Animal Health

Review article

Main Contaminants Affecting Cheese Quality and their Control

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ABSTRACT

Background. Cheese is regarded as an important component of the human diet because of its nutritional value and the health benefits associated with its consumption. **Aim**. To evaluate the factors that influence cheese quality through a description of its principal contaminants. **Development:** A descriptive literature review was conducted. The bibliographic search was carried out in the last quarter of 2025 using the Scopus, SciELO, ScienceDirect, and Dialnet databases. A total of 160 articles published between 2010 and 2025 were reviewed. EndNote was used for bibliographic management. Cheese is a nutrient-dense product, rich in proteins, minerals, vitamins, and lipids. It is considered a functional food whose microbiota may include probiotic bacteria that confer health benefits. Cheese quality depends, among other factors, on the quality of the milk used in its manufacture. Cheese may be contaminated by chemical, physical, or biological agents; therefore, hygiene and sanitation measures are required throughout the production chain to protect consumer health. **Conclusions:** Cheese is a significant dietary foodstuff due to its nutritional composition and the health benefits of its consumption. Maintaining product quality is an essential objective for producers. The principal factors affecting the deterioration of quality indicators are the quality of the milk used and the hygienic conditions of production, which must ensure product safety. **Keywords:** food, contamination; milk. (*Source*: *AGROVOC*)

INTRODUCTION

Dairy products rank among the most important and indispensable items in the food supply chain, particularly for vulnerable populations such as children, the ill, and older adults, which necessitates heightened surveillance of their quality (Riverí Charón *et al.*, 2024). Adequate consumption of milk and its derivatives throughout the life course is important for human health, since these foods are characterized by high nutritional density and biological value. Moreover, they exhibit bioactive properties that contribute to protection against certain diseases (Montoya Jaramillo *et al*., 2023).

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Cheese is regarded as a functional food whose microbiota include probiotic bacteria of the genera *Lactobacillus* and *Bifidobacterium*. Demonstrated beneficial effects of these microorganisms include alleviation of lactose intolerance, prevention of allergic reactions, reduction of plasma cholesterol, inhibition of *Helicobacter pylori* and other enteric pathogens, treatment of conditions such as antibiotic-associated diarrhea and traveler's diarrhea as well as certain inflammatory disorders, and a decreased risk associated with mutagenicity and cancer (Santamarina-García *et al*., 2020; Arteaga-Garibay *et al.*, 2023).

Currently, global population growth is placing the provision of safe, high-quality food among the principal challenges confronting many countries. The increased demand for larger quantities of food creates challenges for food quality and safety and elevates the associated risks to consumer health (Cortés-Sánchez *et al*., 2024).

According to Arteaga-Solórzano *et al*. (2021), continuous monitoring of cheese quality and safety is required because of its nutritive characteristics: it is rich in proteins, minerals, vitamins, and lipids. Cheese contains 37.0% water, 3.5% carbohydrates, 23.0% proteins, 33.0% lipids, and 3.5% minerals. Its lipid fraction comprises saturated, monounsaturated, and polyunsaturated fatty acids, as well as cholesterol. One hundred grams of cheese provide all fat-soluble and water-soluble vitamins except vitamin C (Rodiles-López *et al*., 2023). However, its hygienic and sanitary quality can be compromised by various factors that, if uncontrolled, may lead to serious health problems and economic losses for producers. Therefore, the aim of this study is to evaluate the factors that influence cheese quality by describing its principal contaminants.

DEVELOPMENT

A descriptive literature review was conducted to identify the principal contaminants affecting cheese quality and their control. The bibliographic search was performed in the last quarter of 2025 using the databases Scopus, SciELO, ScienceDirect, and Dialnet, with the keywords cheese; milk quality; cheese quality; dairy product safety; cheese safety. Articles published between 2010 and 2025 were screened; 160 articles were included after selecting those whose content aligned with the study objectives and met the journal’s recency requirements. EndNote was used for bibliographic management.

Factors affecting cheese quality

In the dairy industry, quality control is grounded in the study and analysis of raw milk, since its properties are decisive for ensuring the quality and safety of derived products (Darwesh *et al*., 2025). According to Valdivia *et al*. (2021), the hygienic-sanitary quality of milk depends, among other factors, on the correct execution of milking routines, the hygiene of production units and of the personnel performing milking, and the conditions of storage and transport of this food.

The occurrence of mastitis in herds is highlighted among the challenges affecting milk quality in Cuba (Valdivia *et al*., 2022). This disease causes alterations in protein and lipid composition and promotes the excretion of microorganisms into milk, thereby compromising the quality of milk and its derivatives (Medrano *et al*., 2020; Valdivia *et al*., 2020; Alejos *et al*., 2022; Valdivia *et al*., 2023).

Storage of milk under inadequate conditions also leads to deterioration of its quality. Valdivia *et al*. (2020) report that conserving this product for more than 24 hours at low temperatures promotes an increase in the number and activity of psychrophilic microorganisms, which grow at temperatures below 7°C. These organisms produce proteolytic enzymes, lipases, and thermostable phospholipases that can degrade certain milk components and alter its composition and that of its derivatives. Conversely, storage at temperatures above the recommended range can promote the proliferation of microorganisms that produce acid during growth, which likewise compromise the safety of these products.

Another factor to consider is the presence of microorganisms that constitute the final microbiota of cheese and their origin. These microorganisms may be intentionally added as part of the starter culture, may be naturally present in the ingredients used for cheese manufacture, or may originate from the milking environment, the cheese-making facility, or the materials employed (Santamarina-García *et al*., 2020).

Sodium chloride (salt) content markedly influences cheese quality by enhancing flavor . Low salt concentrations can impair the growth and metabolic activity of lactic acid bacteria and reduce casein's water-binding capacity, with consequent effects on curd structure, texture development, and maturation (Prestes *et al*., 2020). Fat content is a primary determinant of flavor, mouthfeel, and aroma; while increased fat generally produces a finer, creamier curd, excessive fat in long-ripened hard cheeses predisposes the product to oxidative rancidity and the development of off-flavors (Mercanti *et al*., 2004).

Rennet is a mixture of proteolytic enzymes used to coagulate milk proteins—primarily casein—during cheese manufacture (Andrén, 2011). Rennet may be produced on a small, local scale or obtained industrially. Arteaga-Solórzano *et al*. (2021) evaluated the use of industrial rennet and identified it as a positive factor for ensuring the safety of the final product.

Moreover, it must be underscored that the collection and processing of milk and its derivatives entail exposure to contamination risks originating from diverse sources. Contaminants in dairy derivatives can be physical, chemical, or biological in nature. Below is a brief description of the principal contaminants associated with cheese production.

Physical contaminants

Contamination of cheese by foreign bodies is typically accidental; the feasibility of removal depends on the contaminant's nature, the firmness of the curd, and whether the contamination is superficial or internal. When identification is not possible, the affected product must be deemed unfit for further processing, as it may pose consumer discomfort or significant health risks. (Riverí Charón *et al*., 2024).

Chemical contaminants

The presence of chemicals at levels above legally established limits can lead to chronic ingestion of small doses that, by accumulating in the body and depending on their toxicity, cause severe damage to various organs and systems, constituting a significant public-health problem (Reyna & Arteaga, 2022). The main chemical contaminants of concern in cheese technology that may be found in milk are antibiotics; pesticides; heavy metals; and residues of cleaning and disinfecting agents (Darwesh *et al.*, 2025).

Antibiotics

The indiscriminate use of antibiotics and the rise of microbial resistance to these drugs are considered among the principal problems facing humanity today. This situation also poses a challenge for the biopharmaceutical and food industries (Camacho *et al*., 2020). Demand for higher-quality food products has increased, obliging the livestock sector to produce foods free of drug residues to safeguard consumer health (Maldonado-Arias *et al*., 2022).

Antibiotic contamination of milk typically results from failure to observe withdrawal periods, non-prescribed or off-label use, application as feed additives, and inadequate or absent monitoring systems (Darwesh *et al*., 2025). Residues of antibiotics in milk pose direct risks to consumers, including allergic reactions and selection for antibiotic-resistant microbiota, and they have technological consequences for cheese production, such as impaired milk acidification and inhibition of starter cultures (Reyna & Arteaga, 2022).

Anthelmintics

Anthelmintics are employed to treat parasitic infestations; improper use facilitates their entry into the food chain and the contamination of milk. Representative compounds include benzimidazoles and imidazoles. In milk, benzimidazole concentrations are not diminished by cooking, low-temperature storage, baking, or microwave treatment. Levamisole residues are reported to be stable during fermentation and thermal processing of whey and can persist in cheeses (Reyna & Arteaga, 2022).

Pesticides

Pesticide contamination of milk typically arises when livestock are fed forage that was sprayed without observing the recommended withholding periods. Pesticides applied to control insects and other parasites in housing facilities also constitute a hazard; the risk they pose depends on their toxicity and environmental persistence, and more persistent compounds are often more hazardous even when their intrinsic toxicity is lower. Some of these substances can bioaccumulate in the animal’s adipose tissue (Darwesh *et al*., 2025).

Heavy metals

Heavy metals are considered metallic elements and metalloids with a higher density compared with other metallic elements (5 $g \cdot cm^3$) or an atomic weight between 63.5 and 200.6 g/mol. They are widely distributed in the environment and can induce systemic toxicity even at low levels of exposure (Reyna & Arteaga, 2022). Milk can be contaminated with these compounds by exogenous or endogenous routes: exogenously when contamination occurs after milking, generally from equipment, and endogenously when the lactating animal ingests heavy metals via water or feed and eliminates them in the milk. The most important elements that may be present in milk are copper, cadmium, lead, zinc, tin, iron, mercury, aluminum, arsenic, and molybdenum (Darwesh *et al*., 2025).

Cleaning and disinfection agents

Cleaning and disinfection agents commonly used in dairy facilities can contaminate milk; however, when these products are properly rinsed, the risk of residue presence is negligible. In cases of significant producer negligence, disinfectant concentrations may reach levels sufficient to reduce the activity of lactic acid bacteria in milk, with consequent negative effects on cheese quality. (Reyna & Arteaga, 2022).

Biological contamination

Biological contamination in the cheese industry primarily refers to the presence of pathogenic microorganisms and their toxic metabolites. The source of these microorganisms may be the raw milk itself, as the principal raw material, and/or may be associated with poor hygienic practices during handling and processing.

One of the greatest concerns in the food industry for ensuring product safety is the presence of pathogenic microorganisms. Most foodborne disease outbreaks are attributable to these biological agents rather than to chemical or physical contaminants. It should also be noted that microorganisms destroyed by subsequent cooking processes may previously have produced toxins that are harmful to health (Argüello *et al*., 2020).

Cheeses provide an ideal environment for microbial proliferation due to their content of carbohydrates, proteins, and high moisture. The microorganisms most frequently associated with cheese contamination and implicated as primary causes of foodborne illness include *Staphylococcus aureus*, *Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, and *Coxiella burnetii*. Other species have also been linked to outbreaks associated with contaminated cheeses, notably *Campylobacter* spp., *Brucella* spp., *Shigella* spp., *Clostridium perfringens*, and *Bacillus cereus* (El-Sayed *et al*., 2022).

According to Martínez-Vasallo *et al*. (2019), contamination of cheese with *S. aureus* can occur via two principal routes. The first is direct contamination when animals are infected and raw milk from these animals is used for cheese production. The second arises from inadequate hygiene practices, which can lead to contamination during processing or post-production contamination due to improper storage (e.g., lack of refrigeration), exposure to contaminated environments (equipment and surfaces) at points of sale, or contamination by food handlers who are carriers.

The presence of Staphylococcus aureus in cheese samples is associated with inadequate monitoring of pasteurization time and temperature and, potentially, with cross-contamination from production personnel. Contamination by enterobacteria may result from deficiencies in workers' hand-washing practices (Santos *et al*., 2019).

Aranda *et al*. (2025) report that cheese is highly susceptible to contamination by mycotoxin-producing fungi, primarily species of *Aspergillus* (*A. niger, A. flavus*) and *Penicillium* (*P. commune*, *P. solitum*, *P. palitans*, *P. crustosum*).

Aflatoxins

Aflatoxins are widely distributed and can impair animal productivity and food security. They exert toxic, mutagenic, teratogenic, carcinogenic, and immunosuppressive effects. These compounds enter the food chain primarily through contamination of crops (Reyna & Arteaga, 2022).

These compounds are produced primarily by fungi of the genus *Aspergillus*, notably *A. flavus* and *A. parasiticus*, under specific environmental conditions of humidity, temperature, and nutrient availability. Approximately 18 aflatoxin types have been identified; the most important food contaminants are aflatoxins B1, B2, G1, and G2. Aflatoxin B1 (AFB1) is the most toxic and prevalent worldwide and has demonstrated carcinogenic and cytotoxic potential in animals and humans (Cravero-Ponso *et al*., 2020; Pichardo-Matamoros & Elizardo-Matamoros, 2020).

Aflatoxin M1 (AFM1) is a metabolite formed via cytochrome P450 activity in bovine hepatocytes following ingestion of feed contaminated with Aflatoxin B1 (AFB1); it can cross physiological barriers and be excreted in milk, urine, and feces. This toxin may be present in milk and dairy products and represents a public-health hazard. The maximum permissible limit for AFM1 in milk and dairy products is 0.5 ppb (µg/L), according to CAA (Cravero-Ponso *et al*., 2020).

Exposure of consumers to AFM1 is regarded as one of the most significant food-safety concerns in the dairy sector, since AFM1 is heat-stable and is not eliminated by standard pasteurization processes. In lactating cows that ingest feed contaminated with AFB1, AFM1 residues can be detected in milk within 12–24 hours after ingestion and may persist for up to five days after removal of the contaminated feed, with reported transfer rates from AFB1 to AFM1 in milk ranging from 0.30 to 7.26%. The conversion and excretion of AFB1 as AFM1 in milk are correlated with milk production: higher-yielding cows tend to secrete greater concentrations of AFM1 in their milk. (Pichardo-Matamoros & Elizardo-Matamoros, 2020).

The degradation or inactivation of aflatoxins in feed and milk can be achieved by different methods, including physical, chemical, or biological approaches. The purpose of these treatments is to reduce the biotransformation of AFB1 to AFM1 in the animal to decrease transfer into milk, or to act directly on the milk to lower AFM1 concentrations. Among the most promising technological strategies are adsorbents (bentonite) combined with yeasts, biocontrol (yeasts and *Lactobacillus* spp.), and vaccination against aflatoxins (Pichardo-Matamoros and Elizardo-Matamoros, 2020).

Detection of contaminants in cheese

With the aim of minimizing the risks of illness and harm caused by food consumption, a set of control measures is implemented to ensure that a safe product reaches the final consumer. Detecting contaminants that may be present in dairy products is essential to guarantee food safety. It is important to emphasize that each stage of the food production process involves controlling potential contaminants, and at the end of the production cycle the appropriate checks are carried out on the final product.

During the production process, removal of physical contamination by foreign material is carried out using various methods that are implemented once raw materials enter the production line. The first step in eliminating physical hazards in cheese production is milk filtration. Among the methods used to detect physical contaminants at later stages of the process are metal detection, X-ray inspection, and near-infrared spectroscopy, which are the main technologies for detecting physical contaminants (Farag *et al*., 2023; Payne *et al*., 2023).

From the standpoint of biological and chemical contamination, efforts focus on applying increasingly sensitive and precise techniques in order to identify the main contaminants of this nature that affect human health. In this regard, for the detection of microorganisms in samples, although conventional culture-dependent microbiological techniques are not ruled out and are still used, there is a trend toward using immunoassay methods and techniques based on molecular biology. Specifically, biosensors have been employed to detect *Listeria monocytogenes* in milk and cheese samples. These technologies are used primarily to minimize turnaround times for obtaining assay results, which is critical in the industry (El-Sayed *et al*., 2022; Mushtaq *et al*., 2025). Aflatoxins are detected in cheese samples through the use of various analytical techniques, either by ELISA or chromatographic methods (Malissiova *et al*., 2024; Yousof *et al*., 2024).

For the detection of heavy metals in dairy products, spectroscopic and spectrophotometric methods are used (Macías-Andrade *et al*., 2025). Antibiotics are detected by high-performance liquid chromatography coupled to fluorimetry, and chemical sensors are also employed (Virto *et al.*, 2022).

Risk factors that compromise the safety of dairy products

Milk and dairy product safety fundamentally depends on the hygienic quality of the milk. Among the main difficulties faced by small-cale milk producers in obtaining hygienic products are informal and unregulated marketing, handling, and processing; a lack of financial incentives to improve quality; and an insufficient level of knowledge and skills regarding hygienic practices (Riverí Charón *et al*., 2024).

In a study carried out in the city of Juliaca in Peru by Chambí-Rodríguez *et al*. (2022), some of the difficulties affecting cheese marketing that could contribute to foodborne illness from this product were identified. It was found that most suppliers do not have the appropriate equipment for proper cheese production, and inspections and follow-ups of sanitary records are not carried out frequently.

Moreover, Arguello *et al*. (2020) identified the following risk factors associated with cheese production: the extent of handling during processing, the level of knowledge about process hygiene, and the methods used for cleaning and disinfection.

Arteaga-Solorzano *et al*. (2021) identified deficiencies in the fresh-cheese production process in Manabí, Ecuador, that promoted high microbial counts in the product. Notably: improper milking routines and hygiene; inadequate infrastructure with poor waste-management systems; lack of recommended utensils and containers for cheese making; an unprotected exterior environment around the production room; and workers who had not received training related to the production process.

These authors consider that cheese producers require specific facilities, equipment, and utensils for this activity to ensure the safety of the raw material. The Somatic Cell Count of the milk must also be taken into account. High values of this indicator suggest the presence of mastitis with the potential risk of finding zoonotic microorganisms such as *Staphylococcus aureus* in the product. Other detected shortcomings correspond to the lack of proper cleaning and disinfection protocols for equipment and milking procedures, the use of water with inadequate microbiological quality, and poor milk storage conditions.

It has been experimentally shown that as cheese storage time increases, the microbial load also rises. Fresh cheese is highly susceptible to microbial spoilage by molds, yeasts, psychrotrophic microorganisms, and *Enterobacteriaceae* (Soria Herrera, 2020).

Control measures

Taking measures that guarantee product quality and implementing preventive actions that ensure strict compliance with sanitary handling, cleaning, and disinfection standards are key elements in obtaining safe foods. Above all, considering that contamination of these products can occur at any point in the food supply chain. It is essential that production facilities meet hygiene and quality standards to achieve this objective (Santos *et al*., 2019; Guzmán *et al*., 2024).

The proper implementation of the Hazard Analysis and Critical Control Points system is a key element in managing the quality of the cheese production process to ensure safe food. It is worth noting that when the measures corresponding to good hygiene and manufacturing practices are applied (or complied with) at each production stage, the risk of producing contaminated cheeses that cause foodborne illness is minimized (Farag *et al*., 2023).

CONCLUSIONS

Cheese is an important food in the human diet because of its nutritional content and the health benefits its consumption offers. Preserving its quality is an essential goal for producers. Among the main factors that influence the deterioration of these indicators are the quality of the milk used in its production and the hygienic conditions in which it is made, which must guarantee its safety.

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AUTHOR CONTRIBUTION STATEMENT

Research conception and design: ALVA, YRF, AJRC; data analysis and interpretation: ALVA, YRF, AJRC; manuscript writing: ALVA, YRF, AJRC.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.