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Research Article

Review on Role of Biosecurity in the Production of Safety and Quality Milk in Dairy Farms of Ethiopia

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Abstract

Biosecurity in dairy farming encompasses a set of practical management and operational measures designed to prevent the introduction, establishment and spread of infectious diseases, toxins and other contaminants within and between farms. It aims to safeguard animal health, milk quality, and public health by creating a controlled environment where biological risks are minimized. Effective biosecurity involves proper farm design, controlled animal movement, disinfection procedures, pest and rodent management and the maintenance of hygienic milking and feeding practices. The well-being, nutrition and care of dairy animals such as cattle, buffalo, goats, and sheep directly determine the safety, composition, and market value of milk and other dairy products. When animals are stressed, malnourished, or poorly managed, they become more susceptible to diseases that can compromise productivity and contaminate milk with pathogens or residues. Likewise, unhygienic milking, storage, or transport practices increase the risk of spoilage and milk-borne infections, endangering consumer health. Globally, biosecurity is recognized as a cornerstone of the One Health framework, which emphasizes the interdependence of animal health, human health and environmental sustainability. However, in Ethiopia, the adoption of biosecurity measures remains limited due to smallholder production systems, inadequate veterinary support, lack of awareness and infrastructural constraints. Strengthening biosecurity practices through farmer education, extension services and policy enforcement is therefore essential. Enhanced biosecurity will not only improve animal welfare and milk quality but also ensure food safety, support sustainable livelihoods and boost the competitiveness of Ethiopia's dairy sector in domestic and export markets.

Keywords

Biosecurity, Dairy Farming, Milk Quality, Food Safety, Animal Health, Ethiopia, One Health, Smallholder Systems

1. Introduction

Biosecurity in dairy farming refers to a comprehensive system of management and operational measures designed to prevent, control and eliminate the introduction and spread of infectious agents, toxins and contaminants that threaten the health of dairy animals and the safety of milk. In simple terms, it encompasses every preventive step that keeps disease and contamination out of the farm and the food chain [13]. Because dairy animals mainly cattle, but also buffalo, goats and sheep are biological producers of milk, their health, nutrition and management directly influence the safety, composition and marketability of milk. Poor animal health and unhygienic handling practices are major contributors to milk-

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borne diseases and spoilage [7]. Globally, biosecurity is recognized as a cornerstone of One Health, linking animal health, public health and environmental protection. According to the Effective biosecurity implementation reduces up to 70% of disease-related productivity losses in dairy herds. In Ethiopia, where milk is often produced under smallholder or semi-intensive systems with limited infrastructure, biosecurity adoption is still low [6]. Yet it is a vital foundation for improving milk quality, ensuring food safety and enhancing the competitiveness of the Ethiopian dairy sector in both local and export markets. [4].

2. Importance of Biosecurity in Milk Production

2.1. Protection of Animal Health

Healthy dairy animals are the backbone of sustainable milk production. Infectious and parasitic diseases such as mastitis, brucellosis, tuberculosis, listeriosis, and foot and mouth disease (FMD) are among the major threats to productivity and milk quality. Biosecurity practices such as controlled animal introduction, vaccination, sanitation and movement control act as barriers that reduce disease introduction and spread. [11].

A study in central Ethiopia reported that over 85% of dairy farms lacked quarantine facilities and 97% lacked disinfection systems like footbaths, leading to frequent disease transmission. Reduced disease incidence not only improves milk yield but also decreases dependence on antibiotics, minimizing the risk of drug residues in milk. [10]. these results in longer productive lifespans for animals, lower treatment costs and improved profitability for farmers.

2.2. Assurance of Milk Safety

Milk's composition (rich in water, fat and protein) makes it an excellent medium for microbial growth. Biosecurity practices directly impact milk hygiene by reducing microbial contamination at the source. [1]. Clean feed and water, healthy udders, sterile milking equipment and pest-free environments are the first line of defence. Smallholder dairy farms that implemented basic biosecurity and hygiene protocols in Ethiopia recorded 30–40% lower total bacterial counts (TBC) compared to farms without such measures. By reducing microbial, chemical (drug residues, pesticides, mycotoxins) and physical hazards (dirt, hair, debris), biosecurity ensures compliance with safety standards such as the Ethiopian Standard ES 3460:2009 and the Codex Alimentarius guidelines on raw milk hygiene. [5].

2.3. Reduction of Economic Losses

Disease outbreaks and contamination result in significant economic losses through reduced milk yield, fertility issues, veterinary costs and market rejection [8]. Biosecurity minimizes these risks, thereby improving farm profitability and milk marketability. Evidence from and shows that Ethiopian farms adhering to milk safety practices (clean milking, proper waste disposal, and animal health records) gained 10–25% higher prices per litter in urban markets [2]. Strong biosecurity thus represents a strategic economic investment, rather than merely a health cost.

2.4. Protection of Public Health

Raw milk can serve as a vehicle for zoonotic pathogens such as *Brucella spp.*, *Mycobacterium bovis*, *Listeria monocytogenes*, *Salmonella spp.*, and *Campylobacter jejuni*. Chemical residues from veterinary drugs and feed additives can also pose chronic health risks [14]. By ensuring healthy herds, restricted drug use, isolation of sick animals and hygienic milking, biosecurity helps protect consumers from milk-borne diseases [12]. Strengthening biosecurity is therefore not only an animal health issue but also a public health imperative aligned with national food safety and One Health strategies. [15].

3. Core Components of Dairy Farm Biosecurity

3.1. Farm Perimeter and Access Control

Establish secure fencing and gates to prevent unauthorized entry. Maintain a logbook for all visitors and vehicles. Install disinfection points (footbaths, wheel dips). Restrict farm access only to trained personnel. Research in Oromia showed that farms with basic access control had lower disease incidence and better hygiene indicators compared to open-access farms [8].

3.2. Animal Health Management

Source animals only from disease-free farms. Quarantine new animals for 2–4 weeks. Follow vaccination schedules (e.g., against FMD, Lumpy Skin Disease, Brucellosis). Keep accurate animal health and treatment records. However, 87% of farms surveyed in Ethiopia lacked isolation areas, and only 40% implemented vaccination protocols consistently [10]. In Ethiopia mastitis alone leads to major economic losses through reduced milk yield, compromised milk quality, increased treatment expenses and higher culling rates [9]. Improving biosecurit is crucial for disease control and milk safety.

3.3. Milking Hygiene and Equipment Sanitation

Milking is the most critical contamination point. Wash udders with clean water and dry with disposable towels. Use pre- and post-milking teat dipping. Wash hands before and during milking. Clean and sanitize milking equipment with

approved detergents. Discard milk from animals under treatment. According to studies, farms that practiced proper milking hygiene achieved reduced somatic cell counts (SCC) and improved sensory quality of milk [3].

3.4. Feed and Water Biosecurity

Feed and water are often overlooked but are major contamination pathways. Ensure clean, potable water free from pathogens or heavy metals. Store feed properly to avoid mold and mycotoxin contamination (especially *Aflatoxin B1*). Source feed ingredients from certified suppliers. In Ethiopia, only 7% of farmers were aware of feed-related milk contamination risks [5].

3.5. Waste and Manure Management

Implement proper manure collection and disposal systems. Separate waste areas from milking and feeding zones. Compost manure or use biogas systems to reduce pathogen load. Ensure regular cleaning of barns and drainage systems. Failure to manage manure can spread pathogens and attract pests, compromising milk hygiene.

3.6. Personnel Hygiene and Training

Workers should wear clean boots and clothing, and wash hands regularly. Train all workers in hygiene, disease recognition, and record-keeping. Limit staff movement between animal groups. Training and extension services have a proven impact trained farmers are twice as likely to implement hygiene protocols.

3.7. Vector and Pest Control

Use physical barriers, screens, and traps to exclude pests. C ontrol flies, rodents, and stray animals. Clean feed and water storage regularly. Effective pest management prevents recontamination even in otherwise hygienic farms.

4. Biosecurity and Milk Quality Assurance

Biosecurity directly impacts measurable milk quality indicators: Microbial Quality: Reduces total bacterial counts (TBC), coliforms, and SCC. Chemical Safety: Minimizes drug residues, mycotoxins (e.g., aflatoxin M1), and pesticide contamination. Sensory Quality: Ensures clean taste, smell, and color by avoiding contamination and spoilage.

5. Integration with Quality Management Systems

Biosecurity is the first layer of a complete quality assurance system, supporting: Good Agricultural Practices (GAP) and Good Hygienic Practices (GHP); Hazard Analysis and Critical Control Point (HACCP) implementation; Traceability and certification (e.g., ISO 22000, Global G. A. P.); One Health alignment, ensuring animal, human, and environmental safety. Integration allows farms to achieve market differentiation, compliance with export standards, and participation in premium milk value chains.

6. Challenges to Effective Biosecurity Implementation

Low awareness and training gaps among smallholder farmers. Weak enforcement and lack of incentives for compliance with hygiene regulations. Limited infrastructure, especially clean water supply, milking facilities, and isolation pens. Resource and service constraints limited veterinary access, diagnostic support, and inputs. Fragmented coordination across stakeholders (farmers, cooperatives, regulators, and extension). To overcome these barriers, Ethiopia requires targeted extension training, strong policy enforcement, financial incentives for clean milk production, and coordinated value-chain-based interventions.

7. Discussion

Biosecurity is essential in dairy farming for protecting animal health, ensuring milk safety, and improving economic returns. By preventing the introduction and spread of infectious agents and contaminants, it reduces disease, lowers antibiotic use and minimizes chemical residues in milk. In Ethiopia, low adoption of biosecurity in smallholder and semi-intensive systems exposes herds to diseases like mastitis, brucellosis and FMD, compromising productivity and public health. Beyond animal health, biosecurity ensures milk hygiene by controlling microbial, chemical, and physical contamination through clean water, healthy udders, sanitized equipment and pest control. Farms implementing these practices achieve higher milk quality, better marketability and premium prices. Core measures farm access control, animal health management, milking hygiene, feed and water safety, waste management, personnel training, and pest control work together to enhance milk quality and compliance with national and international standards. Challenges in Ethiopia include limited awareness, inadequate infrastructure, weak enforcement and fragmented stakeholder coordination. Overcoming these barriers requires training, policy support, financial incentives and strengthened veterinary and extension services. Strengthening biosecurity is thus both a public health necessity and a strategic investment for a safe, competitive, and sustainable dairy.

8. Conclusion

Biosecurity is not optional it is a core requirement for pro-

ducing safe, high-quality, and market-competitive milk. It improves animal health, enhances milk safety, protects consumers, and ensures the long-term sustainability of dairy farms. In Ethiopia, where dairy farming plays a crucial socio-economic role, strengthening biosecurity through training, infrastructure investment, and policy enforcement will deliver substantial benefits. Future efforts should focus on monitoring adoption rates, quantifying impacts on milk quality, and supporting farmers through integrated extension and incentive mechanisms.

9. Recommendations

1) Strengthening biosecurity in Ethiopia's dairy sector requires a multifaceted through regular on-farm programs focusing on hygiene, quarantine, vaccination, and waste management, alongside integrating biosecurity into agricultural and veterinary extension.
2) Policy development and enforcement should focus on implementing national biosecurity standards aligned with OIE guidelines and strengthening milk inspection and certification mechanisms.
3) Research and monitoring frameworks must be established to assess biosecurity adoption and its impacts on milk quality, disease reduction and farm profitability.

Abbreviation

FMD	Foot and Mouth Disease
TBC	Total Bacterial Count
SCC	Somatic Cell Count
GAP	Good Agricultural Practices
GHP	Good Hygienic Practices
HACCP	Hazard Analysis and Critical Control Point
ISO 22000	International Organization for Standardization
OIE	World Organisation for Animal Health
FAO	Food and Agriculture Organization of the United Nations

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this work. The views expressed are based solely on scientific evidence and best practices in dairy farm biosecurity and no financial, personal, or professional relationships influenced the content or conclusions presented.

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