

IMPLEMENTATION OF THE HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP) SYSTEM TO UF WHITE CHEESE PRODUCTION LINE

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Background. HACCP, or the Hazard Analysis and Critical Control Point System has been recognised as an effective and rational means of assuring food safety from primary production through to final consumption, using a “farm to table” methodology. The application of this preventive oriented approach would give the food producer better control over operation, better manufacturing practices and greater efficiencies, including reduced wastes.

Material and methods. The steps taken to put HACCP in place are described and the process was monitored to assess its impact. Assessment of the hygiene quality of the UF white cheese products line before and after HACCP showed an improvement in quality and an overall improvement in the conditions at the company.

Results. HACCP was introduced for the in UF White Cheese line at Misr Milk and Food, Mansoura, Egypt, for safe and good quality foods products. All necessary quality control procedures were verified for completeness and to determine if they are being implemented to required standards. A hazard analysis was conducted to identify hazards that may occur in the product cycle, Critical Control Points (CCPs) were determined to control the identified hazards. CCP signs were then posted on the factory floor. Critical limits were established at each CCP, corrective actions to be taken when monitoring indicates deviation or loss of control were established. Verification procedures were established to confirm that the HACCP system is working effectively. Documentation concerning all procedures and records was established and integrating HACCP with ISO 9000 under one management system was applied.

Conclusions. The HACCP system in this study for UF White Cheese line manufacture is developed step-by-step based on the twelve steps mentioned in the literature review. The prerequisite program was provided to deal with some hazards before the production to simplify the HACCP plan.

Key words: HACCP, CCPs, UF white cheese, food safety

INTRODUCTION

Nowadays there is an ever increasing consumer demand for safe and high quality foods of prolonged life. Several quality/safety management systems (e.g., ISO 9000, Total Quality Management, and HACCP) were developed for the food industry. The importance of implementing such systems for rather biochemically unstable products like cheese [Sandrou and Arvanitoyannis 2000], a product characterised by great variety worldwide, is apparent.

HACCP, has been recognised as an effective and rational means of assuring food safety from primary production through to final consumption, using a “farm to table” methodology. 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 and Steed 1999, Mortimore and Wallace 1997].

The hazard analysis and critical control point (HACCP) system is a preventative measure that assesses hazards, estimates risks and establishes specific control measures that emphasize prevention rather than reliance on end-product testing [A simple guide... 1993]. The main potential hazards in most dairy products are microbiological [Tranter 1990], and the dairy industry has increased its efforts for quality and safety assurance through the development and implementation of proactive programmers such as HACCP [Ito 1974].

Cheese is the most popular dairy products in the world, produced in a great range of types and forms throughout the world countries [Fox et al. 2000]. World cheese production has increased at an average annual rate of 4.2% over the past 20 years. Investigations of outbreaks of food borne diseases arising from cheese show that certain conditions frequently contribute to causation [FDA 2001]. When such outbreaks do occur they usually involve large number of people. Therefore the adherence to strict quality system is of paramount importance for the ensuring the safe production of cheese [Hill 2000, Temelli et al. 2006]. HACCP system is a process that identifies and assesses the hazard and risks associated with the manufacture, storage and distribution of foods and implements the appropriate control aiming at the elimination or reduction of these hazard at specific points of production line [Abdl-Salam 1998, Dillon and Griffith 1995, International Standard... 1998, Zhao 2003].

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. 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 and Wallace 1997, Morris 1997, IFST 1998, Smukowski 1996].

This paper focuses on the flow diagrams based on the production line of UF white cheese and presents an analysis of the hazards and of the critical control points (CCP) before and after application of HACCP system at one plant in Egypt.

MATERIAL AND METHODS

Application of HACCP system

The steps used to apply the HACCP system in UF white cheese Products line were described by Kassem et al. [2001] as follows:

- The support of senior management of the company for food safety and HACCP application was sought and obtained.
- A team was formed which included: production manager, production engineer, consultant of food hygiene and sanitation, consultant of food microbiology and a technician from the laboratory.
- Products were described in terms of ingredients, processing, packaging, storage and distribution.
- Each step in the process was outlined in sequence in the flow diagram from raw materials through processing, packaging and storage.
- In order to identify the hazards the following actions were undertaken:
- Observing operations. Each product preparation process was observed for:
 - Receipt of raw materials, storage, heat treatment, cooling and packaging
 - Fermentation, concentration, homogenization, additives, temperature, packaging and storage.
 - Personal hygiene, education, health, cleanliness, habits, premises, equipment, floors, walls and ventilation (working conditions).
- Measuring operations. Time and temperature applied during the production and storage of milk and dairy products were measured and recorded on the flow diagrams.

Evaluation of the chemical and microbiological UF white cheese quality before and after HACCP implementation

First, samples of UF white cheese were examined for physical, chemical and microbiological contamination before HACCP application. Second, another samples (of the same products) were examined after HACCP application. The physical hazards were examined for the presence of wood, stone, bone, metals, dust and straw. The chemical analysis (pH, Acidity, Fat, Total Solids (TS), Solids Not Fat (SNF), Formalin and Antibiotic) were described by Scott [1986]. The microbiological procedures (Detection of Total viable cell count (TVCs), coliforms, *Staphylococcus aureus* and Enumeration of mould and yeast) were those recommended in the International Commission on Microbiological Specification for Foods [Microorganisms... 1996]. Culture media were those of Oxoid, Biolife and Difco.

Developing a HACCP plan of UF white cheese production line

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]. In the

development of a HACCP plan, five preliminary tasks need to be accomplished before the application of seven principles HACCP (Canadian Food Inspection Agency (CFIA), 2001; Fig. 1).

Assemble HACCP team
 Describe the final product
 Identify the products intended use
 Construct the process flow diagram
 Verify the flow diagram
 Implement principle 1. Conduct a hazard analysis
 Apply principle 2. Identify the Critical Control Points (CCPs)
 Employ principle 3. Establish critical limits
 Implement principle 4. Establish CCP monitoring procedures
 Organize principle 5. Establish corrective action
 Institute principle 6. Establish verification procedures
 Principle 7. Establish record keeping procedures

Fig. 1. Summary of the HACCP system

UF White cheese operation

The main procedures to UF White cheese operation were described by Scott [1986], Kosikowski and Mistry [1997] as follows in Figure 2.

Milk reception (**CCP1**)
 Milk cooled to 5°C
 Storage
 Standardisation
 Pasteurisation 72°C/15 s (**CCP2**)
 Milk heating 50-60°C
 Ultra-filtration unit
 Concentrate, permeate
 Homogenised
 Pasteurisation and cooling 40-45°C
 Addition salt (**CCP3**), CaCl₂, rennet solution (**CCP4**)
 Trays filling and incubation 40-45°C (**CCP5**)
 Coagulation (**CCP6**)
 Trays cooled at 5°C
 Cheese cutting (**CCP7**)
 Packaging
 Brine or permeate solution added
 Storage, distribution

Fig. 2. The main procedures and (CCPs) to UF White cheese operation

HACCP on UF White cheese production line

The Institute of Food Science and Technology [IFST 1998] strongly supports: “the application of HACCP-based systems for cheese manufacture at all stages 'from farm to fork’”.

RESULTS AND DISCUSSION

Development of UF white cheese HACCP plan

1. Prerequisite program. There are several programs used in UF white cheese production line: 1. Buildings and facilities must be of sound construction and good repair and designed to: permit easy and adequate cleaning and proper hygiene; minimize pest and environmental contamination; minimize cross contamination; provide adequate lighting in inspection areas; provide potable water supply; provide personal hygiene practice; control surrounding areas to reduce entry of dust, runoff, pests and other potential contamination sources. 2. Equipment used in the process must be designed, constructed, maintained and operated to allow for: effective cleaning of surfaces; contamination control; calibration and maintenance to ensure control. 3. Persons who process product should establish hygiene practice to ensure: washing of hands prior to contact with product; training is provided on critical control points, allowable tolerances and corrective actions required. 4. All employees must: be provided documented procedures to ensure the processes do not pose a health risk; adhere to documented procedures; be involved in the preparation of a HACCP system. 5. A documented sanitation program must exist that includes: equipment cleaning; housekeeping audits and associated corrective actions; pest control; waste disposal; bin inspections. 6. Incorporated into the existing documentation there must be: process flowcharts and critical control points; monitoring mechanism for these control points; corrective action process; traceable records. 7. A formalized customer complaint process must exist that includes a product recall process.

Table 1. Production description form

Formal product name	UF White cheese
Product description and food safety characteristics:	UF White cheese moisture (%) – 60-65% pH – 6.0-6.5 salt – 2.5-4.5%
Packaging used:	cans (2-16 kg), plastic box (650 g-1 kg)
Labelling requirements:	keep refrigerated
Storage and distribution:	temperature of storage is $\leq 7^{\circ}\text{C}$. Distributed using refrigerated ($\leq 7^{\circ}\text{C}$) to wholesale and retail outlets
Intended consumers:	consumers of all ages consume this product
Intended use:	ready to eat product

2. Product description. UF White cheese belongs to soft cheese category with the moisture contents ranging from 60-65%. The moisture should be measured for each batch in this line. Measurement of the pH and the salt concentration is specifically set up for this cheese line to produce the best quality UF white cheese. Cans and plastic box

is used as packaging material, which meet the safety requirements for this line. The shelf life of this product could be longer than three month. 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 1).

3. List of product ingredients and incoming materials. All the ingredients and the possible microbiological (M), chemical (C) and physical (P) contamination or hazards in raw material will be listed in Table 2. The table also includes the preventative measures for the hazards in each raw material.

Table 2. Hazards in ingredient and incoming material analysis chart

Ingredient and material	Hazards	Preventative measure
Milk	MCP	store <4°C proper transfer equipments sanitize equipment proper personal hygiene and handling
Rennet	M	qualified product supply, store <4°C
Salt	MP	qualified product supply, store at room temperature proper personal hygiene and handling
Water	MCP	supply quality water
Cans and plastic box	MCP	qualified product supply

M – microbiological, C – chemical, P – physical.

4. Process flow diagram. UF White cheese steps and process flow diagrams are shown in Figure 2. The adjustment is determined based on the temperature, time and salt change. If the condition cannot be controlled the product will be reject.

5. Hazard identification. In Table 3, the preventative measures are provided for the hazards in each process step. All the control situations are set up under the requirements in this line to make safe and quality UF white cheese.

6. Critical control points (CCPs) in the UF white cheese production line. The CCPs were identified according to the HACCP decision tree as recommended by [Pearson and Corlett 1992, Codex Alimentarius... 1993, Riswadkar 2000]. The CCPs are shown in Figure 2.

7. HACCP control chart. The HACCP control chart (Table 4) shows all the potential critical hazards that can occur during processing UF White cheese production line. It is the most essential part of the whole HACCP plan, which is the organisation analysis and documentation of the CCPs. The steps that contain those CCPs will be emphasised during production. It can be seen from the table that receipt of raw milk was a critical control point (CCP) because high acidity (chemical hazard) cannot be eliminated by any subsequent processing steps. Pasteurized, processing and packaging material were also CCPs because the subsequent steps mentioned in the flow diagrams (Fig. 2) cannot

Table 3. Hazard analysis chart

Process step	Hazards	Preventative measure
Milk	MCP	proper equipment setting, sanitize all the transfer equipment
Pasteurisation	MCP	72°C, 15 s proper pasteuriser setting, sanitize all the equipment
Rennet	MCP	sanitize the container used for diluting rennet, proper personal hygiene and handling
Trays filling	MCP	sanitize the trays filling and the thermometer, proper personal hygiene and handling, pest control
Coagulation	MP	40°C, 60 min, proper personal hygiene and handling
Cutting	MCP	correct knife size for optimum curd size, sanitize the cutting tools and the cutter's hands and arms, proper personal hygiene and handling
Salting	MCP	2.5-4.5% salt, moisture content is optimum at 60-65%, sanitize the salt container and the stirring tools, supply quality water, proper personal hygiene and handling
Storage and distribution:	MP	temperature of storage is $\leq 45^{\circ}\text{F}$. Distributed using refrigerated ($\leq 45^{\circ}\text{F}$), proper building setting, proper storage condition setting, pest control

eliminate any existing hazards mentioned in the table. To prevent these hazards, the control of time and temperature and the application of the rules of good manufacture practices (GMP) are needed. Time, temperature and GMP limits that should be followed at each process step are mentioned under critical limits (Table 4). These should be followed accurately to avoid hazards occurring. Continuous time, temperature and pH measurements, in addition to visual inspection, are the monitoring procedures that will prevent any deviation in the critical limits. The corrective actions mentioned Table 4 are those to be used if a product was made while there was a deviation in the critical limits. The document also can be used for improvement of a HACCP plan in the future.

Table 4. HACCP control chart

Process step	Hazards	Preventative measure	Critical limits	Monitoring procedure	Monitoring frequency	Corrective action
Milk reception (CCP1)	microbiological chemical and physical contamination	rennet supply qualified packaging material supply	no unqualified material be used	apply supply quality assurance	each supply	change supplier operator training
Pasteurization (CCP2)	survival of pathogens such as <i>E. coli</i> , <i>Staphylococcus aureus</i> , <i>Bacillus cereus</i> , etc.	pasteuriser checks: – check the heat plate – check the temperature controller – check the flow diversion	temperature set at 72°C, 15 s	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
Salting (CCP3)	microbiological contamination	correct level of salt correct mixing during salting	salt% = 5.0%	records and testing	each batch	incorrectly salted curd must not be allowed to progress
Rennet (CCP4)	microbiological contamination physical contamination	proper additional rate agitate properly	rennet: 100 ml/100 kg concentrate agitator set at medium	check the additional rate of the rennet and pH check the rate of the agitator record keeping	each batch each batch	applying more testing on pH adjust agitate rate operator training
Trays filling (CCP 5)	microbiological contamination	proper temperature setting	temperature set at 32°C	check thermometer record keeping	each batch each batch	adjust the heater to change temperature
Coagulation (CCP 6)	microbiological contamination physical contamination	proper time setting and recording take the stirring tools out of the tank	temperature set at 40-45°C time is set at 30-60 min tools prevent coagulation	check the temperature/time and the stirring tools record keeping	each batch each batch	reject product operator training
Cutting (CCP 7)	microbiological contamination	proper time and temperature setting		check the temperature/time record keeping	each batch each batch	adjust the heater to change temperature operator training

Evaluation of the sensory evaluation, chemical and microbiological UF white cheese quality before and after HACCP implementation

Table 5 shows, the sensory evaluation (taste, color and flavor) and chemical analysis were identical, accepted UF white cheese samples. In the same table, shows a decrease in the hazard percentage of *Staphylococcus aureus*, Salmonella spp., Coliforms and Mold & Yeast detected at the UF white cheese line manufacture after applying HACCP, and the plant was then classified as a no hazard (safe) line. Salmonella and mould and yeast were not detected [Houlidou and Sampatakou 1995].

Table 5. Comparison of UF White Cheese analysis before and after HACCP

Test	Before HACCP	After HACCP	Remarks
I. Sensory evaluation			
Taste	accepted	accepted	ES (1008/1970)
Color	natural	natural	(155/1974)
Flavor	accepted	accepted	V1/1991
II. Chemical analysis			
pH	4.41	4.22	
Acidity, %	0.76	0.67	
SNF, %	22.1	23.6	
TS, %	39.0	39.2	
Fat, %	16.9	15.6	
Fat/TS, %	41.02	43.38	> 45%
Moisture, %	62.2	60.8	> 60%
III. Microbiological analysis			
TVCs	6.95	6.14	
Mold and yeast	105	63	
Coliforms	43	23	
<i>Staphylococci</i>	$2 \cdot 10^2$	-ve	
Salmonella spp.	-ve	-ve	

ES – Egyptian standarization, SNF – solid not fat, TS – total solids, TVCs – total viable count (Log_{10} CFU/ml).

CONCLUSIONS

The HACCP system in this study for UF White Cheese line manufacture is developed step-by-step based on the twelve steps 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. 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. Seven CCPS were found in the production in this cheese plant. They are: qualified supply of rennet and packaging material, proper pasteurization, proper setting during adding CaCl_2 , NaCl and rennet, proper setting during coagulation, proper time and temperature during manufacture.

Recommendations

Establishment of standards for microbiological examination for cheese products, Developing a training program for technician who is carrying out the microbiology and chemical analysis, Compliance with the ES guideline for the production of cheese, Emphasise on the sanitarily aspects dealing with producing cheese with minimal microbial count and Raw materials involved in the manufacture of cheese products should be of good microbiological and chemical quality.

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WPROWADZENIE SYSTEMU ANALIZY ZAGROŻEŃ I KRYTYCZNYCH PUNKTÓW KONTROLI (HACCP) DO PRODUKCJI SERA TWAROGOWEGO Z ZASTOSOWANIEM ULTRAFILTRACJI

Wstęp. HACCP, czyli System Analizy Zagrożeń i Krytycznych Punktów Kontroli został uznany za efektywny i wymierny środek gwarantujący bezpieczeństwo żywności od produkcji pierwotnej aż do konsumpcji, zgodnie z metodologią „od pola do stołu”. Zastosowanie systemu nakierowanego na prewencję daje producentowi żywności lepszą kontrolę operacji jednostkowych i całego procesu produkcji oraz większą efektywność redukcji odpadów.

Material i metody. Etapy objęte systemem HACCP opisano, a sam proces poddano monitoringowi w celu oceny jego działania. Analiza stanu mikrobiologicznego przed i po wprowadzeniu systemu HACCP podczas produkcji sera twarogowego po ultrafiltracji wskazała na polepszenie jakości produktu i warunków higienicznych w przedsiębiorstwie.

Wyniki. System HACCP został wprowadzony na linii produkcji sera twarogowego z zastosowaniem ultrafiltracji w przedsiębiorstwie Misr Milk and Food (Mansoura, Egipt) dla zapewnienia bezpieczeństwa i dobrej jakości produktów spożywczych. Wszystkie niezbędne procedury kontroli jakości zweryfikowano i wprowadzono zgodnie z wymaganym standardem. Przeprowadzono analizę zagrożeń w celu identyfikacji niebezpieczeństw, które mogą pojawić się w całym cyklu życia produktu. Wyznaczono też Krytyczne Punkty Kontroli (CCPs) dla kontroli zagrożeń zidentyfikowanych. Na terenie zakładu umieszczono znaki CCP. Wyznaczono limity krytyczne dla każdego CCP. W przypadku odchyleń lub utraty kontroli nad procesem podejmowano ustalone działania korygujące. Ustanowiono procedurę weryfikacji w celu potwierdzenia skuteczności działania systemu HACCP. Dokumentacja systemu HACCP obejmująca wszystkie procedury i formularze została ustanowiona i zintegrowana z ISO 9000 jako jeden system zarządzania.

Wnioski. System HACCP linii produkcyjnej sera twarogowego po UF został opracowany krok po kroku, zgodnie z dwunastoma etapami wymienianymi w literaturze. Programy wstępne wprowadzono w celu lepszej ochrony przed zagrożeniami podczas produkcji oraz w celu ułatwienia realizacji założonego planu HACCP.

Słowa kluczowe: HACCP, CCP (Krytyczne Punkty Kontroli), ser twarogowy po ultrafiltracji (UF), bezpieczeństwo żywności

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