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An implementation of the HACCP system in the production of food-packaging material

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The Hazard Analysis Critical Control Point (HACCP) system according to the Codex Alimentarius model was applied to the processes of five paper and paperboard mills and four plants further converting paper or board intended for contact with foodstuffs. The generalised flow diagrams of the processes are presented. Each of the overall processes contained 40–150 process steps. Normally three to five sessions with HACCP teams and additional private negotiations were needed for each mill or plant. Hazards leading to critical control points (CCPs) were microbiological (handling/storage, circulation water, starch, process environment) and physical (process environment) in mills, and microbiological (storage, lacquers or glues, packaging and process environment), chemical (printing) and physical (storage of products, packaging and process environment) in plants. Specifications, critical limits (e.g., based on different kinds of reports and instructions), monitoring methods (microbiological and visual) and frequency, responsibilities and corrective actions of the processes are presented. Most of the improvements focused on improving the process environment. In five cases, hygiene training was included in the implementation of the HACCP system.
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Introduction

Paper and paperboard are produced in large volumes world-wide: in 1999 the production was 79.5 million tons in Europe. The production of food contact material is about 10 million tons. The safety and purity of food-packaging materials are important topics. A food producer must ensure that all possible risks related to the use of contaminated packaging materials are eliminated by applying the Hazard Analysis Critical Control Point (HACCP) system [3,17,20]. There is a demand in the EU legislation [6] that food business operators must have a quality system such as the HACCP system to ensure the safety of foodstuffs. To a certain extent, this principle has also been transposed to the food-packaging industry. The importance of hygiene in the paper and packaging industry has increased considerably as a result of more specific demands in legislation, tighter international competition and increasing customer requirements. The safety and quality demands of paper- and paperboard-based packaging materials can be dealt with using an HACCP system [9,10,12]. This system achieves compliance with some of the following directives and legislation: "Materials in contact with food" [5] and similar national legislation, particularly in Finland [7], Germany [1], the Netherlands [22] and the USA [8].

HACCP is a new approach in the paper and packaging industry. Very few investigations have hitherto been published. Bovee *et al* [3] applied an HACCP approach to a food-packaging process for refillable (PET) polyethylene terephthalate bottles, Blakistone [2] presented a hazard analysis of the paper-making process, and Galeano *et al* [9] presented a formal HACCP application in a generic container plant. This paper presents applications of the HACCP system for nine mills or plants producing paper, paperboard and packaging materials and points out amendments to the production processes resulting from the implementation of the HACCP system.

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Materials and methods

Processes and products

Applications of the HACCP system to the processes of five paper and paperboard mills and four plants further converting paper or paperboard intended for contact with foodstuffs were conducted. Following a proposal of the company and bearing product safety in mind, the most important process lines related to food-packaging products were chosen as target processes for the HACCP system.

Different kinds of processes producing paper, paperboard and packaging materials for food applications were chosen:

I. Mills producing paper or paperboard (products for three different product branches from five paper and paperboard mills): (1) greaseproof papers from one mill; (2) one side coated papers from one mill; (3) coated board products from three different mills. An example of a simplified flow diagram of the manufacturing process is given in Figure 1.

II. Plants for converting paper or paperboard (products for three different product branches from four converter plants of paper or paperboard): (1) coated paper products from one plant; (2) various paper sacks from one plant; (3) cartons from two different

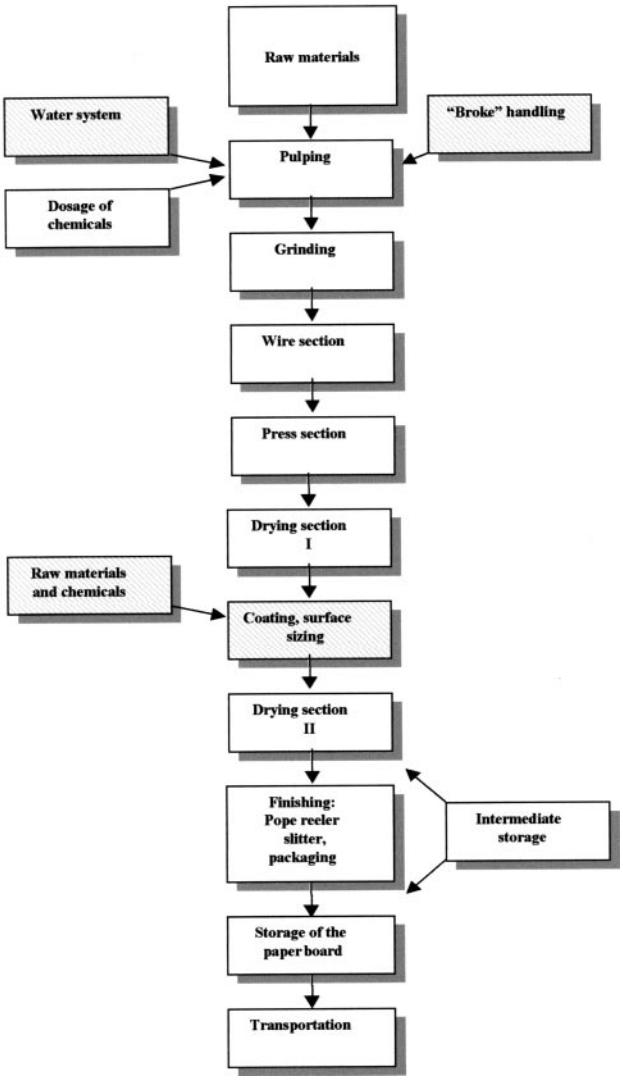

Figure 1 A common simplified flow diagram can be constructed for paper or paperboard mills. Critical process phases (CCPs) are marked as shadowed boxes (see Table 1). The process environment as a whole is considered as a CCP.

plants. An example of a simplified flow diagram of the carton converting process is given in Figure 2.

HACCP plans for the processes

The HACCP plans for the processes were made up in accordance with the Codex Alimentarius model [4]. In these studies GMP considerations such as a hygiene plan, personnel hygiene instruction, a procurement plan or a maintenance plan are included in the HACCP studies.

Step 1. An assembly of the HACCP teams: It was first ensured that all relevant knowledge and expertise was available for development of the HACCP plan. The HACCP system mainly focuses on microbiological, chemical, physical and biological hazards, but expertise relating to the processes and process control plays an essential role in the sessions of the HACCP teams. Normally three to five sessions of the HACCP teams were needed, along with additional private negotiations for each mill or plant. The HACCP teams consisted of 5 to 20 persons representing, e.g., management, marketing, quality control and processing in the mill or plant.

Steps 2–3. Product descriptions were given previously: See above.

Steps 4–5. Construction of flow diagrams and on-site confirmation of flow diagrams: Flow diagrams were prepared including all relevant steps in manufacturing where raw materials and intermediary products join the flow, steps where reworking and recycling take place, and subcontracted work. Each of the overall processes contained 40–150 process steps and they were discussed in detail by the HACCP teams. The flow diagrams were verified by the HACCP teams, who supervised on-site confirmations. Examples of simplified flow diagrams of the paper and paperboard manufacturing process and carton converter processes are given in Figures 1 and 2.

Steps 6–10. Hazard analysis, determination of critical control points (CCP), establishments of critical limits and monitoring systems and corrective actions for each CCP: Understanding the microbiology of the paper and paperboard manufacturing is an essential part of preparing an HACCP plan. The heat treatment (80–120°C) and drying at the end of the papermaking process improve the microbiological quality of the final paper product. However, these operations are not sufficient to eliminate bacterial spores occurring in the pulp [19]. An understanding of possible microbiological, chemical, physical and biological hazards connected to the processes under evaluation is essential for the team. All relevant reasons for hazards in every

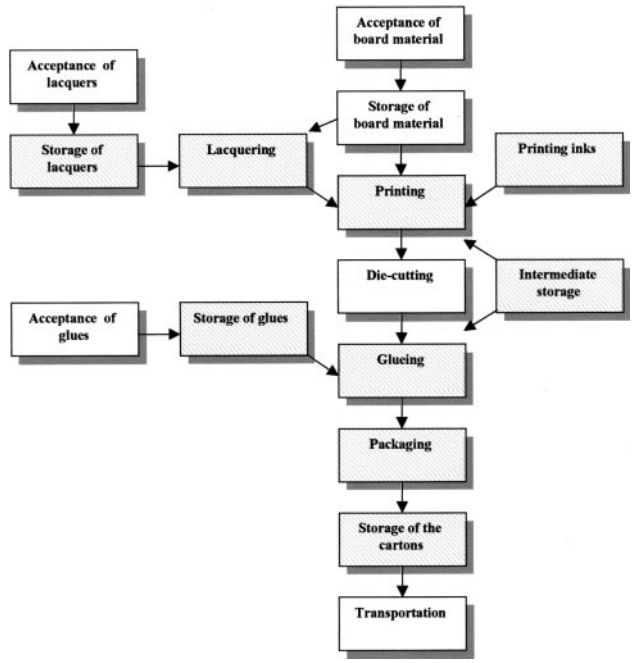

Figure 2 A common simplified flow diagram can be constructed for converting plants, irrespective of the materials used, e.g., paper or paperboard. Critical process phases (CCPs) are marked as shadowed boxes (see Table 2). The process environment as a whole is considered as a CCP.

Table 1 Identification and monitoring of important process phases (ranked as CCPs) in the paper or paperboard processes

Raw material, process step or function	Hazard	Specifications/critical limits	Monitoring method and frequency	Responsibility	Corrective actions
Handling/storage of "broke" (3/5 mills)	Microbiological (reasons: growth of potential pathogenic microbes and contamination of microbes, long storage times, anaerobic conditions)	Reports of biocide suppliers Critical limits are set according to results gathered in mills	Microbiological laboratory, every week	Person responsible for the "broke" and its biocide dosages	Changing/checking the dosages of used biocides, changing biocides, washing procedures of storage tanks
Circulation water (2/5 mills)	Microbiological (reasons: biofilm formation)	Reports of biocide suppliers Critical limits are set according to results gathered in mills	Microbiological laboratory, every month	Person responsible for the water system and its biocide dosages	Changing/checking the dosages of used biocides, changing biocides, washing procedures of tanks
Starch for surface sizing (5/5 mills)	Microbiological (reason: growth of potential pathogenic microbes)	Reports of biocide suppliers Critical limits are set according to results gathered in mills	Microbiological laboratory, every week	Person responsible for surface starch and its biocide dosages	Changing/checking the dosages of used biocides, changing biocides, washing procedures of tanks
Starch (as strength aid) and spray starch (3/5 mills)	Microbiological (reason: growth of potential pathogenic microbes)	Reports of biocide suppliers Critical limits are set according to results gathered in mills	Microbiological laboratory, every week	Person responsible for starch and its biocide dosages	Changing/checking the dosages of used biocides, changing biocides, washing procedures of tanks
Process environment, working practices (2/5 mills)	Physical and microbiological (reasons: unsuitable working practices)	Reports, documents and instructions related to internal hygiene audits	Visually, every day	Person responsible for working practices	Hygiene training, activated monitoring
Process environment, birds and insects (2/5 mills)	Biological and microbiological (reasons: birds and insects)	Reports and documents from daily monitoring and the pest control company	Visually, every day and monthly by the pest control company	Person responsible for daily monitoring	Protection and deterrent procedures, activated monitoring

Table 2 Identification and monitoring of important process phases (ranked as CCPs) in the converting plants of paper or paperboard

Raw material, process step or function	Hazard	Specifications/critical limits	Monitoring method and frequency	Responsibility	Corrective actions
Storage of fibre raw materials, reused pallets, and end products, intermediate storage (4/4 plants)	Biological and microbiological (reasons: birds and insects)	Reports and documents from the pest control company and from person responsible for daily monitoring	Visually, every day by the responsible person and monthly by the pest control company	Person responsible for daily monitoring	Protection and deterrent procedures, activated monitoring
Storage of end products, (1/4 plants)	Physical and microbiological (reasons: dust, dirt and sand, etc.)	Reports, documents and instructions related to internal hygiene audits and cleaning	Visually, every day	Person responsible for working conditions	Checking of the cleaning schedules, hygiene training, activated monitoring
Use of lacquers or glues (2/4 plants)	Microbiological (reason: growth of potential pathogenic microbes)	Working instructions for using lacquers/glues	Sensory evaluation, constantly	Person responsible for use of lacquers and glues	Abandoning lacquer or glue, washing procedures of tanks and pipes, reclamation
		Critical limits for microbes are set according to results gathered in mills	Microbiological laboratory, every week		
Printing (2/4 plants)	Chemical (reason: smell and taste defects)	Quality specifications for inks used for food-packaging materials	In laboratory, twice a week	Person responsible for inks	Abandoning faulty products, changing/checking the specifications, reclamation
Different phases of the processes (2/4 plants)	Informative hazard (wrong information on packages due to faulty printings or mixed products during dispatch, health risk for consumers)	Working instructions for quality checkers of printing and dispatchers	Visually, constantly	Quality checkers of printing and dispatchers	Abandoning faulty products, declaration of the incident
Packaging (1/4 plants)	Physical and microbiological (reasons: unsuitable working conditions dirty floors and surfaces, etc.)	Reports, documents and instructions related to internal hygiene audits and cleaning	Visually, every day	Person responsible for working conditions	Checking of the cleaning schedules, hygiene training, activated monitoring
Process environment, working conditions (2/4 plants)	Physical and microbiological (reasons: unsuitable working conditions dirty floors and surfaces, etc.)	Reports, documents and instructions related to internal hygiene audits and cleaning	Visually, every day	Person responsible for working conditions	Checking of the cleaning schedules, hygiene training, activated monitoring
Process environment, working conditions and practices (1/4 plants)	Physical (reasons: pieces of glass from lambs and bottles)	Reports, documents and instructions related to internal hygiene rules and audits	Visually, every day	Every person, hygiene manager	Hygiene training, activated monitoring

single process were discussed with the HACCP teams. Reports of the biocide suppliers during a long period were handled and microbiological critical control points were set according to the results.

The main routes for microbes to enter from packaging materials into food for liquid packaging boards are the raw edge, cutting dust from processing of the blanks, or damaged polyethylene coating facing the paperboard [15]. Microbiological hazards can be caused by modified industrial starches used for surface sizing of paper and paperboard. Secondly, chemical hazards may include unacceptable ingredients, chemical contaminants, oil and lubricants, and other chemicals, for example, substances causing odours. Most often physical hazards can be pieces of glass, metal or plastics, bolts, earrings, hair, pens, dust and sand. There are some general hygienic considerations that apply to the products, such as prevention of biological contamination by means of pest control. Biological hazards include birds, rodents and insects, which should be taken into account by decreasing possibilities for them to come into contact with the process or with food-packaging materials [13,21]. Reports of the clients' complaints and problems identified by workers (physical hazards) were background material for hazard identifications.

Specifications, critical limits, monitoring methods, frequency, responsibilities and corrective actions were discussed with the HACCP teams. The severity and probability of a hazard were scored from 1 (least) to 3 (most) and when the risks were evaluated as "3" the process step was considered as a CCP. This was a very practical way of decision making after a very profound discussion within a HACCP team bearing in mind that the HACCP systems were applied in nine processes containing 40–150 process steps. It revealed the real situation in each process.

Steps 11–12. Establishment of verification procedures, documentation and record keeping: Various kinds of documentation models were supplied to the factories for monitoring selected CCPs and ensuring appropriate corrective actions.

Hygiene training

Hygiene training was included in implementation of the HACCP plans in five companies. The training was divided into a general part and specific parts targeted to the personnel responsible for various activities, e.g., guidance in microbiologic hygiene control methods for laboratory workers. The general phase of the personnel training included lectures, demonstrations and group work on subjects such as basic general microbiology, principles of the HACCP system, determination of CCPs and the control parameters to be measured in the hygiene and safety management system, and hygiene aspects in production, e.g., the effect of personal hygiene on product safety.

Results

Each of the overall real processes contained about 40–150 process steps and was discussed in detail by the HACCP teams. The flow diagrams of the processes were presented in more detail to the companies. It was then possible to discuss and identify all potential hazards and to evaluate possible CCPs. A summary of the CCPs is presented in Tables 1 and 2. The relevant hazards for CCPs, specifications, critical limits, monitoring methods and frequency, responsibilities and corrective actions of both processes are presented.

Paper and paperboard mills

In the simplified flow diagram of mills producing paper or paperboard (Figure 1), the most common CCPs identified in the study are indicated as marked boxes. Identification and monitoring of these process phases are presented in Table 1. The microbiological hazards of handling or storage of "broke," the circulation water and starch as well as the process environment were found to be relevant hazards. Physical and biological hazards and working practices were also considered as real hazards. In this study, critical limits were set and monitoring was accomplished according to the reports of biocide suppliers, microbiological results gathered in mills and knowledge of process operation. Biocide suppliers were carrying out microbiological analyses and dosing biocides and giving the critical limits together with the factories. The amounts of biocides were different depending on products and processes. Corrective actions included adjusting or checking the dosages of biocides, washing procedures, hygiene training and activated monitoring. Microbiological and visual monitoring and their frequency were determined according to the HACCP plan. The responsibilities and corrective actions were also specified.

Converting plants

In the simplified flow diagram of plants for converting paper or board (Figure 2), the most common CCPs identified in the study are indicated as marked boxes. Identification and monitoring of the process phases are presented in Table 2. Microbiological and biological hazards of the storage of all kinds of materials and the use of lacquers or glues were considered relevant hazards severe enough to be ranked as CCPs. Chemical and physical hazards as well as hazards arising from lacking or incorrect information were relevant in the printing, packaging and process environment. Specification and critical limits were included in reports and documents, working instructions and reports of hygiene audits. Responsibilities were indicated, and corrective actions introduced, such as protection and deterrent procedures, abandoning materials or products, washing and hygiene training. Microbiological and visual monitoring and their frequency were determined according to the HACCP plan.

The mills and the plants

On the basis of the HACCP evaluations, a list of various product safety targets for process development was drawn up. More hand-cleaning facilities were established and checking of detergents and cleaning schedules were completed. Coating of floor surfaces in the storage area and installation of unbroken fluorescent lamps were started. The following items were proposed: the use of plastic bottles instead of glass in the refreshment drink machine, covering windows with nets against insects and birds, and changes in the use of doors in storage areas and layout changes.

Discussion

The paperboard used for food packaging should have a lower content of microbes than the food to be packed. Food-packaging paper and paperboard mainly contain spore-forming bacteria belonging to the genera *Bacillus*, *Paenibacillus* and *Brevibacillus* as contaminants. The contaminants are usually found in quantities from <50 to 250 cfu/g homogenized paperboard, which are lower levels than in many foods [16]. Of those frequently found, especially the *Bacillus cereus* group, *B. licheniformis*, *B. subtilis*,

and *Brevibacillus brevis* are species capable of hydrolysing food components, and some strains of these species produce food poisoning toxins or may grow at refrigerator temperatures [14]. The microbiological quality of starches affects the hygiene of food grade paperboard. The starch-spoiling bacteria include e.g., *B. coagulans*, *B. licheiniformis*, *B. amyloliquefaciens* and *B. stearothermophilus*. These species grow under simulated mill conditions at 50°C and depolymerise starch by producing cyclodextrins and α-glucosidase [14]. According to the study of Suihko and Skyttä [19] concerning recycled fibre pulps and boards, the microbiological quality of pulps from different mills varies considerably. In this study no recycled fibre pulp was used.

Hygiene training of personnel in industrial companies in the application of the HACCP system has been shown to be an essential element for effective implementation of HACCP and an active hygiene and safety management system [11]. The aims of the training are to increase the motivation for changes in working practices stemming from the implementation of the HACCP system, to increase knowledge of the potential hazards threatening product safety, and to inform mill personnel of activities to be carried out in the implementation of HACCP. Furthermore, during training courses the mill personnel were able to participate in and affect the improvement actions necessary for implementation of the hygiene and safety management system. The training course often encouraged participation in regular training events organised by the company itself, and improved the commitment of personnel to implementation of the HACCP system.

The seven principles of the HACCP system can be summed up in three elements: hazard analysis, measures for hazard control and verification and documentation of the system, which is the most time- and resource-consuming element in the maintenance of the system. However, the HACCP system is compatible with the implementation of total-quality management systems based on the ISO 9000 series of standards, and is the system of choice for the management of food safety within such systems. According to this study some of the measures usually known as "good manufacturing practices" were handled here as CCPs because the mills or plants pinpointed the importance of the measures as real hazards for product safety. As a result of the HACCP evaluations, a list of various product safety targets for process development was established. Most of the improvements were aimed at a better process environment, which was considered in the processes as a CCP. After the implementation of the HACCP plans, it was possible to target microbiological hygiene surveys in these industrial factories [18]. According to the study by Galeano *et al* [9] and this study, adopting the HACCP system will empower the staff to better control the process and comply with regulations and specifications. It will bring added value to the operation and provide a more cohesive corporate food-packaging safety system.

Conclusions

As a result of implementation of the HACCP system to the process lines, the management of product safety and quality is under better control in these mills and plants. The relevant hazards were identified, the risks were estimated and specific control measures that emphasized prevention and control rather than reliance on end product testing were established. Various product safety targets for process development were also established. Most of the improvements were aimed at an improved process environment.

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