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

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## ABSTRACT

The Hazard Analysis and Critical Control Point (HACCP) System has been recognized as an effective and rational means of assuring food safety from primary production 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. HACCP was introduced in the UF white cheese line. Misr milk and Food Company, Mansoura, Egypt, 2002, for safe and good quality food products. 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. Steps for implementation were as follows: 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 be occur in the product cycle, from farm delivery to retail, and to assess the preventative measures for controlling them, 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, appropriate monitoring system was established for at each CCP to monitor its control, 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 were established and integrating HACCP with ISO 9000 under one management system.

## 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 characterized by great variety worldwide, is apparent. HACCP, has been recognized 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). 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 (International Life Sciences Institute, 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 K., 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 and 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 Organization (ISO), 1998 and 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 and 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.

MATERIALS 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.,* (2002) 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 (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 manufacture**

The main procedures were described by Scott, (1986); Kosikowski and Mistry (1997) as follows in Fig. 2.

Milk reception **(CCP1)**
Milk Cooled to 5°C
Storage
Standardization
Pasteurization 72°C/15 sec **(CCP2)**
Milk heating 50 - 60°C
Ultra-filtration unit
Concentrate, permeate
Homogenized
Pasteurization and cooling 40- 45°C
Addition salt **(CCP3),** $CaCl_2$, 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) UF of white cheese manufacture**

**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<br>Moisture%: 60-65%<br>pH: 6.0-6.5<br>Salt: 2.5 -4.5% |
| Packaging Used: | Cans (2 -16 kg),<br>plastic box (650 g -1 kg) |
| Labeling Requirements: | Keep refrigerated. |
| Storage and Distribution: | Temperature of storage is ≤ 7°C. Distributed using refrigerated (≤ 7°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 pH and 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 months. 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.

**4. Process flow diagram**

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

**Table 2: Hazards in ingredient and incoming material analysis chart**

| Ingredient and Material | Hazards | Preventative measure |
|---|---|---|
| Milk | *MCP | Store < 4 ºC<br>Proper transfer equipments<br>Sanitize equipment<br>Proper personal hygiene and handling |
| Rennet | M | Qualified product supply, store < 4 ºC |
| Salt | MP | Qualified product supply, store at room temperature<br>Proper personal hygiene and handling |
| Water | MCP | Supply quality water |
| Cans and plastic box | MCP | Qualified product supply |

*** M: Microbiological C: Chemical P: Physical**

## 5. Hazard identification

**Table 3: Hazard Analysis Chart**

| Process step | Hazards | Preventative measure |
|---|---|---|
| Milk | MCP | Proper equipment setting,<br>Sanitize all the transfer equipment |
| Pasteurization | MCP | 72ºC, 15 sec<br>Proper pasteurizer setting,<br>Sanitize all the equipment |
| Rennet | MCP | Sanitize the container used for diluting rennet,<br>Proper personal hygiene & handling |
| Trays filling | MCP | Sanitize the trays filling and the thermometer,<br>Proper personal hygiene & handling,<br>Pest control |
| Coagulation | MP | 40ºC, 60 min,<br>Proper personal hygiene & handling |
| Cutting | MCP | Correct knife size for optimum curd size,<br>Sanitize the cutting tools and the cutter's hands and arms,<br>Proper personal hygiene & handling |
| Salting | MCP | 2.5 -4.5% salt,<br>Moisture content is optimum at 60-65%,<br>Sanitize the salt container and the stirring tools,<br>Supply quality water,<br>Proper personal hygiene and handling |
| Storage and Distribution: | MP | Temperature of storage is ≤ 45°F. Distributed using refrigerated (≤ 45°F)<br>Proper building setting,<br>Proper storage condition setting,<br>Pest control |

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 Cntrol Pints (CCPs) in the UF white cheese production line

The CCPs were identified according to the HACCP decision tree as recommended by (Pierson and Corlett, 1992; Codex Alimentarius Commission, 1993 and Riswadkar, 2000). The CCPs are shown in Fig. 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 organization analysis and documentation of the CCPs

**Table 4: HACCP Control Chart**

| Process step | Hazards | Preventative measure | Critical limits | Monitoring procedure | Monitoring frequency | Corrective action |
|---|---|---|---|---|---|---|
| Milk reception *(CCP1)* | Microbiological chemical & physical contamination | rennet supply Qualified packaging material supply | No unqualified material be used | Apply supply quality assurance | Each supply | Change supplier<br>Operator training |
| Pasteurization *(CCP2)* | Survival of pathogens such as *E.coli, Staphylococcus aureus, Bacillus cereus*, etc. | Pasteurizer checks: -check the heat plate -check the temperature controller -check the flow diversion | Temperature set at 72ºC , 15 sec t | Check thermometer and time check equipment is properly running Supervisor managing and record keeping | Each batch<br>Routinely<br>Each batch | Adjust the temperature and time by setting the equipment well<br>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<br>Physical contamination | Proper additional rate<br>Agitate properly | Rennet: 100 ml / 100 kg concentrate<br>Agitator set at medium | Check the additional rate of the rennet & pH<br>check the rate of the agitator<br>Record keeping | Each batch<br>Each batch | Applying more testing on pH<br>Adjust agitate rate<br>Operator training |
| Trays Filling *(CCP 5)* | Microbiological contamination | Proper temperature setting | Temperature set at 32ºC | Check thermometer<br>Record keeping | Each batch<br>Each batch | Adjust the heater to change temperature |
| Coagulation ***(CCP 6)*** | Microbiological contamination Physical contamination | Proper time setting and recording<br>Take the stirring tools out of the tank | Temperature set at 40-45ºC Time is set at 30-60 min<br>Tools prevent coagulation | Check the Temperature/ time and the stirring tools<br>Record keeping | Each batch<br>Each batch | Reject product<br>Operator training |
| Cutting ***(CCP 7)*** | Microbiological contamination | Proper time & temperature setting and | | Check the Temperature/ time<br>Record keeping | Each batch<br>Each batch | Adjust the Heater to change temperature<br>Operator training |

The steps that contain those CCPs will be emphasized 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 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.

**The sensory evaluation,chemical and microbiological of UF White cheese quality before and after HACCP implementation**

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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 Mould & Yeast detected in 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).

## 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 CaCl2, 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 microbiological and chemical analysis, Compliance with the ES guideline for the production of cheese, emphasize 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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## دراسة تطبيقية باستخدام تحليل مصدر الخطر ونقطة التحكم الحرجة (الهاسب) على خط إنتاج الجبن الابيض بطريقةUF

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عرف نظام الهاسب (HACCP) بأنه أحد الوسائل الفعالة التى يمكن إستخدامها للتأكد من سلامة الغذاء من بدء الإنتاج حتى مرحلة الإستهلاك النهائى بإستخدام منهج من المزرعة إلى المائدة . إن تطبيق هذا المفهوم الوقائى يساعد منتجى الاغذية على حسن التحكم فى عمليات التشغيل وممارسات صناعية جيدة وكفاءة أداء مرتفعة بالإضاقة الى تقليل المخلفات .

وفى هذه الدراسة تم تطبيق نظام تحليل مصدر الخطر ونقطة التحكم الحرجة الهاسب (HACCP) على خط إنتاج الجبن الابيض بطريقة UF بشركة مصر للألبان بالمنصورة عام ٢٠٠٢ وذلك للحصول على غذاء آمن صحيا ذو جودة عالية وفيما يلى الخطوات التنفيذية: لذلك :

- تطبيق كل البرامج الضرورية والتى تشمل ممارسات التصنيع الجيدة وإجراءات مراقبة الجودة والادوات المستخدمة فى التحقق من إكتمالها وكذلك التي تم تصميمها وتجربتهاطبقا للماصفات القياسية.
- الاسترشاد بتحليل مصدر الخطرلتعريف الاخطار التى يحتمل تواجدها من الحصاد حتى الاستهلاك النهائى ولتقييم إجراءات وقائية للتحكم فيها
- تحديد نقط التحكم الحرجة للتحكم فى الاخطار التى تم التعرف عليها وقد وضعت علامات لتلك النقط على أرضية المصنع.
- تحديد حدود حرجة لكل نقطة تحكم حرجة
- إنشاء نظام متابعة ملائم للتحكم فى كل نقطة تحكم حرجة كل على حدة
- تم إنشاء الإجراءات التصحيحية التى يتم إتخاذها عندما تشير المتابعة بوجود أى إنحراف أو قصور بالتحكم
- تم عمل الإجراءات للتحقق والتأكد من كفاءة وفاعلية نظام الهاسب وفى النهاية تم توثيق جميع الإجراءات والسجلات
- وأخيرا تم تنفيذ التكامل بين نظام الهاسب والايزو ٩٠٠٠ تحت نظام إداري واحد .