THE DESIGN OF HACCP PLAN FOR A SMALL-SCALE CHEESE PLANT

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ABSTRACT

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Hazards analysis critical control points (HACCP) was developed as a management tool to provide a more structured approach to control identified hazards. It was first developed for the US manned space program to provide pathogen-free food. This is now widely used in the food industry to ensure safe food was produced for the consumer. The purpose of this study is to modify the

generic HACCP model for cheese production based on actual conditions in this cheese plant. A specific model will be developed to boost the safety and quality of cheese products in this plant.

The preservation of raw milk during cheese production was considered to be safe. However, the spread of some diseases by unsafe cheese products reported makes it important to pay attention to the potential contamination in cheese production which could cause hazards to human health. HACCP is most effective when it is plant-specific and product-specific. However, the generic HACCP models have not been applied in most of the small-scale cheese plants. To ensure the food safety in those plants, based on the generic HACCP model this study is pursued to design a specific HACCP model to be suitable in a small-scale cheese plant in western Wisconsin.

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TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER ONE

Introduction

Introduction

HACCP is an acronym for the Hazard Analysis Critical Control Point. It is a system that was developed for assuring pathogen-free foods for the space program by the Pillsbury Company, the U.S. Army, and the National Aeronautics and Space Administration (NASA) in the 1960s. HACCP was used in the food processing industry for low-acid canned food production in the 1970s. It provides precise process control measures for each step of the entire food manufacturing process. More recently, HACCP has been used in the meat and poultry industry that is regulated by the United States Department of Agriculture (USDA). It is also used in the seafood, juice and egg industries, which are regulated by the Food and Drug Administration (FDA). Now, the FDA is considering developing regulations for the dairy industry too (Bardic, 2001; Riswadkar, 2000).

In dairy industries, HACCP is already being applied as a quality control program, from fluid milk to ice cream to cheese. Cheese is a product that preserves raw milk. Due to the high acidity (low pH value) in the cheese-making process, the pathogens in the milk are killed. However, in cheese manufacturing, problems associated with the presence of Listeria monocytogenes, Salmonella enteritidis, Staphylococcus aureus, Escherichia coli and others have been documented. The traditional quality testing and inspection used in the cheese factory is applied to the product once a problem presents itself. It is thus difficult to get 100% product inspection because of human error, obtaining sufficient samples and so on. HACCP was originally developed as a “zero defects” program and considered to be synonymous with food safety. It is a straightforward and logical system that uses preventative action to address potential microbiological, chemical and physical hazards that are identified in the process. HACCP is a science-based system used to ensure that food safety hazards are controlled to prevent unsafe food from reaching the consumer (Bardic, 2001; Mortimore & Wallace 1997; Morris, 1997; IFST, 1998; Smukowski, 1996). HACCP is applied to the following:

1. Identify where hazards occurs along the process
2. Establish a control and monitoring process
3. Document all activities
4. Ensure continuity in preventative measures

(Mortimore & Wallace 1997)

Most large cheese manufactory companies have implemented HACCP into their quality control systems in order to produce safe and good quality product. However, seldom do small-scale cheese plants implement their own HACCP plans. HACCP is a plant-specific and product-specific quality system (Morris, 1997). To boost the quality of their cheese products, it would be of great benefit to small-scale cheese plants if they develop and implement HACCP plan based on their specific productions.

Statement of the study

The purpose of this study is to design a HACCP plan model for a small-scale cheese plant in western Wisconsin. The model is modified from several generic HACCP models. This study started in the fall semester, 2002. The researcher worked in the plant, made observations of the plant environment, and discussed potential hazards with the cheese maker and the operation director in order to develop the specific HACCP model.

Needs for the study

This study is specifically designed for a small-scale cheese plant that was just restructured and needs a better quality control system to produce quality, safe cheese. The HACCP model can be applied in the plant to replace the traditional inspection and quality procedure in order to prevent the hazards in the cheese product.

Objectives

1. To evaluate the current methods of analysis on hazards that appear during the processing and control procedures used in the plant.
2. To set up a specific HACCP plan for this small-scale cheese plant.
3. To document the HACCP plan in order to demonstrate the effectiveness of its application.

Significance of the study

A brief and specific HACCP plan model will be developed in this study. It is the first HACCP plan to be developed based on the actual conditions in this small-scale cheese plant. It is a good start for a small plant, which has limited resources and capital to perform the HACCP model as its quality control system.

The small cheese maker is more acutely affected by the consequences of unsafe product. The HACCP model in this study is planned to prevent hazards that could appear during the processing in this plant. It is a more efficient and cost effective quality control tool for the small cheese maker.

Limitations of this study

This study is limited to the researcher's time and the working experience in cheese plants.

FDA Definitions (2001):

HACCP (Hazard Analysis Critical Control Point): A system designed to identify, evaluate, and control of the potential food safety hazards.

HACCP Plan: The written document to describe the procedures based on the principles of HACCP and specific conditions.

Hazard: A biological, chemical, or physical agent that is reasonably likely to cause illness or injury in the absence of its control.

Contamination: exposure of food products to hazards, which can cause illness, disease, or even death.

Prerequisite Programs: Procedures, including Good Manufacturing Practices that address operational conditions providing the foundation for the HACCP system.

Critical Control Points (CCPs): points in the process where hazards can occur and controls can be applied to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Critical Limit: A maximum and/or minimum value to which a biological, chemical, or physical parameter must be controlled at a CCP to prevent, eliminate, or reduce to an acceptable level the occurrence of a food safety hazard.

Monitor: To conduct a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.

Corrective Action: Procedures followed when a deviation occurs.

Verification: Those activities, other than monitoring, that determine the validity of the HACCP plan and that the system is operating according to the plan.

Other Definitions

Good Manufacturing Practice (GMP): GMP is part of quality assurance which ensures that products are consistently produced and controlled to the quality standards. It is based on the knowledge and skills throughout the food system, from raw materials, through processing of the consumer products and distribution.

Laboratory Accreditation: laboratory's quality system conforms to the requirements of an appropriate standard and of a laboratory's technical competence to perform specific tests or calibrations

ISO 9000: ISO 9000 is a series of standards to define, establish, and maintain an effective quality system for manufacturing and service industries.

Statistical Process Control Techniques: Statistical process control (SPC) is scientific methods for analyzing data and keeping the process within certain boundaries.

CHAPTER TWO

Literature Review

Introduction

This chapter will discuss the necessity for and the history of HACCP as well as the studies of the application and principle of HACCP. It will conclude with a report of findings of the significance of HACCP on cheese processing.

Necessity for HACCP

According to a 1996 U.S. Dept. of Agriculture (USDA) report, “food-borne microbiological contamination in the U.S. causes an estimated 9,000 deaths and 33 million human illnesses annually.” The cost of treating these human illnesses and the subsequent loss in productivity is estimated to be $9.3 to $12.9 billion annually (Riswadkar, 2000).

Recent headlines have reported food safety problems. Such as, AP-Detroit reported: "Hot dogs blamed for Listeria outbreak" in June 1999; New York Times reported: "12th death is linked to tainted meat at plant" on Jan. 27, 1999; and CNN reported: "Armed with E-coli horror stories, consumer groups demand safer meat" on Nov. 10, 1999 (Riswadkar, 2000).

Consumer expectations about food quality and safety have risen, prompting food processors to seek systems and programs that improve food safety.

Traditional quality assurance programs and facility inspections have proven to be inadequate in controlling many food-borne illnesses. Therefore, Food and Drug Administration (FDA), USDA and other food regulatory agencies are seeking alternative approaches that will effectively and comprehensively evaluate a food plant's ability to produce consistently safe and high-quality foods. (Riswadkar, 2000)

The HACCP system is one such alternative, which focuses on identifying and preventing hazards rather than relying on intermittent checks of manufacturing processes and random sampling (Riswadkar, 2000).

History of HACCP

HACCP was developed by the Pillsbury Company along with NASA in the 1960s. It was originally developed as a microbiological safety system to ensure food safety for astronauts. At that time most food safety and quality control systems were based on end product testing, which is an inefficient method due to product waste. Therefore, a preventative system needed to be developed to give a high level of food safety assurance (Bardic, 2001; Bennet & Steed, 1999; Mortimore & Wallace, 1997).

The HACCP approach was based on the engineering system, Failure, Mode and Effect Analysis (FMEA). This system identified potential problems at each operational stage and proposed solutions to such problems before deploying effective control mechanisms (Mortimore & Wallace, 1997).

Like FMEA, HACCP looks for hazards, but in the interest of product safety. Control and management systems are then implemented to ensure that the product is safe for the consumer (Mortimore & Wallace, 1997).

Originally, HACCP was based on the following principles:

1. Comprehensive hazard analysis and risk assessment.
2. Determination and identification of critical control points (CCPs).
3. Monitoring of CCPs.

(Riswadkar, 2000, P33-34)

Subcommittees of both the National Conference on Food Protection and National Academy of Sciences recommended that the HACCP approach be adopted by both the U.S. food industry and other regulatory agencies in 1986. This led to the formation of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) in 1987. This committee expanded the HACCP's original principle to include the following seven principles now widely accepted as the standard (Riswadkar, 2000, P33-34):

1. Conduct hazard analysis and risk assessment.
2. Identify critical control points in food preparation.
3. Establish critical limits for each CCP.
4. Establish procedures for monitoring the CCPs.
5. Establish corrective action protocol for each CCP.
6. Establish procedures for effective recordkeeping.
7. Establish procedures for an effective verification (audit).

These principles allow safety and quality to be built into each step within the process rather than focusing on the final step, the finished product. Even potential consumer abuse and misuse is addressed by HACCP principles.

A systematic hazard analysis is used to identify critical control points (CCPs) at each step of the process. These points must be controlled in order to ensure food safety and prevent food-borne illnesses. With HACCP in place, a food processor can identify and monitor specific food-borne hazards that are microbiological, chemical or physical in nature. Microbiological hazards are bacterial, viral, or enteric and parasitic organisms. Chemical hazards include naturally occurring elements (such as mycotoxins from mold), toxic mushrooms, plant toxins and chemicals added during food processing (such as pesticide residues, food additives and lubricants). Though physical hazards occur less frequently in food processing they do pose problems when fragments like glass, stone, or metal are found in the product (Riswadkar, 2000).

Advantages of HACCP

HACCP is a systematic and scientific program. Based on its proactive and preventative model, it gives consumers more confidence in product safety. It focuses on identifying and preventing hazards from contaminated food by enabling the processor to focus on CCP's. It prevents inefficiency associated with blanket sanitation measures. It permits more efficient and effective government oversight, primarily because the recordkeeping tracks compliance with food safety laws over a period rather than sporadic monitoring on any given day. Finally, HACCP also helps food companies compete more effectively in the world market (FDA, 2001; Dillon and Griffith, 1995).

Recently, the FDA (2001) established HACCP for the seafood and juice industries. In 1998, USDA established HACCP for meat and poultry processing plants. Most of these establishments were mandated to start using HACCP by January 1999. Small-scale plants had until Jan. 25, 2000.

The FDA (2001) is considering establishing the HACCP as the food safety standard in other areas of the food industry, including both domestic and imported food products.

To determine the feasibility of such regulations, the agency is also conducting pilot HACCP programs with volunteer food companies producing cheese, frozen dough, breakfast cereals, salad dressing, bread, flour and other products (FDA, 2001).

Developing of HACCP

HACCP should be especially developed to each specific product and for each process of production. Some prerequisite programs should be set up first, which help to simplify the critical control points in HACCP. Quality Audit (QA) /Quality Control (QC) programs, sanitation programs, microbiological analysis, preventative-maintenance programs, employee training programs, Good Manufacturing Practices (GMPs) and Standard Sanitation Operating Procedures (SSOPs) are all prerequisites to HACCP (Morris, 1997).

The identification of CCP's in raw materials is important for developing HACCP, since most of the hazards are brought in by raw materials. Many points in food processing can be considered control points, but few are CCPs. "Critical Control Points should be established only at those points in a process where lack of control is likely to result in a potential safety hazard." (Morris, 1997, n.p.). Since there are many controlled operations in food processing, these CCPs can be critical points steps or procedures during food processing. For example: sanitation as a prerequisite program will get rid of some chemical hazards on the utensils. The goal of these CCPs is to ensure that food safety hazard can be prevented, controlled, reduced or eliminated. For example, the time-temperature relation in pasteurization is a CCP (Riswadkar, 2000).

Another important area to consider is the Microbiological testing. This test is ineffective in monitoring CCPs because of the time required to obtain results, even with the rapid 48-hour systems recently developed (Morris, 1997). Consequently, some specific temperature, time and pH controls have been used in the cheese making process for a long time to control the quality of the product. Therefore, those chemical and physical check points can be used to monitor the critical hazards.

Cheese and HACCP

Attention has been drawn to the hazards to human health due to the potential presence of pathogenic bacteria from the raw milk used in cheese production. Recommendations have been given for safe production of cheese applying Hazard Analysis Critical Control Point (HACCP) principles.

A. Cheese Making

Cheese making is the process of removing water, lactose and some minerals from milk to produce a concentrate of milk fat and protein. The essential ingredients for cheese are milk, rennet, starter cultures and salt. The semi-firm gel is formed by adding rennet that causes the milk proteins to aggregate at a certain pH; then, it is cut into small curds. Then, the whey (mostly water and lactose) begins to separate from the curds. Acid production by bacterial cultures is essential to aid in the expulsion of whey from the curd and largely determines the final cheese moisture, flavor and texture (Hill, 2000).

According to several resources, the main procedures to make cheddar cheese are as follows (Hill, 2000; Macrae et.al, 1993; Jenkins, 1996; Potter, 1995; Fox et al., 2000; Kosikowski and Mistry, 1997; Scott, 1986):

1. Pasteurize

Most cheese is produced from milk that has been pasteurized. Pasteurization is one of the major critical control points in the cheese making process. It helps to increase health to the consumer by destroying the pathogenic micro-organisms present in the raw milk. High-Temperature-Short-Time (HTST) pasteurization is widely used. This flow method system consists of heating plates, a holding tube, a flow diversion valve, and time-temperature recording charts. This method heats the milk to 72^{o}C for at least 15 seconds.

2. Addition of the starter culture:

Cultures are the prepared inoculate of bacteria, yeast and moulds. They have two purposes in cheese making which are to develop acidity and to promote ripening. Lactic acid cultures contribute to both of these functions, while numerous special or secondary cultures are added to help with the second function.

The starters for cheddar are mesophilic homofermenative cultures of Lactococcus lactis subsp. Lactis and cremoris. There is generally a ripening period of 30-60 min depending upon the type of starter added.

3. Protein coagulation:

Casein is the major protein in milk. During cheese production, rennet, a coagulating enzyme, is stirred into the milk. Under certain acid condition, rennet then separates the casein from the whey and causes the individual cells of the casein to clump together to form the gel network.

4. Cutting:

Proper cutting is extremely important to both quality and yield. The small curd particles could be lost by the improper cutting and handling of the curd. Both early cutting when the curd is fragile and late cutting when the curd is brittle cause losses of particles. The curd is ready to cut if it breaks cleanly when a flat blade is inserted at 45^o angle to the surface and then raised slowly. Curd size has a great influence on moisture retention, so the cutting wire should be chosen carefully.

5. Cooking:

The cooking and stirring will cause an increase in the acidity. Therefore, the moisture, lactose, acid, soluble minerals and salts, and whey proteins will be expelled. After cutting, the curd is gently stirred in the whey, and the temperature is raised from 30 to 38°C over a period of 45-60 min.

6. Drainage:

The whey is drained when the pH of the curd is 6.0. The curds are allowed to settle; a strainer is inserted, the exit gate valve is opened, and the greenish colored whey is diverted to a storage tank.

7. Cheddaring:

Cheddaring is used only for cheddar cheeses as a curd treatment to achieve a particular texture for milling the cheese. The curds are matted for 15 minutes following complete whey removal. A longitudinal cut is made down the middle of two trenched curd columns with a large bread knife. Horizontal columns are then cut at intervals of approximately 25.4 centimeters (10 inches). The curd blocks are spaced at about 2.5 centimeters (1 inch) apart, allowed to rest for 15 minutes and then turned over. This is repeated twice at 15 minute intervals with all loose curds swept under the blocks. Individual blocks are piled double and turned over every 15 minutes so that new surfaces are exposed. If necessary, the blocks are piled three high for the last 30 minutes.

8. Milling:

Milling is a process of reducing the size of cheddared curd into small pieces so that salt can be applied. Milling is done when the pH 5.2-5.4 is reached for the draining whey.

9. Salting:

The purpose of salting is as follows: to inhibit the growth and activity of pathogenic and food-poisoning microorganisms; inhibit the activity of various enzymes in cheese; reduce the moisture of cheese; change cheese proteins which influence cheese texture and protein solubility; and affect cheese flavor. Cheddar cheese is salted with the dry salt. 1.5-2.0% salt is spread manually over the milled curd.

10. Hooping and pressing:

The salted cheese was shaped into the metal hoops which are lined with muslin cloth. During hooping, the curds are allowed to form a continuous mass. Pressing the mass helps to form loose curd particles into a compact mass and expel whey. The cheese is pressed overnight with low pressure initially and then gradually increasing the pressure to 75 kPa. This is because initial high pressure compresses the surface layer and traps moisture in the body of the cheese which would be undesirable.

11. Ripening:

Cheese ripening exposes the prepared cheese to certain environmental conditions (temperature, humidity and so on) for several months to several years depending on the cheese type. The purpose is to break down the proteins, lipids and carbohydrates (acids and sugars) which releases flavor compounds and modifies cheese texture. Cheddar cheese is ripened at 2-12°C for 3-12 months, depending on the maturity required in the final product. The cheese is then cut and packed in retail packs.

B. HACCP on Cheese:

HACCP principles have been written into the requirements of the UK Food Safety (General Food Hygiene) Regulations 1995 and the Dairy Products (Hygiene) Regulations 1995. The Institute of Food Science and Technology (IFST) strongly supports: “the application of HACCP-based systems for cheese manufacture at all stages 'from farm to fork'” (IFST, 1998, P119).

For the consistently reliable production of microbiologically safe cheese, IFST considers the following measures important (1998, p.121):

1. A HACCP-based risk assessment and Good Manufacturing Practice should be employed at all stages of production and handling, from the farm to the consumer.
2. For those products where a risk assessment indicates a hazard from pathogens in the raw milk, the milk should undergo full pasteurization or a process of equivalent effect.

Developing a HACCP plan for the small-scale cheese plant can be difficult. Therefore, this study will pursue a brief HACCP plan based on the actual conditions in this plant.

CHAPTER THREE

Research Design

Introduction:

This chapter includes a description of the subject that was selected, the research method and process that was used in this study and how this study was approached by introducing the HACCP recordkeeping forms.

Subject selection and description:

This study was conducted in a small-scale cheese plant (less than 10 employees) in Wisconsin. This is an old plant which was being restructured to include an effective control system to boost product quality and productivity.

The restructuring was aimed at expanding the company's market. Consequently, the company plans for effective quality system to ensure safe and good quality products.

Research method:

This study did not use quantitative research because quantitative requires data analyzing. The purpose of this study was to design a HACCP model not to implement it in the actual situation. Therefore, there is no statistical data.

This study matched a qualitative approach because it provides depth and careful scrutiny of the program situations, events, employee interactions and observed behavior. It gives the intricate details of phenomena that are difficult to convey with quantitative methods. Qualitative research is exploratory and open-minded which is applicable to this study (Patton, 1987).

Research approach:

This research was done for a small-scale cheese plant. The researcher designed a brief HACCP plan based on the setting and processing in this plant in order to improve the cheese product quality. Based on the principle and several existing generic models of HACCP, the recordkeeping forms of the model in this study were designed in the following manner:

1. Prerequisite program
2. Product description.
3. List of product ingredients and incoming materials.
4. Process flow diagram.
5. Hazard identification.
6. Critical control points determination.
7. HACCP control chart.

1. Prerequisite program:

Prerequisite programs involve several steps and procedures to provide a safe environment and condition for the production of cheese. These programs are crucial to determine the critical control point. Without the programs, the researcher needs to consider more hazards that are possible to the product from outside of the process. The prerequisite programs for this small-scale cheese plant are based on the building design, pest control, storage and transportation, sanitation, water supply, equipment and personal hygiene.

2. Product description:

This part of the model gives criteria on how to describe the product characteristics for the consumers. It is important that the consumers know how to properly use and store the product (See: Table 3.1). All the details of the product description provide the information on possible critical hazards that could affect the quality and safety of the product. It helps the researcher to make the right decision on how to prevent the possible hazards. For example, the cheddar cheese is a ready-to-eat product; therefore, the pasteurization process is a critical step in cheese making process.

Table 3.1: Production Description Form

(Canadian Food Inspection Agency, 2001)

1. Product Name	
2. Important product characteristics (Moisture, pH, salt, preservatives…)	
3. How it is to be used	
4. Packaging	
5. Shelf life	
6. Where it will be sold	
7. Labeling instruction	
8. Distribution condition	

3. List of ingredients and incoming materials:

Hazards are seldom created by themselves in processing. Most of the hazards come from the ingredients and incoming materials. For example, the raw milk contains harmful bacterial such as E.coli, Staphylococcus aureus, Salmonella that could contaminate the end product. All the ingredients and the possible microbiological (M), chemical (C) and physical (P) contamination or hazards will be listed in Table 3.2.

Table 3.2: Raw Material and Potential Hazards Form

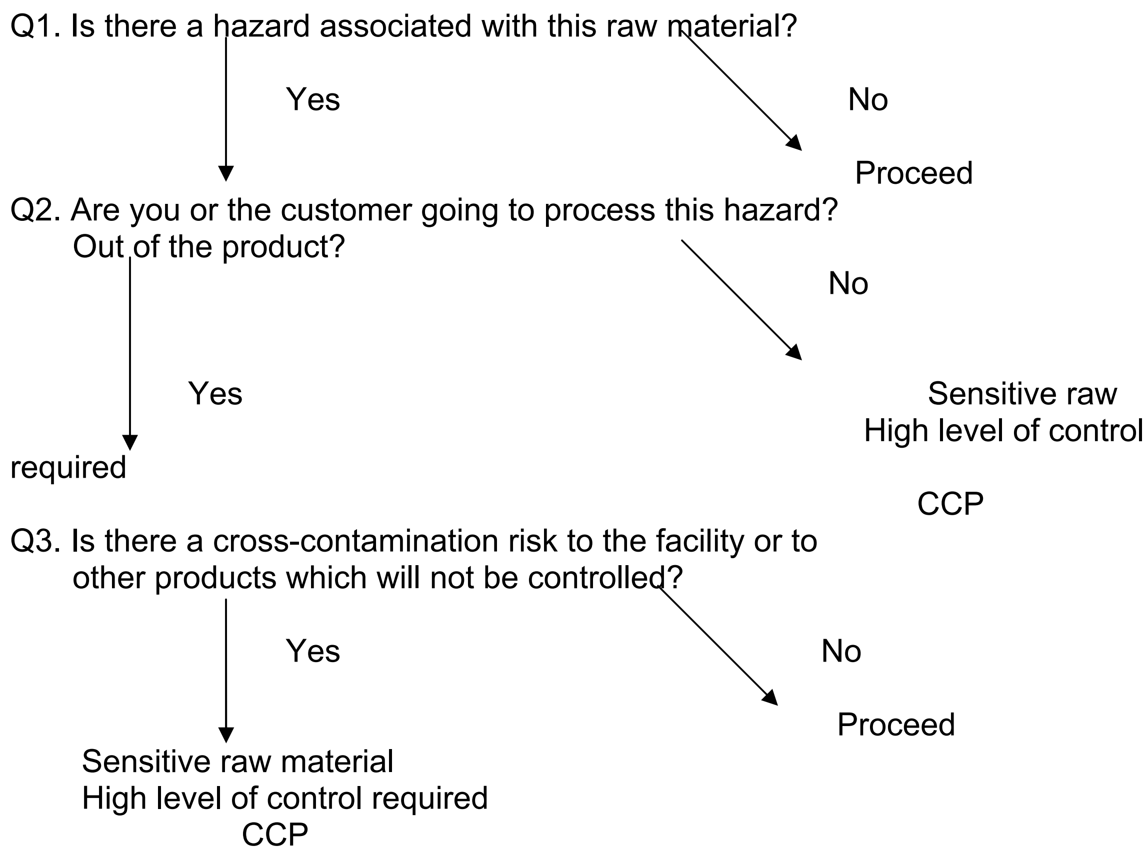
(Canadian Food Inspection Agency, 2001)

Main ingredient		Other ingredient		Packaging	
Milk	MCP	Starter culture	CP	Cryovac	MCP

The CCP decision tree will help to identify appropriate CCPs in the process. Using a CCP Decision Tree promotes structured thinking and ensures a consistent approach at every process step and for each hazard identified. It is a flow of three questions. All three questions focus on analyzing the hazards in the raw material and determining whether or not each hazard is a critical control point. Using the decision tree will allow the producer to identify the potential critical hazards in raw materials.

Figure 3.1: CCP Raw Material Decision Tree

(Mortimore and Wallace, 1997)



4. Process flow diagram:

The process flow diagram is made of a sequence of steps through the whole process; a concise explanation of each step is given to describe how the final product is made. It is used to document the production and distribution processes and helps to identify hazards at each step. It includes the processes from the raw material to the production procedure to the distribution. See sample at Figure 4.1 in chapter four.

5. Hazard identification:

Hazard identification is helpful to identify potential microbiological, chemical and physical hazards that may occur during each step of processing. Microbiological hazards are pathogens or harmful bacteria introduced during production. Another microbiological hazard stems from improper personal hygiene. Chemical contaminants include the plant toxins and chemicals added during food processing. For example, the excess detergent left on the just cleaned equipment. A physical contamination is foreign material that could come from incorrect personal handling or bad environmental conditions.

In the hazard analysis chart (Table 3.3), both the preventative measures and the type of hazards are identified within each process step. The preventative measures control the hazards by eliminating or reducing the occurrence of hazards to an acceptable level.

Table 3.3: Hazard Analysis Chart Form

(Mortimore and Wallace, 1997)

Process step	Hazard	Preventative measure

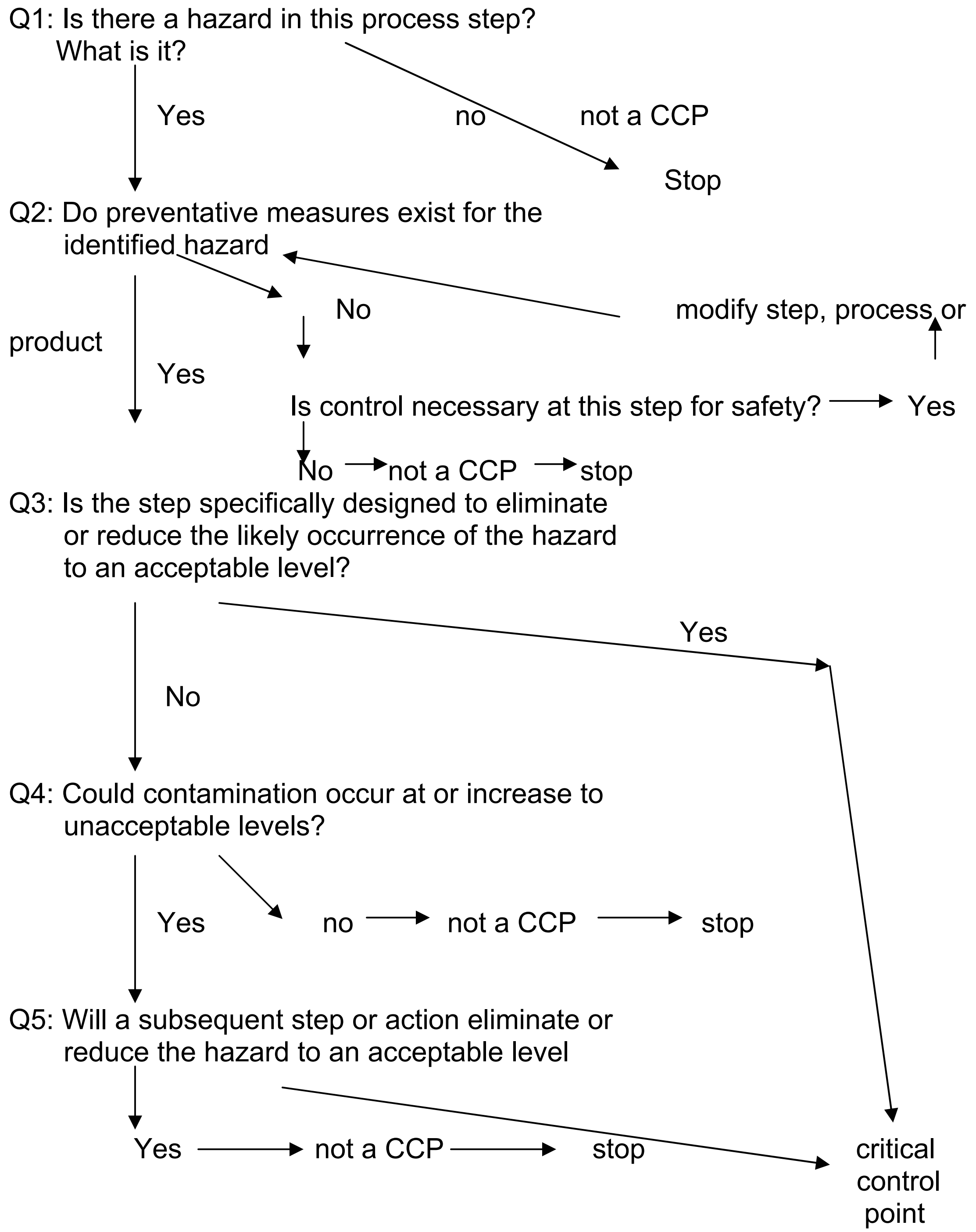
6. Critical control points determination:

There are two parts in this section. The first part is the critical control point (CCP) decision tree (Figure 3.2); the second part is the CCP decision matrix (Table 3.4).

The CCP decision tree for the processing phase will help to identify appropriate CCPs in the process. It is a flow of five questions that focus on analyzing the hazards in the process and determining whether or not each hazard is a critical control point.

Figure 3.2: CCP Process Decision Tree

(Mortimore and Wallace, 1997)



The five following questions are in the decision tree (Mortimore and Wallace, 1997):

Question 1 identifies the hazards in a specific process step. To answer this question, the researcher needs to think about the entire potential hazard in this step. No one hazard should be neglected in this part. If there is a hazard then go to the question 2.

Question 2 is to find out whether or not there is a preventative measure for the identified hazard. The researcher should use the information in the hazard identification section. If there are no preventative measures, the researcher should ask if control is necessary at this step. If yes, the step, process or the product needs to be modified. If this is a preventative measure, the process moves to the question 3.

Question 3 is made for some special process steps, which are set up for controlling the hazards; for example, pasteurization for the raw milk. If this process step is designed to deal with the hazards, this process is a CCP. If not, go on question 4.

Question 4 identifies the contamination involved in the process. The researcher must combine the condition of the process and the possible hazards. For example, does the environment of the process include hazards? Does the personal action in this process include hazards? If the contamination could occur at or increase to an unacceptable level, move to question 5.

Question 5 identifies a subsequent action that can eliminate the hazards. If there is an action, this process step is not a CCP. If there is not one, it should be a critical control point.

The CCP decision matrix lists all the answers (Yes/No) for every question based on each hazard. The matrix provides space for the researcher to expand why the hazard is a critical control point or not.

Table 3.4: Process Decision Matrix Form

(Mortimore and Wallace, 1997)

Process step and hazard	Q1	Q2	Q3	Q4	Q5	CCP	Notes
	Y	Y	N	Y	Y	N	

7. HACCP control chart:

The HACCP control chart (Table 3.5) is made based on the CCPs in the processing. For each CCP, the identified hazards and preventative measures will be listed in this chart. In addition, the critical limits, monitoring, corrective action and responsibility will be summarized in this chart. All the information is well organized and documented for a HACCP plan. It helps the company easily manage all the information.

Table 3.5: HACCP Control Chart Form

(Mortimore and Wallace, 1997)

Process step	Hazards	Preventative measure	Critical limits	Monitoring procedure	Monitoring frequency	Corrective action	Responsibility

Critical limits are the boundaries for controlling each hazard based on the preventative measure. Critical limits are the absolute tolerances of the hazard levels to ensure safety. The researcher needs to fully understand the safety criteria at each CCP so that the proper critical limits can be provided. It is important that a measurable factor accompanies the critical limit so that it can be routinely monitored. Some factors that are commonly used as critical limits include temperature, time, pH, moisture or salt concentration and titratable acidity (Mortimore and Wallace, 1997).

To demonstrate a process is operating within the critical limits, monitoring is used to measure or observe a CCP. The procedure is important to ensure that the process is under safety control. Monitoring is more effective with repeated inspection and testing. The data should be recorded continuously too. Some discontinuous systems are also used in monitoring. The frequency of monitoring shows how often monitoring needs to be provided. It depends on the type of CCP and monitoring procedure (Mortimore and Wallace, 1997).

When a deviation from a critical limit occurs at a CCP, a corrective action needs to take place, according to HACCP principle 5. The researcher should also incorporate corrective actions that will prevent deviation at the CCP. The corrective actions should be specified on the HACCP plan. Those actions should focus on both the CCP and the specific circumstances and environment of the processing (Mortimore and Wallace, 1997).

The responsibility should be considered both in monitoring and corrective action. The most important issue with responsibility is ensuring it is properly assigned. An operator in processing needs to know the necessary procedures and the correct way to follow them. It is also important to define which individuals are responsible for documenting and certifying the corrective action procedures. This information will be crucial in verifying that the required action has been taken. This is particularly important for legal issues (Mortimore and Wallace, 1997).

CHAPTER FOUR

Report of Findings

Introduction

Based on the principle of the HACCP and several generic models, the HACCP model was designed in chapter three. In this chapter, the designed model is further modified to suit the real situation of the cheese plant to boost the quality control system in order to produce safe and quality end products.

Prerequisite program

There are several programs used in this plant:

1. Building design:

The building designs are the premises for the production. It should be noted whether the paint on the walls and ceiling is or is not peeling; the ceiling is or is not leaking; the floor is sloped for liquid to drain and the door is self-closing. It should be routinely cleaned and sanitized by a professional housekeeper. The floor should be cleaned daily.

2. Pest control:

The pest control activities should be contracted to professional in food industries. The UV light could eliminate the flies and the mice trap could eradicate the mice.

3. Storage and transportation:

The specific conditions of the store room need to provide appropriate temperature and humidity for the raw materials and the final products. Daily inspection of the conditions could ensure a consistent environment to prevent the hazards and produce quality products. Proper transportation equipment should be used and the proper environmental conditions should be monitored for each batch.

4. Sanitation:

The sanitation facilities should be properly set up to eliminate possible hazards. The sanitation tube connected with the facilities should be long enough to reach all the areas that need to be sanitized. The strength of the chlorine solution should be 200ppm; daily check is required. The sanitation should be used on all the equipment, containers and tools in the process. Sanitation should be part of the personal hygiene too.

5. Water supply:

Potable water should be used in the process. The water potability testing should be verified and recorded every half year. The filter for the water needs to be checked monthly.

6. Equipment:

All the equipment needs to be checked routinely to ensure a smooth running system. The equipment should be operating properly and should be free of cracks, rust and dents.

7. Personal hygiene:

The employee should be well-trained on the personal hygiene. The supervisor should conduct checks daily. The employee needs to wear a hat or a hair net while working and needs to wash and sanitize his/her hands before working. The employee should apply appropriate action based on the personal hygiene requirements in the cheese making area. The employees must also be free of disease.

Product description

Based on the FDA regulation, the optimum moisture is 39%. Cheddar cheese belongs to hard cheese category with the moisture contents ranging from 30-45%. The moisture should be measured for each batch in this plant. Measurement of the pH and the salt concentration is specifically set up for this cheese plant to produce the best quality cheddar cheese. Cryovac is used as packaging material, which meet the safety requirements for this plant. The shelf life of this product could be longer than one year because it is a low acid food and this particular cheese is made with pasteurized milk. This ready-to-eat product will be sold retail and must be distributed in a refrigerated condition and the label needs to instruct the consumers to refrigerate the product.

Table 4.1: Product Description

(Modified from Canadian Food Inspection Agency, 2001)

1. Product Name	Cheddar Cheese
2. Important product characteristic (moisture,pH, salt, preservatives…)	Hard cheese Moisture%: 30-45% PH: 5.2-5.4 Salt: 1.5 -2.0%
3. How it is to be used	Ready to eat
4. Packaging	Cryovac, vacuum seal
5. Shelf life	Several years
6. Where it will be sold	Retail store
7. Labeling instruction	Keep refrigerated
8. Distribution condition	Refrigerated

<u>List of ingredient and incoming material</u> (Include Table 4.2 and Table 4.3)

In Table 4.2, MCP is representing the microbiological, chemical and physical hazards in the raw material. The table also includes the preventative measures for the hazards in each raw material. See detail in Table 4.2.

Table 4.2: Hazards in Ingredient and Incoming Material Analysis Chart:

(Modified from Canadian Food Inspection Agency, 2001)

Ingredient & material	Hazards	Preventative measure
Milk	MCP	Store < 4 ºC Proper transfer equipments Sanitize equipment Proper personal hygiene and handling
Starter culture	M	Qualified product supply, store < -40 ºC
Rennet	M	Qualified product supply, store < 4 ºC
Salt	MP	Qualified product supply, store at Room temperature Proper personal hygiene and handling
Water	MCP	Supply quality water
Cryovac	MCP	Qualified product supply

The decision matrix is then filled out based on the answers given to the questions from the decision tree (Figure 3.1). Four CCPs are found in the material. The qualified products supply for starter culture and the rennet could control the microbiological hazards in the production. As a qualified product, the salt needs to be out of foreign material. The brand name of the packaging material is qualified for cheese packaging. However, the quality of the products produced in this cheese plant still need to be well-controlled to prevent all the three types of hazards. Other hazards are control points that could be controlled in a prerequisite program or other process. See detail in Table 4.3.

Table 4.3: Material Decision Matrix

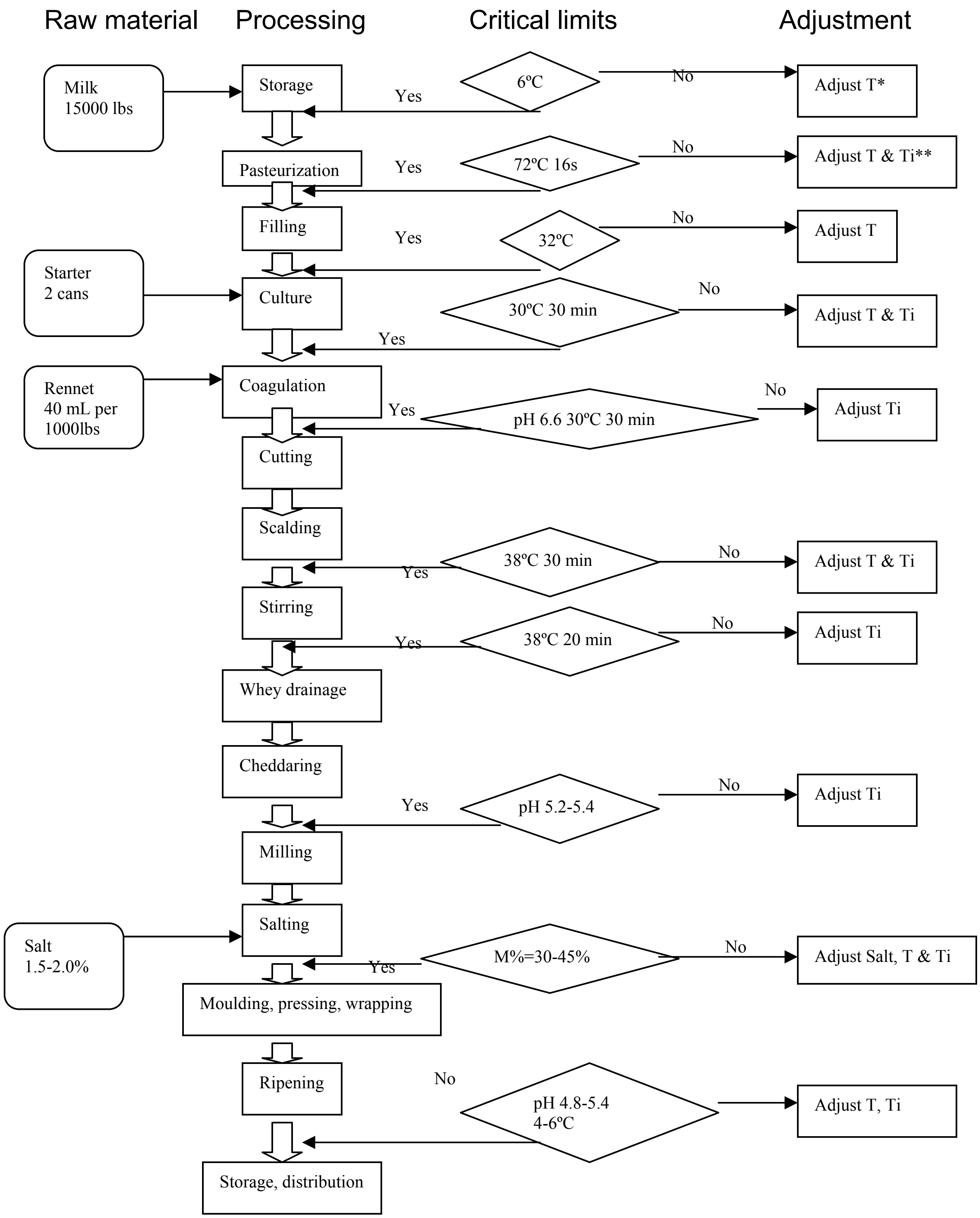
(Modified from Mortimore and Wallace, 1997)

Raw material	Q1	Q2	Q3	CCP?	Notes
Milk					
-M	Y	Y	N	N	The raw milk is considered to associate with hazards, such as salmonella. However, the heat process: pasteurization will deal with those hazards.
-C	Y	Y	N	N	Prerequisite program: equipment and sanitation
-p	N	--	--	N	Filters for incoming raw material and during pasteurization
Starter culture					
-M	Y	N	--	Y	Qualified product supply is critical
Rennet					
-M	Y	N	--	Y	Qualified product supply is critical
Salt					
-M	Y	Y	N	N	Prerequisite program: personal hygiene & food storage
-P	Y	N	--	Y	Quality product supply is critical
Water					
-M	Y	Y	N	N	The water is used to wash all the equipment and adjust the moisture; those processes are provided both before and after the heat process.
-C	Y	Y	N	N	Prerequisite program: quality water supply
-P	N	--	--	N	Filter for water
Cryovac					
-MCP	Y	N	--	Y	Qualified product supply is critical

Flow diagram

The flow diagram is specific for the cheese production in this plant. It is made of four parts: raw material, processing, critical limits and adjustment. The reason is the producer needs to check the condition of each step during processing. If it is inside the critical limits, the process continues; otherwise the process is stop and the proper adjustment is made. The adjustment is determined based on the temperature, time and salt change. If the condition cannot be controlled the product will be reject. See detail in Figure 4.1.

Figure 4.1: Flow Diagram



* T: Temperature ** Ti: Time

Hazards identification

In Table 4.9, the preventative measures are provided for the hazards in each processing step. All the control situations are set up under the requirements in this plant to make safe and quality cheese. See details in the table.

Table 4.4: Hazard Analysis Chart

(Modified from Mortimore and Wallace, 1997)

Process step	Hazards	Preventative measure
Adding milk	MCP	Proper equipment setting, Sanitize all the transfer equipment
Pasteurization	MCP	72ºC 16 sec, Proper pasteurizer setting, Sanitize all the equipment
Filling	MCP	Heat to 32ºC, Sanitize the milk tank, the stirring tools and the thermometer, Proper personal hygiene & handling, Proper building setting (tank is without cover), Pest control
Adding starter culture	MP	Medium agitate Proper personal hygiene & handling
Adding rennet	MCP	pH 6.61 30ºC Sanitize the container used for diluting rennet, Proper personal hygiene & handling
Coagulation	MP	30 min, Stop stirring and take tools out, Proper personal hygiene & handling
Cutting	MCP	pH 6.57 Correct knife size for optimum curd size, Sanitize the cutting tools and the cutter's hands and arms, Proper personal hygiene & handling
Scalding	M	38ºC 30 min, Proper personal hygiene
Stirring	MCP	38ºC 20 min, Sanitize the stirring tool, Personal hygiene and handling

Table 4.4: Hazard Analysis Chart (continue)

(Modified from Mortimore and Wallace, 1997)

Process step	Hazards	Preventative measure
Whey drainage	MCP	pH=6.4 Sanitize all the tools, Proper recycle whey setting, Proper personal hygiene and handling
Cheddaring	MCP	Consistently monitor pH during cheddaring Sanitize the knife, Proper personal hygiene and handling
Milling	MCP	pH=5.35 (5.2-5.4) Sanitize the milling machine, proper personal hygiene and handling
Salting	MCP	1.5-2.0% salt, Moisture content is optimum at 39%, Sanitize the salt container and the stirring tools, Supply quality water, Proper personal hygiene and handling
Moulding	MCP	Sanitize the moulding container and cloth, Proper personal hygiene and handling
Pressing	MP	Proper pressure at 75kpa, Proper whey drainage setting, Proper personal hygiene and handling
Wrapping	MCP	Proper vacuum machine setting, Sanitize the container, scale and tools, Proper personal hygiene and handling
Ripening	MP	Proper building setting, Proper storage condition setting, Pest control

Critical control points determination

Based on the process decision tree, there are seven CCPs identified. See detail on Table 4.5. All those seven CCPs are determined based on the following requirements in this plant.

1. The time and temperature of the pasteurizer is the most critical control point in the cheese making. Most of the pathogens are eliminated or reduced to the safety level.

2. The filling temperature is critical because it can provide the best situation for the starter culture to grow and at the same time, restrain the growth of the pathogens.

3. The supply and the amount of starter culture used in the production is the most guarded secret for a plant. Starter culture is used to produce acid before adding rennet. The rate of adding starter and rennet is very critical for the safety and also the flavor and aroma for the cheese. See detail in Table 4.6. It can be controlled by pH before adding rennet. The rate of agitation is very critical in this plant according to the producer. If the rate is too high, the air in the milk will interrupt the coagulation; if the rate is too low, the starter cannot be mixed well in the milk.

4. The time of coagulation controls how well the gel forms before cutting. If the gel is cut early, some proteins will be lost and the pathogens will grow. According to the producer, if the stirring tools are kept in the vat during coagulation, the proteins will not be formed into a gel network. It is very critical for the production in this plant.

5. The final pH is critical to control the growth of the pathogens. The low value of the pH inhibits pathogen growth and guarantees safe cheese.

6. The scalding and stirring time and temperature could influence the cheese to get the desired pH and moisture.

7. The rate of salt is very critical because under-salting will affect acid but over-salting will allow the growth of the pathogenic bacteria.

Table 4.5: Process Step Decision Matrix

(Modified from Mortimore and Wallace, 1997)

Process step and hazard	Q1	Q2	Q3	Q4	Q5	CCP	Notes
Pasteurize							
-M	Y	Y	Y			Y	Correct temperature and time kill the vegetative pathogens
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation
-P	Y	Y	N	Y	Y	N	Prerequisite program: proper equipment running & personal hygiene training
Filling							
-M	Y	Y	N	Y	N	Y	Correct temperature is critical for starter growth
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation the transfer equipment and milk vat
-P	Y	Y	N	Y	Y	N	Prerequisite program: proper personal hygiene
Adding starter & rennet							
-M	Y	Y	N	Y	N	Y	Proper additional rate of starter and rennet is critical Prerequisite program: personal training
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation
-P	Y	Y	N	Y	N	Y	Proper amount of agitate is critical before coagulation Prerequisite program: personal hygiene
Coagulation							
-M	Y	Y	N	Y	N	Y	Proper coagulation time is critical
-P	Y	Y	N	Y	N	Y	The foreign material such as the stir tool is critical for protein coagulation
Cutting, Scalding & Stirring							
-M	Y	Y	N	Y	N	Y	Correct temperature and time are critical
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation
-P	Y	Y	N	Y	Y	N	Prerequisite program: personal hygiene training
Cheddaring							
-M	Y	Y	N	Y	Y	N	Prerequisite program: personal hygiene
-C	Y	Y	N	Y	N	N	Prerequisite program: sanitation
-P	Y	Y	N	Y	N	N	Prerequisite program: personal training
Milling							
-M	Y	Y	N	Y	N	Y	Proper pH before milling is critical
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation equipments
-P	Y	Y	N	Y	Y	N	Prerequisite program: proper running of equipments & personal training

Table 4.5: Process Step Decision Matrix (continue)

(Modified from Mortimore and Wallace, 1997)

Process step and hazard	Q1	Q2	Q3	Q4	Q5	CCP	Notes
Salting							
-M	Y	Y	N	Y	N	Y	Proper amount of salt is critical
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation
-P	Y	Y	N	Y	Y	N	Prerequisite program: personal training
Moulding, Pressing & Wrapping							
-M	Y	Y	N	Y	Y	N	Prerequisite program: personal hygiene
-C	Y	Y	N	Y	Y	N	Prerequisite program: sanitation
-P	Y	Y	N	Y	Y	N	Prerequisite program: personal training
Ripening							
-M	Y	Y	N	Y	Y	N	Prerequisite program: food storage
-P	Y	Y	N	Y	Y	N	Prerequisite program: pest control

HACCP control chart

The HACCP control chart (Table 4.6) shows all the potential critical hazards that can occur during processing in this small scale cheese plant. It is the most essential part of the whole HACCP plan, which is the organization analysis and documentation of the CCPs. (see detail in Table 4.6). The column of the responsible will be filled out by the operator or the supervisor who is responsible for the control. The steps that contain those CCPs will be emphasized during production. The documentation of the HACCP plan which is suitable for the conditions in this small-scale cheese plant will help to prevent and eliminate those critical hazards in its production. Therefore, safe and quality cheese products could be produced in this plant. The document also can be used for improvement of a HACCP plan in the future.

Table 4.6: HACCP Control Chart

(Modified from Mortimore and Wallace, 1997)

Process step	Hazards	Preventative measure	Critical limits	Monitoring procedure	Monitoring frequency	Corrective action	Responsibility
Raw & packaging material CCP # 1	Microbiological chemical & physical contamination	Qualified starter & rennet supply Qualified cryvoac supply	No unqualified material be used	Apply supply quality assurance	Each supply	Change supplier Operator training	
Pasteurization CCP #2	Survival of pathogens such asE.coli, *Staphylococcus aureus, Bacillus cereus, etc.*	Pasteurizer checks: -check the heat plate -check the temperature controller -check the flow diversion	Temperature set at 72ºC Time set at 16 sec	Check thermometer and time check equipment is properly running Supervisor managing and record keeping	Each batch Routinely Each batch	Adjust the temperature And time by setting the equipment well Call the engineer to repair	
Filling CCP #3	Microbiological contamination	Proper temperature setting	Temperature set at 32ºC	Check thermometer Record keeping	Each batch Each batch	Adjust the heater to change temperature	
Adding starter & rennet CCP #4	Microbiological contamination Physical contamination	Proper additional rate Agitate properly	Starter: 2cans, Rennet: 40 mL per 1000 lbs milk pH is measured at 6.6 before adding rennet Agitator set at medium	Check the additional rate of the starter and rennet & pH check the rate of the agitator Record keeping	Each batch Each batch	Applying more testing on pH Use active starter culture Adjust agitate rate Operator training	
Coagulation CCP #5	Microbiological contamination Physical contamination	Proper time setting and recording Take the stirring tools out of the tank	Time is set at 30min Tools prevent coagulation	Check the time and the stirring tools Record keeping	Each batch Each batch	Reject product Operator training	
Cutting, scalding & stirring CCP #6	Microbiological contamination	Proper time & temperature setting	Temperature is set at 38ºC, scalding for 30min and stirring for 20min	Check the temperature and the time Record keeping	Each batch Each batch	Adjust the heater to change temperature Operator training	
Milling CCP #7	Microbiological contamination	More cheddaring time control the pH Use of an active starter culture at the correct addition	pH is measured at 5.2-5.4	Consistently monitor pH during cheddaring Supervisor's managing and record keeping	Each batch	Reject product Applying more testing on pH Operator training	
Salting CCP #8	Microbiological contamination	Correct level of salt Correct mixing during salting	Salt%=1.5-2.0%	Records and testing	Each batch	Incorrectly salted curd must not be allowed to progress	

CHAPTER FIVE

Conclusions and Recommendations

Statement of the problem

The study designed a HACCP plan model for a small-scale cheese plant to improve the safety and quality of its products.

Method and procedures

The form of this HACCP plan model was modified from several generic HACCP models used in this study. The form is then further modified based on the identified CCPs that were found from the observation and research that was conducted in the plant.

Findings and conclusions

The model is developed step-by-step based on the seven principles of HACCP system mentioned in the literature review. The prerequisite program was provided to deal with some hazards before the production; therefore, to simplify the HACCP plan. The product description was used to alert the consumer to the potential hazards in the final products. Then, the potential control points of the hazards appeared in both raw material and the process will be studied along with the prevention measures. By answering the questions in the decision trees, the critical control points were determined. Finally, the HACCP control chart was developed to include components of several HACCP principles which are critical limits, monitoring, corrective action and responsibility.

Eight CCPS were found in the production in this cheese plant. They are:

1. Qualified supply of starter, rennet and packaging material.

2. Proper pasteurization
3. Proper temperature of filling
4. Proper setting during adding starter and rennet
5. Proper setting during coagulation
6. Proper time and temperature during scalding and stirring
7. Proper pH for milling
8. Proper salting

From the literature review, HACCP is an improved system compared to the traditional sampling and testing quality control. Not only because it is a prevention instead of a reaction which reduces the risk of processing and selling unsafe products; also because it is a cost-effective program which is fairly useful in a small-scale cheese plant such as the subject in this study. Money is saved by only spending on the critical control area of processing instead of the cost of samples and the instruments to test the end products.

Recommendations

The HACCP plan in this study has not been implemented in the cheese making process because of the limited resources and time. As a HACCP system, the verification procedures which are the seventh principle must be included. This principle can be effective by using an audit method to ensure the HACCP plan is properly practiced in the production.

HACCP should become part of the culture of the plant. Improvement should be continues.

To effectively implement a HACCP system, Supply Quality Assurance and Good manufacturing Practice are essential supports. To ensure both the validity and security of a HACCP system, Laboratory Accreditation and ISO 9000, and use of Statistical Process Control Techniques will be very useful.

HACCP is a universal system; it ensures the food safety for importing and exporting food products.

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