitering, M.H. and Mead, G.C. (1994), "The HACCP concept: identification of potentially hazardous micro-organisms", *Food Microbiology*, Vol. 11 No. 3, pp. 203-14.

Peters, R. (1995), "What is HACCP?", Proceedings of the First Australian HACCP Conference, *Food Operations*.

Pierson, M. (1995), "HACCP verification", Proceedings of the First Australian HACCP Conference, *Food Operations*.

Sellenhein, M.R (1991), "Performance measurement", *Management Accounting*, September, pp. 50-53.

Soliman, F. (1998a), "Automation of patient dependency systems", *Journal of Medical Systems*, Vol. 22 No. 4, pp. 225-36.

Soliman, F. (1998b), "Patient dependency knowledge based systems", *Journal of Medical Systems*, Vol. 22 No. 5, pp. 353-66.