Investigations on milk quality management by risk assessment within the HACCP system

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Abstract. Through their composition, milk and dairy products are one of the most important resources of bioactive compounds for both humans and animals. The industrialization of milk has brought benefits in terms of speed and volume of raw material processing, but also the need for an efficient management to keep under control various microbiological, chemical, or physical risks. The HACCP system, an innovative system in the early 2000s, provides traceability, necessary for full control of risks in the manufacture of dairy products. The research related to this study aimed to debate some aspects of HACCP system implementing in a dairy plant located in the area of Moldavia, Romania. The identification of the risks that would affect the quality of the milk starting with the farmers, and later at its reception in the dairy plant and on the entire technological flow, allowed a better quality management in order to obtain superior quality products.
Key Words: critical control points, chemical risk, raw material processing, microbiological risk.

Introduction. Milk and dairy products are an important group of food sources of bioactive proteins and essential amino acids whose quality is constantly monitored by specialized laboratories in the official system or in the private network of dairy plants in terms of product compliance with the standard provisions by its chemical composition, nutritional value or physical, microbial, or chemical contaminations (Grădinaru 2017; Möller et al 2008). The presence of contaminants arouses a special interest in the milk industry, some standards on its quality being reconfigured from the perspective of Romania's accession to the European Union in 2007. In this way, standards on the nutritional quality of milk were joined by those on toxicological quality, milk being therefore considered a potential vehicle of many chemical contaminants that, even in the form of residues, can affect the health of the consumer (Grădinaru et al 2015a,b; Peristeropoulou et al 2015).

In milk industry, the technical quality control has been naturally helped by legislative bases for the management of quality control (Council 1993; Ministry of Health 1996), among the most well-known such systems deserving to be mentioned HACCP – Hazard Analysis and Critical Control Points. Such a logical, coherent, and unitary approach, with the identification step by step of the potential risks that may appear on the technological flow of manufacturing offered the possibility of a better management and control in the dairy industry, with lower financial losses than in the situation of finding some non-compliant finishes (Gardner 1997; Jan et al 2016).

The aim of the paper is to present some aspects related to the implementation of the HACCP system principles in a dairy plant, mainly based on the assessment of chemical risks, but also of microbiological and physical ones.

Material and Method. The present study was carried out in a medium-sized dairy plant located in Moldavia, Romania, and aimed to analyze the technological flow of milk processing, identifying critical control points of risks and corrective measures that can be

taken in this regard, in agreement with the HACCP management system. It should be mentioned that the dairy plant in question decided to implement the food safety system based on risk analysis in critical control points since 2006, thus respecting the obligation to implement the HACCP system in the field of food production, distribution, storage, and delivery until the end of 2006, by Government Decision no. 924 of August 11, 2005.

Results and Discussion. Milk, like any other food, can be both a source of active compounds necessary for the body growth and development, but also a vector for various contaminants of microbial, physical, or chemical origin. Its industrial control has long exceeded the limits of occasional testing and only for basic physico-chemical parameters, new plans and strategies being found in the specific HACCP quality assurance system that naturally complemented the ISO 9000 standards in the field. At the organizational level, the implementation of the HACCP system involves the active participation of decision makers in the management system who, after making the decision to introduce such a system, formed and trained the work team for the development, validation, implementation, and audit of the HACCP plan. In the case of milk, as in the case of any raw material introduced in a technological flow, a special importance in the operation of the HACCP system is the construction of the technological flow diagram, a HACCP plan being necessary for each assortment or finished product. In this paper, for a more comprehensive presentation, the formulation of a block scheme for obtaining the main dairy assortments was chosen (Figure 1), based on which the identification and evaluation of possible risks, critical control points, monitoring procedures and corrective actions that have been taken will be further discussed.

Regardless the stage of milk processing, for any type of risk we tried to identify some causes that were the basis of its occurrence and what can be done to limit the effect of that potential risk. An important aspect of any HACCP plan is the recording of all data in specific documentation prepared by approved persons, responsible for each sector of activity, and which will be the basis for future verifications in the form of internal audit reports.

When **the stage of receiving raw milk** is considered, the main categories of risks identified were those of a chemical, microbial, and physical nature.

The potential chemical risks (antibiotics, hormones, pesticides, detergents, toxic metals, counterfeits, aflatoxins, nitrates etc.) have been classified as CCP2 risks (Critical Control Points 2), in the sense that any form of control applied reduces the risk but does not eliminate it completely, but remaining up to an acceptable level. Their presence in raw milk may be related to: (i) antibiotics, growth hormones, or various other drugs used in various treatments of animals; (ii) polluted water and air with various chemicals; (iii) contaminated feeds with fertilizers and pesticides; (iv) detergents, disinfectants, or various chemicals used in cleaning installations, milking, milk storage, transport equipment, floors, walls, ceilings of the shelter and of the dairy, and which remain as washing residues in the absence of an efficient rinse. Such risks can be effectively controlled if firstly at the level of farms are used records of various chemicals using in agriculture or in cleaning/disinfection activities, as well as a rational use of veterinary drugs in therapeutics, respecting the withdrawal times for their residues. The organoleptic examination of the feed for animals is particularly important, the moldy or any other non-conforming parts of their quality enforcing their elimination from the diet. The problem of antibiotic residues is particularly important for the dairy industry and consumer health, by affecting the development of microorganisms` cultures needed in the manufacture of fermented dairy products and the risks of allergies, antibiotic resistance, intestinal flora imbalances, and toxicity induced by antibiotic residues in milk in human or animal consumers. Their control is mandatory to be performed by rapid tests at the reception of milk, screening tests which can be doubled in authorized laboratories, with the release of official analysis bulletins that can serve as proofs.

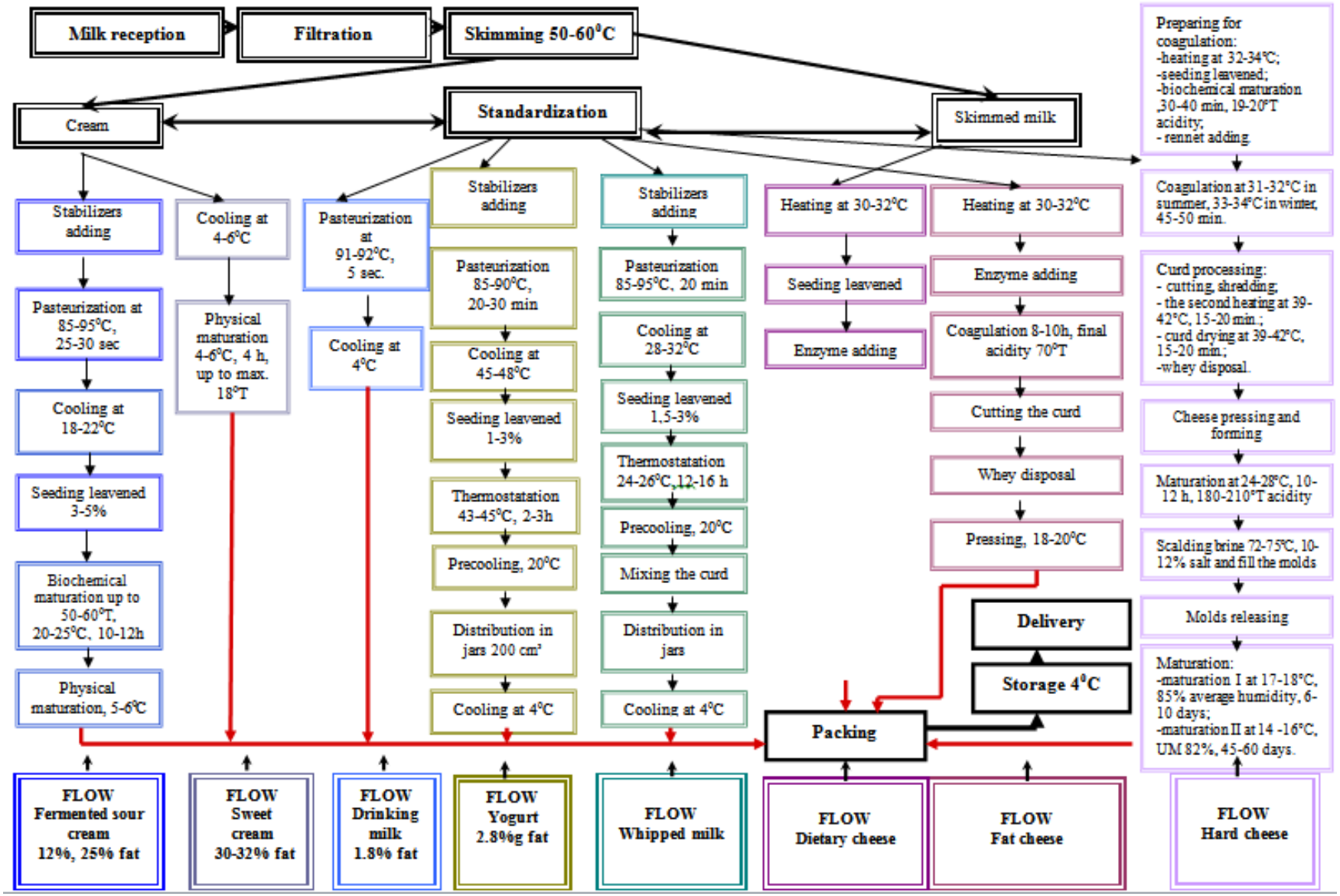

Figure 1. The block scheme of dairy products obtaining.

It is particularly important for the dairy products manufacturer to identify farmers' suppliers of contaminated or non-compliant milk quality standards and to remove them from the supplier network until they can demonstrate the quality of the supplied milk. It is often even recommended to request warranty certificates from them, because the losses in the dairy industry by introducing non-compliant milk into processing can be huge and someone has to bear the consequences.

Raw material milk can be also microbiologically contaminated, not just chemically. Various contaminating microorganisms of raw milk are already known, the most well-known being *Mycobacterium tuberculosis, Bacillus antracis, Bacillus cereus*, *Salmonella* spp., *Staphylococcus aureus*, *Campylobacter jejuni*, *Shigella* spp., *Listeria monocytogenes*, *E. coli* etc. The control exercised over them at this stage of the technological flow is considered a simple CP (Control Point) through actions related to the rapid determination of somatic cells number, the total number of germs, the temperature and pH of the received raw milk. An essential component in the control of these microbiological risks is their supervision in the milk production chain, taking into account that the main sources of contamination are either sick or carrier animals, or even the people involved. Therefore, it becomes important to educate farm workers on basic rules of personal and milking hygiene; also, milk from sick animals must be separately milked and not delivered for processing. Of such importance is the storage of fresh milk in isothermal tanks, at refrigeration temperature, as well as its transport to dairy plants, thus limiting the exponential multiplication of milk microorganisms.

Raw milk can be also contaminated with hair, straw, insects, shards of glass, pebbles etc., all of them being included in physical risks. Undoubtedly, they may be perceived as intentional fraud, but rather as a result of inadequate hygiene of the animal or shelter, or of milking personnel or equipment. The control exercised over these risks is a CP, the organoleptic examination of the milk at its reception being particularly important but not sufficient. For this reason, some actions related to the filtration of milk both at the farm level and at its introduction in the milk truck, or from it in the reception tank of dairy plants, efficiently contribute to their removal.

The technological **stage of pasteurization and cooling of milk** is another important point of control of chemical and microbiological risks. Regarding the chemical risks, although some substances, even therapeutical ones such as antibiotics, are inactivated at the pasteurization temperatures of milk, the control at this stage rather refers to the prevention of additional contamination of milk with cleaning and disinfection substances in the pasteurization mechanism, which have not been effectively removed by rinsing. In the case of microbiological risks, the temperature applied to the milk in accordance with the time period undoubtedly ensures the limitation in number of many specific microorganisms.

In **seeding leavened or with curd stage**, a special attention must be paid to the quality of leaven or of curd, as well as to the quality of the milk that serves to activate or of one that must to be activated. The risks are mainly microbiological, contamination with bacteriophages in microbial cultures, or with *Listeria monocytogenes* in the case of curd. The control applied in this step is part of the CP category.

Additional contamination with microorganisms or various impurities may take place in the **stage of calcium or sodium salts using**, where appropriate. This control point, categorized as CCP1, ensures the elimination of the risk by observing the concentrations provided by the brine and even by the simple visual observation of some impurities in the composition of the added salts.

The failure to comply the temperature or the duration of the **thermostatation / maturing / coagulation stage,** or inadequate hygiene in the processing sector, are other risk factors that may cause a microbiological contamination of the milk on its processing technological flow, as well as during **the processing operation of the curd, pressing, scalding and molding**.

Unlike the afore discussed stages, considered as simple CPs, **the packaging stage** is a CCP1 in the evaluation and limitation of microbiological risks, ensuring their complete elimination by the control exercised over the hygiene and cleaning standards of

workers and on packaging section, of the pipes and dispensers or by monitoring the action times of the sterilizing substances on packings.

Long **storage** periods at temperatures that do not respect the range of 2-4°C, on shelves without the possibility of air flow, also subject the finished products to microbiological risks, by exponential multiplication of pathogens. This control point is considered CCP2, by its applying the risk being reduced to an acceptable level.

Such an identification of the critical control points on the milk technological flow, of potential risks, and of preventive and coercive measures, represented one of the most important conditions to be fulfilled by the dairy plant in question for obtaining a compliant milk both on the national and the European market. Obtaining a quality milk is not only a responsibility of the processor, the most important influencing factors being found at the farm level, considering the maintenance conditions and animal health, the health of the working staff, the management of nutrition, reproduction, and veterinary therapy activities. The implementation of the HACCP system has brought numerous benefits in terms of quality management of the finished product, by following the production stages "from farm to fork" potential risks being identified and suppliers kept under control, with the possibility of a quick identification of those who offer raw milk not in accordance with quality standards. Moreover, by knowing the technological flow chart for each assortment and identifying the risks associated with certain work stages, various supervision and control actions could be applied in order to guarantee the obtaining of quality finished products. A more efficient control implies a better recording of the work data, an internal audit team performing their periodic verification.

Conclusions. Milk and dairy products must meet certain quality parameters in order to be suitable for consumption, both on the national and on European market. The HACCP system allows the identification, correction, or elimination of various risk factors, starting with the stage of raw milk obtaining and ending with dairy products. The implementation of the HACCP program in the investigated dairy plant allowed for a better evaluation and selection of raw material suppliers, how to obtain, harvest and store milk on farms but also in collection centers, ending with the control of technological processes and the finished dairy products before their delivery on the market.

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