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Implementation of ricotta cheese production process in Tunisia

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Abstract

Despite the acknowledged contribution of Small and Medium Enterprises (SMEs) to the food industry, there is increasing evidence that Hazard Analysis Critical Control Point (HACCP) implementation is limited in this sector, with the burden of implementation perceived as potentially insurmountable. The purpose of this study was to modify the generic HACCP model for Tunisian ricotta cheese production based on actual conditions in this cheese plant. A specific model was developed to ameliorate the safety and quality of ricotta cheese products in this plant. Food safety measures were used at each step in the supply chain, but most of these measures were prerequisite programs rather than critical control points from a HACCP system.

Introduction

Cheese is the generic name for a group of fermented milk-based food products, produced in a great range of flavours and forms throughout the world. While many dairy products, if properly manufactured and stored, are biologically, biochemically and chemically very stable, cheeses are, in contrast, biologically and biochemically dynamic and consequently, inherently unstable (Fox, 1993). For more than twenty years, food safety professionals have promoted the HACCP system of food safety so vigorously that they have, in fact, oversold the utility of the HACCP concept (Sperber, 2005). (HACCP) Hazard Analysis of Critical Control Points is a preventive, structured, systematic and documented approach to ensure food safety (Buchanan, 1990). It is a system aiming at the production of zero defective products which separates the acceptable from the non-acceptable or the essential from the non-essential (Dobson, 1995). Practical experience and a review of food safety literature indicate that success in developing, installing, monitoring and verifying a successful Hazard Analysis Critical Control Point (HACCP) system is dependent on overcoming a complex mix of managerial, organisational and technical hurdles (Taylor, 2001). Ricotta is a high-moisture soft cheese that has traditionally been prepared by heating whey, that is the soluble fraction of milk, rich proteins, minerals and lactose separated from casein during the manufacture of cheese, in open kettles and then acidifying the hot liquid (85–90ºC) with lactic or citric acid to coagulate the whey proteins and/ or casein (Modlera and Emmons, 2001). The aim of this publication was the implementation of the Hazard Analysis Critical Control Point (HACCP) system to Tunisian traditional ricotta cheese products.

Product description

Ricotta cheese is probably the oldest and the best known whey cheese, in which protein is recovered by heat precipitation (Mucchetti *et al*., 2002). It is produced by using either cheese whey, milk cow, or a mixture of both. If made from whole milk, ricotta cheese is soft, pleasant and creamy with a delicate texture and a slightly caramel flavour (Pizzillo *et al*., 2005). A strong flavour in milk affects flavour in the product when making white or brown whey cheese (Delacroix-Buchet and Lambert, 2000). Whey used in the present study was taken from Tunisian cheese produced of 100% milk. Ricotta is a high-moisture soft cheese that has traditionally been prepared in Tunisia by first heating combinations of whey and milk in open kettles, and then adding (1 to 1,5 kg) of salt to enrich the whey and improve the texture of the final cheese product (Jaenicke, 1991) and finally, acidifying the hot liquid (80–85°C for 25 minutes) with acetic acid, to coagulate or aggregate the whey proteins and/or casein (Maubois and Kosikowski, 1978; Modler, 1988). The rough acidification (pH = 5.9) by the addition of acetic acid (500 ml), entails

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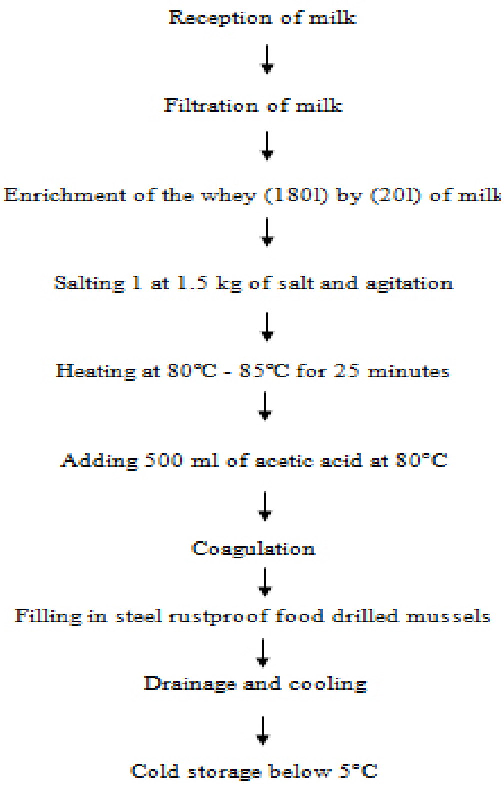

Figure 1. Flow chart of Tunisian ricotta cheese in making process

the floating and separation of casein from the whey in more or less granular parts. Progressively, this acidification, leads to the formation of a smooth, homogeneous coagulum which occupies completely the initial volume of the milk (Brulé and Lénoir, 1987). The coagulated curd mass floats to the surface and is scooped off and placed in steel rustproof drilled mussels at 12°C for 1 h 30 minutes. Ricotta should be kept refrigerated at a temperature below 6°C (EEC, 1992). Traditionally, in Tunisia ricotta is made from whey derived from cheeses and milk and it is consumed fresh, i.e. within a few days from its production. The flow diagram is of great importance because the hazard analysis is carried out according to this diagram. A flow sheet for the Tunisian Ricotta is given in Figure 1.

Hazard analysis and critical control point (HACCP) system

The HACCP concept was originally developed as a microbiological safety system that was applied in the production of foods intended to be used in space in the early days of the USA manned space program. It was developed in the 1960's by the Pillsbury Company working alongside with NASA and the United States Army laboratories at Natick, and was used as a zero defect program aiming at the safety production of foods that would be consumed in zero gravity (Chemat and Hoarau, 2004). End point testing is not a good way to ensure food safety (Sun and Ockerman, 2005), because by the time the results are obtained, the food would be served and consumed and hard to trace or recall. Therefore, during the processing, more procedures must be taken and then monitored with a HACCP system. Food safety programs in the past used to correct the hazard conditions after they happen. The HACCP approach is to control problems before they happen (Swane *et al*., 2003) during processing and/or serving. By following the procedures of safety food production with the HACCP system, foodborne illnesses will be reduced and safer foods will be served (Sun and Ockerman, 2005). Hazard Analysis Critical Control Point (HACCP) is a hazard preventive concept and a method that has been used to control food processing procedures by identifying the hazards of food production and their critical control points and reducing the risks. Walker and Jones (2002) stated that the use of HACCP is an approach for the prevention and control of foodborne diseases by identifying hazards and risks at every stage of the food production and determine where controls are needed. (Sun and Ockerman, 2005). To understand the importance of HACCP system, it is necessary to understand its specific terminology. The common terms are defined below (Chemat and Hoarau, 2004); Hazard: Any biological, chemical or physical factor which can lead to an unacceptable risk for consumer safety or product quality. CCP: Any place, person, operation or protocol where inadequate control would result in food danger apparition. Preventive action: All the techniques, methods and actions which would result in eliminating the danger or reducing it to an acceptable level. Corrective action: A procedure to follow when the monitoring indicates that a CCP is not monitored. Critical limit: A criterion or parameter which must be respected to ensure that the monitoring is effective. Deviation: Non-respect of a critical limit. Verification: Methods, procedures and controls used to determine if the HACCP system is effective and reaches the fixed objectives.

In order to check whether the seven HACCP Principles have been properly used, the assessor would have to consider whether the hazard analysis has been competently undertaken and appropriate control measures identified (Mortimore, 2000).

Principle 1: List the steps in the process where significant hazards occur and describe preventive measures (Mortimore and Wallace, 1994). All possible hazards (physical, chemical, microbiological) are identified in a process flow diagram. Their importance is estimated for every single process, storage, marketing and products supply stage (Mortimore and

Table 1. Hazard Analysis Chart

Ingredient/Process Step	Potential Hazard introduced, controlled or enhanced at this step	Is the potential food safety hazard significant?	Justification for decision	What control measures can be applied to prevent the significant hazards?	Is this step a critical control point (CCP)?
Reception of milk	**Physical:** None is identified at this time.				
	Chemical: Antibiotic residues Pesticides Aflatoxines	No	Milk containing antibiotics and other undesirable substances should be rejected	Result of chemical analysis	No
	Biological: Microbiological contamination	No	- Long exposure of milk to relatively high temperature and temperature variation during transportation could result in pathogen growth. - Proper personal hygiene and handling. - Sanitize equipment.	- Awareness of the producer - Proper cold storage (below 5ºC during production and transport) and cooking temperatures will reduce the potential growth of pathogens.	Yes
Filtration of milk	**Physical:** Foreign body	Yes	-Milk is filtered in order to ensure the removal of any extraneous material which represents a physical hazard	- Control of filter integrity - Elimination of foreign bodies - Maintenance of filters	No
	Chemical: None is identified at this time.				
	Biological: Microbiological contamination	No	-Improper filter cleaning results in microbiological contamination	- Control of filter cleaning procedures. - Control of hygiene practices during filtration.	No
Heating at 80ºC - 85ºC for 25 minutes	**Physical:** None is identified at this time.	No			
	Chemical: None is identified at this time.	No			
	Biological: Survival of pathogens such as *Salmonella*, *Listeria monocytogenes*, *Staphylococcus aureus* and pathogenic *E. coli*.	Yes	-Proper time/temperature (80°C- for 25 min) relationship during cooking will destroy the pathogenic microorganisms present in the whey and milk. Heating will destroy parasites.	- Check the thermometer and the time. - Proper heating setting (80- for no less than 20 min) - Check if the equipment is properly running. - Proper personnel hygiene and handling.	Yes
Adding 500 ml of acetic acid at 80ºC	**Physical:** None is identified at this time.				
	Chemical: None is identified at this time.				
	Biological: Microbiological contamination	Yes	-Improper addition of acetic acid will cause microbiological contamination.	- Acetic acid should be obtained from certified suppliers and stored at room temperature. - Doses should be respected (between 400 at 500 ml).	No
Enrichment of the whey (180l) by (20l) of milk	**Physical:** None is identified at this time.				
	Chemical: None is identified at this time.				
	Biological: Microbiological recontamination	Yes	-Improper whey or milk, equipment and personnel recontamination of the raw material.	-Proper whey drainage setting - Proper milk used. - Proper personnel hygiene and handling. - Check if equipment is properly running.	No
Salting and agitation	**Physical:** Foreign body	Yes	-Salt quality o which may contain metals.	- It is better to purchase food salt from a supplier. - Elimination of foreign body.	No
	Chemical: None is identified at this time.				
	Biological: Pathogens	Yes	-Hazards may include potential growth of undesirable microorganisms either environmental or personnel Inhibit the growth and activity of pathogens and food poisoning microorganisms.	- The quantity of added salt (0,5-1%) should be respected. - Qualified product supply should be stored at room temperature - Proper personnel hygiene and handling. - The program of cleaning and disinfection of equipments should be respected.	No
Coagulation	**Physical:** None is identified at this time.				
	Chemical: None is identified at this time.				
	Biological: Microbiological contamination	No	-Coagulation temperature at 80- will reduce potential pathogen survival.		
Filling in rustproof steel drilled mussels	**Physical:** None is identified at this time.				
	Chemical: None is identified at this time.				
	Biological: Microbiological contamination	No	-Proper personal hygiene and handling Sanitize the perforated trays and all equipments.		
Drainage and cooling	**Physical:** None is identified at this time.				
	Chemical: None is identified at this time.				
	Biological: Potential pathogen growth.	Yes	-Improper cooling temperature and long exposure of ricotta to relatively high temperature could result in pathogen growth. Temperature is set at from 1h to 1h30 min.	-Proper cold drainage and cooling (below) and the exposure of ricotta to a time below 1h30 min reduce the potential growth of pathogens. - Proper personnel hygiene and handling	**Yes**
Cold storage below	**Physical:** None is identified at this time.				
	Chemical: None is identified at this time.				
	Biological: Potential pathogen growth.	Yes	-Storage temperature must be maintained at or less in order to ensure the microbiological safety of this product	-Weekly calibration of temperature recording device - Temperature must be maintained below - Good hygienic condition (cleaning + disinfection) -The product should not be left more than 7 days before its consumption. - Respect of the program of cleaning and disinfection of the equipments.	Yes

Wallace, 1994).

Principle 2: Identify the critical control points (CCPs) in food preparation. The points where control is critical for controlling the safety of the product (critical control points) are established by the HACCP team (Efstratiadis and Arvanitoyannis, 2000).

Principle 3: Determine the critical limits for preventive measures associated with each CCP.

Principle 4: Establishment of procedures for monitoring CCPs. Monitoring and supervising requirement (frequency, responsibility) for keeping CCPs within their critical limits are specified by

Table 2. HACCP Control Chart

Process step	Hazard	Preventive measure	Critical limits	Monitoring procedure	Monitoring frequency	Corrective action
Receiving raw milk	High microbial load	Milk should be received at < and pH > 6.10	Milk should be received at < and pH > 6.10	-Temperature and pH measurements -Index cards of follow-up of the temperature	At every receiving time	Received milk should be rejected if contamination is evident
Heating at 80ºC-85ºC for 25 minutes	Survival of pathogens such as *Salmonella, Listeria monocytogenes, Staphylococcus aureus* and pathogenic *E.coli*.	Time and temperature control 80- for 25 min	Heating at 80- for 20 minutes	- Time and temperature measurements -The application of the rules of good manufacture practices - Calibration of thermometer	At every heat treatment	Time and temperature should be corrected.
Drainage and cooling	Potential pathogen growth	Temperature is set at for 1h at 1 h 30 min.	Temperature is set below for 1h30 min.	- Time and temperature measurements - Weekly calibration of temperature recording device.	At every cooling	-Temperature and time should be adjusted by well setting the equipment. - The product should be rejected if contamination is evident.
Cold storage below	Potential pathogen growth	Temperature must be maintained at or less for five days	storage at temperature < and less for 7 days	- Temperature measurement - Weekly calibration of temperature recording device.	At every storage	- The cause of deviation should be identified and eliminated - The CCP should be brought under control after corrective action is taken. - Measures to prevent recurrence are established. - No product that is injurious to health is introduced into commerce.

the HACCP team (Efstratiadis and Arvanitoyannis, 2000).

Principle 5: Establish corrective actions to be taken when monitoring indicates a deviation from an established critical limit (Chemat and Hoarau, 2004).

Principle 6: Establishment of thorough record-keeping and control procedures for the documentation of HACCP. Records must be kept to demonstrate that HACCP functions properly and is continuously under control so that the appropriate corrective action can be undertaken whenever deviations from the critical limits are observed (Mortimore and Wallace, 1994).

Principle 7: Establish procedures for the verification that the HACCP system is working correctly (Mortimore and Wallace, 1994).

Hazard analysis

Hazard identification is helpful to identify potential microbiological, chemical and physical hazards that may occur during each step of the processing. Microbiological hazards are pathogens or harmful bacteria introduced during production such as *Salmonella*, *Listeria monocytogenes*, *Staphylococcus aureus*, pathogenic *E. coli* and chemical contaminants added during food processing. A physical contamination is a foreign material that could come from incorrect personal handling or bad environmental conditions. The description of all the unitary operations of a process must be relevant and verified practically by auditing the plant (Figure 1). For each part of this process, evaluation and classification of hazards are done. In this way, a grade is given to each hazard that has been identified according to its severity, its risk of occurrence and its ability to be detected. The results of the analysis for the safety hazards and CCPs in the processing of Tunisian ricotta cheese are shown in Table 1.

Critical control points determination

Based on the process decision tree, there are four identified CCPs. See detail in Table 2. All those tree CCPs are determined according to the following requirements in this plant. The temperature of received raw milk is very critical because its long exposure to relatively high temperature and temperature variation during transportation could result in pathogen growth. The heating Time and temperature is the most critical control point in the ricotta cheese making. Most of the pathogens are eliminated or reduced to the safety level. The temperature and time of drainage and cooling are critical to control pathogen growth. Continuous temperature control (below 15°C) in parallel with time (below 1 h 30 min) is essential to limit the growth of any survived pathogens. Storage temperature must be maintained at 5°C or less in order to ensure the microbiological safety of this product.

HACCP control chart

The control is necessary in case the relative hazard is associated with CCP. The HACCP control chart of Tunisian ricotta is shown in Table 2, where parameters such as significant hazards and critical limits of CCP, monitoring contents, corrective actions, records, and verification were studied. Monitoring is the measurement or observation at a CCP level to check if the Tunisian ricotta process is operating within the critical limits. Corrective actions are considered when the monitoring results show that there is a need to prevent deviation from a CCP. Records offered evidences that the processing was under control. Verification is one of the most important parts of the HACCP system, ensuring that the Tunisian ricotta is manufactured safely from day to day.

Conclusion

The implementation of systems aiming at safety (HACCP) in the food industry and, in particular, in the dairy factories has shown a remarkable improvement in terms of product safety and quality. Identification of CCPs in the cheese production lines has resulted in satisfactory Hazard control and restriction and thus leading to less defective products than in the past. The method proposed here is ‘‘a posteriori’’analysis, in that it establishes the relevant hazards and the CCP only after conducting a rational and careful analysis of the production process, that leads to an understanding of the propensity of a given step to generate each particular hazard. The selection, training and education of assessors themselves and verification of their competency are critical success factors in achieving uniform safe food control. However, quality audit of HACCP system revealed that the non conformity of the product is the result of some causes. Therefore, HACCP approach (Food Safety Recommendations, Codex Alimentarius, 1993) is a deficiency system where the mainly fault, in my opinion, is the consistency of controlling the safety food hazards. The safety food management system goes beyond the food safety recommendations (Blanc, 2006) and because its benefits and requirements that did not appear in the 12 hazards Analysis and Critical Control points (HACCP system) application steps described in the Codex Alimentarius, the implementation challenge of SFMS (ISO 22000) becomes really necessary to Tunisian traditional ricotta cheese products.

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References

Brulé, G. and Lénoir, J. 1987. La coagulation du lait. In : Le fromage, A. Eck (Eds.). p. 1-21. Paris: Lavoisier.

Buchanan, R. I. 1990. HACCP: a re-emerging approach to food safety. Trends in Food Science and Technology 1: 104-106.

Chemat, F. And Hoarau, N. 2004. Hazard analysis and critical control point (HACCP) for an ultrasound food processing operation. Ultrasonics Sonochemistry 11: 257-260.

Codex Alimentarius Commission 1993. Codex Committee on Food Hygiene: Guidelines for the Application of the HACCP System, (Alinorm 93/13A, Appendix B), Food and Agriculture Organization/Word health/ Organization, (1993). Rome, Italy.

Delacroix-Buchet, A., Lambert, G. 2000. Sensorial properties and typicity of goat dairy products. Proceeding of 7th Conference International sur les Caprins, 559–563. Tours, France.

Directive EEC 92/46. 1992. Hygienic rules for the production and marketing of raw milk, heat treated milk and products based on milk. L268 (14/9/92).

Dobson, J. 1995. Quality systems. For European masters degree in food studies.

Efstratiadis. M. M. and Arvanitoyannis. I. S. 2000 Implementation of HACCP to large scale production line of Greek ouza and brandy: A case study. Food Control 11: 19-30.

Fox, P. F. 1993. Cheese: An overview. In P. F. Fox, (Eds.), Cheese: Chemistry, Physics and Microbiology, p. 1–36. London: Chapman and Hall.

Jaenicke, R. 1991. Protein satbility and molecular adaptation to extreme conditions. Eur. Journal of Biochemistry 202: 715-728.

Maubois, J. L. and Kosikowski, F. V. 1978. Making ricotta cheese by ultrafiltration. Journal of Dairy Science 61: 881-884.

Mc Swane, D. Z., Rue, N., Linton, R. and Williams, A. G. 2002. Essentials of food safety and sanitation. (3rd ed.) Upper Saddle River, NJ: Pearson Education.

Modlera, H. W. 1988. Development of a continuous process for the production of ricotta cheese. Journal of Dairy Science 71: 2003-2009.

Modlera, H. W. and Emmons, D. B. 2001. The use of continuous ricotta processing to reduce ingredient cost in further processed of cheese products. International Dairy Journal 11: 517-523.

Mortimore, S. 2000. An example of some procedures used to assess HACCP systems within the food manufacturing industry. Food Control 11: 403-413.

Mortimore, S. and Wallace, C. 1994. HACCP: A practical approach. In Efstratiadis. M. M., Arvanitoyannis. I. S., 2000. London: Chapman and Hall.

Mucchetti, G., Carminati, D. and Pirisi, A. 2002. Ricotta fresca vaccina ed ovina: osservazioni sulle tecniche di produzione e sul prodotto. Il Latte 27: 154-166.

Pizzillo, M., Claps, S., Cifuni, G.F., Fedele, V. and Rubino, R. 2005. Effect of goat breed on the sensory, chemical and nutritional characteristics of ricotta cheese. Livestock Production Science 94: 33-40.

Sperber, W. H. 2005. HACCP does not work from Farm to Table. Food control 16: 511-514.

Sun, Y. M. and Ockerman, H. W. 2005. A review of the needs and current applications of hazard analysis and critical control point (HACCP) system in food service areas. Food Control 16: 325-332.

Taylor, E. A. 2000. HACCP and SME's: problems and opportunities,

chapter 8., p. 13-30. In T. Mayes and S. Mortimore (Eds). Making the most of HACCP. Woodhead Publishing Ltd., Cambridge.

Walker, E. and Jones, N. 2002. An assessment of the value of documenting food safety in small and less developed catering businesses. Food Control 13: 307-314.

Internet: Didier Blanc 2006. ISO Management System, Downloaded from *http// WWW. ISO. Org/ims.*May-june 20.