Control and Ensuring Safety in Fresh Cheese Production

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Abstract. In the context of a rapidly evolving global environment, ensuring food safety and quality has become a paramount concern for producers. The Hazard Analysis and Critical Control Points (HACCP) system provides a systematic approach for identifying and managing risks throughout the food production chain. It is founded on internationally recognized principles for the regulation of critical control points. This study aims to identify potential hazards and delineate the critical control points (CCPs) within a specifically developed technological flowchart for the production of fresh cheese from camel milk, cow milk, and a 1:1 mixture of both. This underscores the significance of detailed monitoring and effective control measures to mitigate associated risks. The findings will serve as a practical foundation for developing targeted risk management strategies for the production of innovative dairy products, including those made from unconventional raw materials such as camel milk.

1 Introduction

The global food industry operates in an environment characterized by increasing regulatory requirements and heightened public expectations regarding food safety [1]. Consumers demand that food products placed on the market are safe for consumption, making risk management a key priority for both producers and regulatory authorities [2]. The implementation of food safety management systems [3] aims to ensure the systematic identification, evaluation and control of hazards throughout the entire food production chain in order to guarantee compliance with legal requirements and the production of safe food. Traceability and documentation at each stage of the process represent essential tools for verifying the effectiveness of applied control measures.

Scientific research confirms the necessity of systematic hazard analysis and the application of the HACCP system as a fundamental instrument for managing biological, chemical and physical risks in food production [4–8]. At the European level, food safety is regulated by Regulation (EC) No 178/2002, Regulation (EC) No 852/2004, Regulation (EC) No 853/2004, Regulation (EC) No 2073/2005 and Regulation (EU) No 1169/2011, which require that all foods placed on the market are safe and traceable at all stages of production and distribution [9–13]. National legislation, including Ordinance No 5/2023 and the Law on the Management of the Agricultural Food Chain, complements the European framework by introducing additional requirements for coordination, official control and transparency within the food supply chain [14–16].

Milk and dairy products are classified as high-risk foods due to their favourable nutrient environment for microbial growth and their susceptibility to rapid microbiological deterioration under inappropriate processing and storage conditions [17]. Factors related to the origin of the raw material, farming conditions and technological processing influence not only product quality but also the microbiological safety of the final dairy products [6,18]. Fresh cheese is a perishable product with a short shelf life and increased vulnerability to biological hazards, which requires strict control of raw materials, hygienic practices and temperature regimes during production and storage [18,19].

Scientific studies indicate that camel milk is characterized by specific technological and microbiological features that complicate the application of conventional processing practices and require additional attention during risk assessment [12,13,20,21,22]. The lack of harmonized regulatory standards for this type of raw material within the European Union, combined with limited practical experience, necessitates the development of adapted food safety management approaches for its processing into dairy products.

The present study aims to develop and apply a HACCP-based risk assessment and management model for the production of fresh cheese from cow milk, camel milk and their 1:1 mixture, focusing on the identification of process-specific hazards, the determination of critical control points and the establishment of appropriate monitoring and corrective actions in accordance with European food safety principles.

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2 Main Raw Materials

This study uses two raw materials: dry whole camel milk from a dromedary camel (*Camelus dromedarius*), imported from a non-EU country, and fresh cow's milk from a local producer. Cow's milk serves as a control sample, as it's technological and quality characteristics are well documented within national and European regulations. It undergoes initial quality control in accordance with regulatory standards [10,11,14], which includes organoleptic evaluation, titratable acidity, fat content, proteins and lactose content, freezing point, total microbial count, somatic cell count, and screening for antibiotic residues. These parameters are used as reference benchmarks, since current regulations specify the physicochemical composition, microbiological criteria, and storage conditions [23,24].

Camel milk powder is supplied with an accompanying quality certificate issued by the manufacturer, confirming compliance with microbiological and chemical parameters (No. 6291056043101/UAE). Dry camel milk by certification involves adhering to specific standards and guidelines set by regulatory bodies such as the Codex Alimentarius, Middle East and North Africa (MENA), and the FDA. These standards ensure the safety, quality, and authenticity of dry milk products. Due to the absence of specific EU product standards for camel milk powder, the evaluation of this raw material within the scope of the present study is based on the supplier's documentation.

Reconstitution of camel milk powder is performed by dissolving the required amount of dry matter in warm potable water (40–45 °C) under continuous stirring until complete dissolution is achieved. The reconstituted milk is allowed to hydrate for approximately 20–30 min prior to further technological processing (preparation method was described by Boukova *et al.,* 2024 [25]).

Samples of fresh cheese are produced using adapted cheese-making technology at the study and production facilities of the Department of Milk and Dairy Products Technology, UFT-Plovdiv. For the experimental work, three batches are prepared: **Ck** – fresh cheese from cow milk (control sample); **Cc** – fresh cheese from reconstituted camel milk; and **Cm** – fresh cheese from a mixture of the two raw materials in a 1:1 ratio.

The entire production process of fresh cheese samples was evaluated (Fig.1). Furthermore the potential biological, chemical, and physical hazards that may exist in the fresh cheese production process were identified and CCPs were selected. The decision tree method, a visual and easy-to-understand analysis, was applied to determine the CCPs. Critical limits, as well as a monitoring system, corrective actions, verifications, and documentation and records were then established according to government regulations and industry standards.

3 Result and Discussion

A complete description of the product and its intended use is shown in Table 1, in terms of type and composition which includes microbiological, chemical, processing, presentation, packaging, storage and distribution conditions as well as the required shelf-life under the prescribed conditions.

Table 1. Product description of fresh cheese and the intended use of the product

Parameters	Cheese samples		
	Ck	**Cc**	**Cm**
Products name(s)	Fresh cheese		
Type of raw material	Cow milk	Reconstituted whole camel milk	Mix milk
Composition	Starter cultural, rennet, and NaCl		
Process	Pasteurization		
Food Safety Characteristics	Support growth of a number of pathogens. No natural protective characteristics. According Regulation (EC) No 2073/2005 and Regulation (EC) No 1441/2007		
Target Market	Consumers of all ages group		
Intended Use	Ready to serve product. Also be used as an ingredient in cooking		
Packaging (Product and Non-product Contact)	Vacuum sealed. Labels are self-adhesive and applied after packaging. Production date is labelled on cheeses via label gun during labelling.		
Storage and Distribution	Product is stored in carton in temperature controlled coolers/rooms. Temperature of storage is 3±1°C. Distributed using refrigerated trucks (3±1°C) to wholesale and retail outlets.		
Shelf –Life	Up to 30 days at temperature 3±1°C		

A detailed flow diagram of the specified areas of the operation, and technical data were gave an accurate representation of the operations. Figure 1 is a representation of the flow diagram for the manufacture of fresh cheese (the numbers indicate each stage in the manufacturing process).

Hazard analysis was conducted at each technological steps starting from the qualification and receipt of the raw materials to the expedition of the final product. All biological, chemical, and physical agents with the potential to cause adverse health effect were identified and evaluated. The significance of each hazard factor were be determined by the severity of the risk (data not published yet).

Based on our hazard analysis fresh cheese manufacture contains three CCPs, which are associated with microbiological hazards arising from raw material quality, pasteurization conditions and storage conditions of the final product.

The decision tree is applied during hazard analysis in order to support the identification of appropriate critical control points within the processing chain. The determination of CCPs is performed according to Codex Alimentarius methodology, taking into account hazard probability, severity of potential health impact and the

availability of subsequent technological control measures [26, 27].

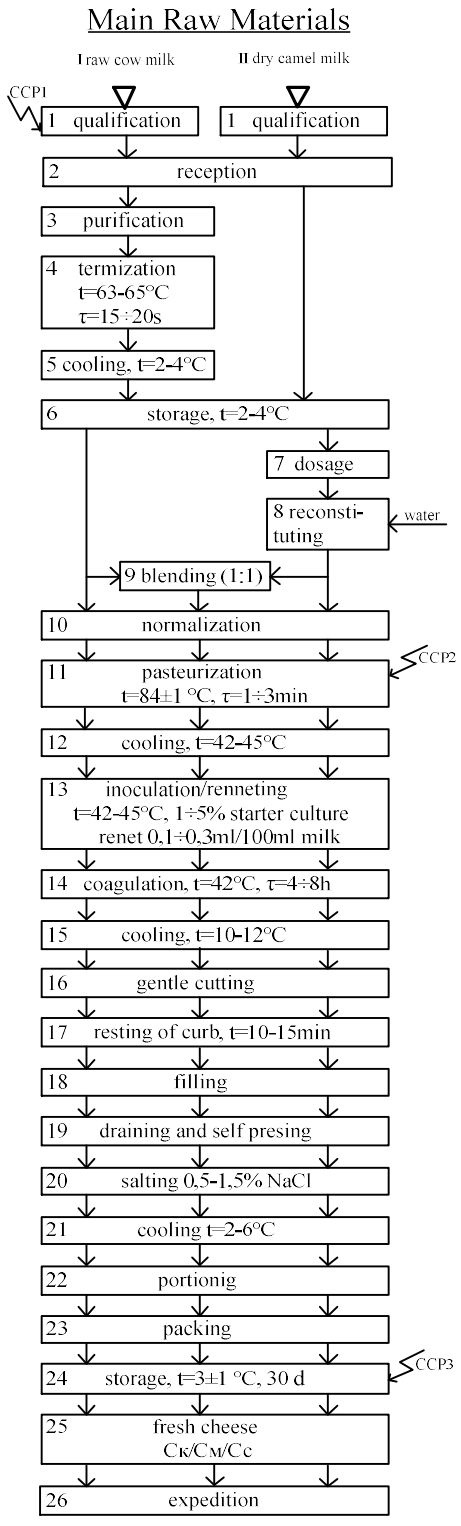

Fig 1. Flow diagram for fresh cheese production

Based on the technological process flow diagram (Fig. 1), the analysis identifies three main critical control points in fresh cheese production: qualification of raw milk samples (CCP1), pasteurization (CCP2) and storage of the final product (CCP3). The acceptance of camel milk powder is classified as a control point (CP), as the associated risk is managed through supplier documentation and certification [28,29]. Those certification ensure the safety, quality, and authenticity of dry milk product. The experimental work was conducted under controlled laboratory conditions in accordance with basic hygienic and technological practices corresponding to prerequisite programs (PRPs), including sanitation of equipment, hygienic handling of raw materials, and prevention of cross-contamination. These conditions ensured a controlled environment for the development and evaluation of the HACCP plan [26-31]. Once the CCPs were determined, it is necessary to define the control criteria upon which the preventive measures will be executed. These criteria are also known as Critical Limits (CL) and Operational limits (OL), which will mark the difference between 'acceptable' and 'unacceptable' in terms of food safety. The critical limits, monitoring, corrective actions, verification, data transcript for the each CCPs of the process shown in Table 2 were identified and validated to assess the acceptability of the product.

CCP1 – The acceptance of raw milk samples is defined as a critical control point due to the potential presence of chemical hazards, particularly antibiotic residues, which cannot be eliminated by subsequent technological processing. Incoming milk is subjected to screening tests for inhibitory substances, combined with organoleptic evaluation and verification of supplier documentation. Monitoring is based on routine testing and documentation review. In the case of non-compliance, the affected batch is rejected and excluded from production. Verification includes periodic evaluation of monitoring results and supplier performance.

CCP2 – Pasteurization is defined as the main biological control step in fresh cheese production. In the present study, pasteurization is carried out at 83-85 °C for 1–3 min, ensuring inactivation of vegetative pathogenic microorganisms and compliance with microbiological safety criteria. Monitoring includes continuous control of time and temperature, with data recorded in production logs. Deviations from critical limits result in reprocessing or exclusion of the affected batch. Verification is performed through review of temperature records and microbiological testing of pasteurized milk and final products. The operational limits established for this CCP are a pasteurization temperature of 83.2–84.8 °C and a holding time of 1.5–2.5 min, ensuring effective inactivation of vegetative pathogenic microorganisms and compliance with microbiological safety requirements.

CCP3 –Storage of the finished product is defined as a critical control point, with temperature being the main controlled parameter. Monitoring is performed through continuous supervision of storage conditions, including regular measurement of refrigeration temperature and documentation of results in designated CCP3 monitoring records. Warehouse personnel are responsible for performing these inspections. The operational limits defined for this CCP include a storage temperature of 2.5–3.5 °C and a maximum shelf life of 30 days, ensuring safety of the final product during storage.

Table 2. Summary of CCPs in the HACCP control chart

Process steps №		**1. Qualification – raw cow milk, reconstituted camel milk, and mix milk**
CCP №		**CCP 1**
Hazard description		Chemical: Antibiotics
Limit values **Critical limits** **Operational limits**		Antibiotic residues - Absent
Monitoring	**What?**	Antibiotic residues, organoleptic parameters, documentation verification
	How?	Incoming control by checklist, receipt, and delivery protocol, and visual inspection
	When?	With each delivered batch
	Who?	Operator/Technologist
Corrective actions		Stop receiving the raw material. Separate the batch. Notify the supplier. Return or destroy the milk.
Verification		External laboratory analyses. Review of incoming control protocols. Supplier audits.
Data transcript		Incoming control protocols, laboratory results
Process steps №		**11. Pasteurization**
CCP №		**CCP 2**
Hazard description		Biological: Pathogenic microorganisms
Limit values **Critical limits** **Operational limits**		T = 83 – 85 °C and hold time 1–3 minutes T = 83–85 °C and hold time 1–3 minutes T = 83.2–84.8 °C and hold time 1.5–2.5 minutes
Monitoring	**What?**	Temperature/Time
	How?	Automatically thermograph recording
	When?	Constantly (automatically)
	Who?	Operator/Technologist
Corrective actions		Immediately correct parameters; re-pasteurize if possible; isolate/reject the affected batch; notify manager.
Verification		Calibration of measuring devices. Microbiological analysis of finished cheese. Internal process audits
Data transcript		Pasteurizer records, calibration protocols, and laboratory protocols
Process steps №		**24. Storage**
CCP №		**CCP 3**
Hazard description		Biological: Pathogenic microorganisms
Limit values **Critical limits** **Operational limits**		T=3±1 °C; Expiry data 30 days T=2–4 °C; Expiry data 30 days T= 2.5–3.5 °C; Expiry data 30 days
Monitoring	**What?**	Temperature
	How?	Digital sensors and visual control
	When?	Constantly (system) + 2 times/day manual check
	Who?	Stock manager
Corrective actions		Batch isolation. Cooling system adjustment/repair. Quality assessment of the product already in storage. Exclusion of non-compliant batches.
Verification		Review of temperature logs. Equipment inspection. Microbiological testing of batches
Data transcription		Temperature logs and inspection reports

4 Conclusion

This study demonstrates the applicability of HACCP methodology for the production of fresh cheese from cow, camel milk and their mixture. The results confirm that the application of HACCP provides a structured and effective framework for hazard identification and risk control. The defined critical control points as a raw milk qualification, pasteurization and storage of the final product—play a key role in ensuring of safety throughout the production chain and comply with regulatory requirements.

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