

Impact of Hygiene Practices on Quality and Shelf Life of Khoa

Dapkekar Santosh Kumar Madhavrao¹ and Dr. Jayanti Tripathi²

¹Research Scholar, Department of Dairy Science

²Professor, Department of Dairy Science
Sunrise University, Alwar, Rajasthan

Abstract: *Khoa is a heat-desiccated traditional dairy product widely used in the preparation of Indian sweets. Due to its high moisture, nutrient density, and manual handling during production, khoa is highly susceptible to microbial contamination and rapid spoilage. Hygiene practices during milk procurement, processing, handling, packaging, and storage play a critical role in determining its microbiological quality and shelf life. This review examines the impact of sanitation, personal hygiene, equipment cleanliness, environmental control, and storage conditions on khoa quality. It highlights the importance of Good Manufacturing Practices Good Hygienic Practices and Hazard Analysis and Critical Control Points systems, as recommended by the Food Safety and Standards Authority of India..*

Keywords: Khoa, Hygiene Practices, Shelf Life, Microbial Quality.

I. INTRODUCTION

Khoa is prepared by continuous heating and desiccation of milk in open pans until it attains a semi-solid consistency. Despite undergoing heat treatment, post-processing contamination remains a major concern due to manual handling, exposure to air, and unhygienic environments (De, 2005). Traditional small-scale units often lack structured hygiene protocols, leading to microbial proliferation and reduced shelf life. Studies have shown that khoa stored under ambient conditions may spoil within 2–3 days, whereas hygienically processed and refrigerated khoa can last up to 10–14 days (Aneja et al., 2002). Therefore, hygiene practices directly influence product stability and safety.

Khoa, also known as mawa, is a traditional Indian dairy product obtained by slow heating and desiccation of milk to a semi-solid consistency. It serves as the base ingredient for a variety of Indian sweets such as peda, burfi, and gulab jamun. The production of khoa is a labor-intensive process involving prolonged heating, stirring, and manual handling, which makes it highly susceptible to microbial contamination and spoilage (Aneja et al., 2002). The quality and shelf life of khoa are strongly influenced by the hygiene practices adopted during all stages of its production, including milk procurement, processing, handling, packaging, and storage.

Raw milk itself is a potential source of microbial load; milk obtained from unsanitary conditions or with high initial bacterial counts can significantly compromise the safety and quality of the final product (Walstra et al., 2006). Contamination can occur through multiple pathways, such as unclean processing utensils, improperly sanitized equipment, exposure to airborne microbes, and poor personal hygiene of the handlers (Jay et al., 2005). In small-scale and cottage industries, where production is largely unorganized, these factors are especially pronounced, resulting in higher microbial proliferation, faster spoilage, and reduced shelf life (De, 2005).

The shelf life of khoa is inherently limited due to its high moisture content, rich nutrient composition, and lack of preservatives. Under ambient storage conditions, traditionally prepared khoa may deteriorate within 2–3 days, whereas proper hygiene practices combined with refrigeration can extend its shelf life to 10–14 days, and further improvements can be achieved through vacuum packaging and cold chain implementation (Singh & Gandhi, 2015). Good Manufacturing Practices and Good Hygienic are therefore critical in reducing contamination, maintaining product consistency, and ensuring consumer safety.

GMP encompasses measures such as proper cleaning and sanitization of equipment, temperature control during heating, and safe water supply, while GHP emphasizes personal hygiene, such as the use of gloves, hairnets, and protective



clothing, as well as regular health checks for workers (Robinson, 2002). Moreover, the implementation of Hazard Analysis and Critical Control Points systems allows for systematic identification and monitoring of potential contamination points during the production process, including milk reception, heating, cooling, and packaging stages. Regulatory frameworks in India, primarily enforced by the Food Safety and Standards Authority of India, provide standards for hygienic processing, microbial limits, and storage conditions for dairy products, including khoa. However, enforcement in the unorganized sector is often inadequate due to lack of awareness, limited access to sanitation infrastructure, and financial constraints, leaving a significant portion of khoa production vulnerable to quality deterioration and safety risks (FSSAI, 2006). Studies have shown that improvements in hygiene practices directly correlate with lower microbial load, delayed spoilage, and better sensory attributes, indicating that hygiene is a critical determinant of both safety and shelf life (Walstra et al., 2006; Singh & Gandhi, 2015).

SOURCES OF MICROBIAL CONTAMINATION IN KHOA

Khoa, a traditional Indian dairy product, is highly perishable due to its elevated moisture content, nutrient density, and semi-solid consistency, making it an ideal medium for microbial proliferation (De, 2005). One of the primary sources of contamination is raw milk quality. Milk with high initial bacterial counts or poor hygiene during milking introduces coliforms, *Staphylococcus aureus*, and other spoilage organisms directly into the product (Walstra et al., 2006). Milk adulteration with water, starch, or synthetic milk further compromises microbial safety and alters physicochemical properties, contributing to faster spoilage (Singh & Gandhi, 2015).

Another significant contamination source is the processing environment and equipment. In traditional small-scale units, open pans ladles, trays, and other utensils are often inadequately cleaned or sanitized, allowing microorganisms to survive and multiply during heating, cooling, or storage stages (Aneja et al., 2002). Stainless-steel equipment with proper cleaning protocols, as implemented in organized dairy units, has been shown to reduce total plate counts and coliform presence significantly (Robinson, 2002). Personal hygiene of workers is equally crucial.

Manual stirring, kneading, and packaging of khoa by handlers without gloves, hairnets, or clean uniforms facilitate contamination by human-associated pathogens, including *Staphylococcus aureus* and *Bacillus* species (Jay et al., 2005). Studies have demonstrated that simple measures such as handwashing, use of gloves, and restriction of sick individuals from production areas can markedly lower microbial load. Environmental exposure during processing and post-production handling is also a critical factor. Cooling of khoa in open-air conditions or storing it in uncovered trays exposes the product to dust, flies, and airborne microorganisms, accelerating spoilage (Walstra et al., 2006). Contamination can further occur during transportation and retail sale, especially in unorganized sectors where ambient storage and unhygienic market conditions prevail.

Additionally, water quality used for cleaning and dilution plays a vital role; contaminated water can introduce pathogenic and spoilage bacteria into the processing environment, undermining product safety. Seasonal variations, such as higher ambient temperatures during summer, exacerbate microbial growth, reducing shelf life to as little as 2–3 days under unhygienic conditions, compared to 10–14 days for properly processed and refrigerated khoa (Aneja et al., 2002). Adoption of Good Manufacturing Practices Good Hygienic Practices and Hazard Analysis and Critical Control Points frameworks effectively mitigates these risks by identifying critical contamination points, monitoring microbial load, and enforcing preventive measures at each stage of production (Singh & Gandhi, 2015).

RAW MILK QUALITY

Poor-quality milk with high initial bacterial load contributes significantly to contamination (Walstra et al., 2006). Raw milk quality is one of the most critical determinants of the safety, nutritional value, and shelf life of khoa, a traditional Indian dairy product. Khoa is prepared by reducing milk through continuous heating, and any variability in the raw milk composition or microbial load directly affects the final product's physicochemical properties, texture, and durability (Walstra, Wouters, & Geurts, 2006).

The milk used in small-scale or unorganized sectors often comes from multiple sources with varying fat and protein content, leading to inconsistent total solids in the khoa. Inadequate testing of milk prior to processing may result in the use of milk with high bacterial counts, somatic cell levels, or adulterants, which not only compromises hygiene but also



accelerates spoilage (De, 2005). Pathogens such as *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* can be present in raw milk due to contamination at the farm level or improper handling during transportation, significantly increasing the risk of foodborne illness and reducing shelf life (Jay, Loessner, & Golden, 2005).

Seasonal fluctuations in milk composition, including changes in fat, protein, and lactose content, further complicate standardization, as khoa produced from dilute or low-fat milk tends to have higher moisture, softer texture, and reduced microbial stability (Aneja, Mathur, Chandan, & Banerjee, 2002). Moreover, milk contaminated with environmental microbes or residues of antibiotics and cleaning agents can interact with the heating process, causing off-flavors, accelerated Maillard browning, and undesirable textural changes, which not only affect sensory quality but also limit storage life (Robinson, 2002).

Implementing pre-processing quality checks, including fat content determination, acidity measurement, and microbial screening, can substantially mitigate these risks. Pasteurization or partial heat treatment of raw milk before khoa preparation reduces initial microbial load and minimizes the proliferation of spoilage organisms during post-production handling (Walstra et al., 2006). Additionally, hygienic practices during milk collection such as using sanitized utensils, maintaining cold storage during transport, and avoiding prolonged exposure at ambient temperatures are essential for preserving milk integrity and ensuring consistent khoa quality (Singh & Gandhi, 2015).

EQUIPMENT AND UTENSILS

Improper cleaning of open pans, ladles, and trays introduces coliforms and spoilage organisms (Jay et al., 2005). Equipment and utensils play a critical role in determining the microbiological quality and shelf life of khoa, as they are in direct contact with the product during its preparation, cooling, and packaging stages. Traditionally, khoa is prepared in open pans or karahis, using ladles, spoons, and trays, which are often cleaned irregularly, leading to microbial contamination and reduced product stability (Aneja et al., 2002). The porosity and surface material of utensils influence bacterial adherence, biofilm formation, and cross-contamination.

For instance, wooden or scratched metallic utensils tend to harbor microorganisms, which survive even after routine washing, thereby increasing the total plate count and risk of pathogenic contamination such as *Staphylococcus aureus*, *Escherichia coli*, and yeast and mold species (Walstra et al., 2006; Jay et al., 2005). Improperly sanitized equipment also facilitates enzymatic degradation and unwanted fermentation, which accelerates spoilage, alters texture, and generates off-flavors in khoa.

Studies have shown that the use of stainless-steel equipment with smooth surfaces significantly reduces microbial load, minimizes residue accumulation, and maintains product uniformity (Robinson, 2002). Moreover, temperature-controlled vessels, such as steam-jacketed kettles, prevent scorching and uneven heating, which otherwise create localized zones favorable for microbial growth. In addition, utensils used for cooling and storage, such as trays and molds, require periodic sterilization to prevent recontamination after thermal processing, as khoa remains highly susceptible to post-processing microbial proliferation due to its high moisture and nutrient content (Singh & Gandhi, 2015).

The cleaning protocols, including the use of hot water, food-grade detergents, and disinfectants, coupled with proper drying, are essential hygiene practices to maintain equipment safety. In modern dairy units, Clean-in-Place systems are employed to automate cleaning, reduce human error, and ensure uniform sanitation of processing lines (Aneja et al., 2002). The frequency of utensil cleaning and the quality of water used are also critical factors; water contaminated with coliforms or inadequately treated can serve as a direct source of contamination, negating other hygiene measures.

PERSONAL HYGIENE

Handlers without proper handwashing practices or protective clothing contribute to contamination by *Staphylococcus aureus* and other pathogens (Robinson, 2002). Personal hygiene is one of the most critical determinants of quality and shelf life in khoa production. Khoa, being a semi-solid dairy product with high moisture and nutrient content, is highly susceptible to microbial contamination, which can occur at multiple stages of production, particularly through human handling. Workers involved in milking, heating, stirring, molding, packaging, and transportation are potential vectors for contamination if proper personal hygiene practices are not followed. Studies have shown that *Staphylococcus*



aureus, coliforms, and yeasts are frequently introduced into khoa through unwashed hands, contaminated clothing, and lack of protective coverings such as gloves, aprons, and hairnets (Jay et al., 2005; Aneja et al., 2002).

In traditional, small-scale production units, the absence of formal hygiene protocols exacerbates the problem, leading to faster spoilage and shorter shelf life. According to Walstra et al. (2006), microbial contamination can cause rancidity, off-flavors, curdling, and textural deterioration in khoa, often within 2–3 days under ambient conditions. The adoption of personal hygiene measures such as regular handwashing with soap, use of sanitized gloves, hairnets, clean uniforms, and prohibition of jewelry has been demonstrated to significantly reduce microbial load and maintain the sensory attributes of the product (Robinson, 2002).

Further, routine health checks for workers help in minimizing the risk of pathogen transfer during production, a practice emphasized under Good Hygienic Practices and Good Manufacturing Practices. Implementation of Hazard Analysis and Critical Control Points systems also identifies critical stages where personal hygiene is pivotal, such as during molding and packaging, where direct contact with khoa is inevitable (De, 2005). In organized dairy units, structured personal hygiene protocols combined with mechanized handling and stainless-steel equipment have been shown to extend the shelf life of khoa from 2–3 days in traditional ambient storage to up to 14 days under refrigerated conditions (Singh & Gandhi, 2015).

Conversely, neglecting personal hygiene not only compromises microbial safety but also impacts consumer perception, as visible dirt, hair, or mold growth reduces acceptability. Moreover, contaminated khoa can serve as a vector for foodborne diseases, highlighting the public health significance of hygiene in the dairy sector. Therefore, comprehensive training programs for workers, strict monitoring, and adherence to personal hygiene standards are essential for both organized and unorganized producers.

ENVIRONMENTAL EXPOSURE

Open-air cooling and sale in uncovered trays expose khoa to dust, flies, and airborne microbes. Environmental exposure is a critical factor influencing the quality, safety, and shelf life of khoa, a traditional dairy product prepared by heat-desiccation of milk. After heating, khoa remains highly perishable due to its high moisture (30–40%), fat, and protein content, which create an ideal medium for microbial growth (Walstra, Wouters, & Geurts, 2006). During traditional preparation, especially in small-scale or cottage industries, khoa is often left to cool in open pans in ambient conditions. This practice exposes the product to various environmental contaminants, including dust particles, airborne microbes, insects, and rodents, all of which can significantly deteriorate product quality (Jay, Loessner, & Golden, 2005).

Airborne microorganisms, including *Bacillus*, *Staphylococcus*, and coliform bacteria, can settle on the surface of khoa, initiating spoilage and reducing the shelf life to as little as 2–3 days under ambient temperatures (Aneja et al., 2002). Furthermore, environmental factors such as humidity and temperature fluctuations accelerate microbial proliferation and biochemical degradation, leading to off-flavors, souring, and textural changes that compromise consumer acceptability (De, 2005). In open-air markets, vendors often display khoa in uncovered trays, which increases exposure to contaminants, including particulate matter from roads, vehicle emissions, and human traffic, further increasing the microbial load (Robinson, 2002). Studies have shown that traditional handling without adequate environmental control is one of the major reasons for high total plate counts, yeast, mold contamination, and occasional presence of pathogenic bacteria in market samples of khoa (Singh & Gandhi, 2015).

Environmental exposure not only reduces microbiological quality but also accelerates oxidative rancidity of milk fat, leading to undesirable sensory changes and decreased shelf life (Tamime, 2009). Implementing simple hygiene measures such as cooling in enclosed or sanitized rooms, covering containers during cooling and display, and avoiding direct contact with external air and vectors can significantly reduce microbial contamination (Aneja et al., 2002).

HYGIENE PRACTICES AND THEIR IMPACT ON QUALITY

Hygiene practices play a critical role in determining the quality, safety, and shelf life of khoa, a traditional Indian dairy product with high moisture and nutrient content that makes it highly susceptible to microbial contamination (Aneja et al., 2002). The quality of raw milk used in production forms the first critical point in ensuring safe and high-quality khoa, as milk with a high initial microbial load or adulterants significantly compromises the final product (Walstra et



al., 2006). Proper testing of raw milk for microbial count, fat content, and adulteration is essential, yet many small-scale producers often neglect this step due to lack of resources or awareness. Equipment sanitation is another vital factor affecting quality; utensils such as open pans, ladles, and trays can harbor bacteria if not cleaned and sanitized regularly. Studies have shown that irregular cleaning of processing equipment increases the total plate count and encourages the growth of spoilage organisms, thereby reducing both shelf life and sensory quality (Jay et al., 2005). Personal hygiene of handlers also directly impacts microbial contamination in khoa. The use of gloves, hairnets, clean uniforms, and proper handwashing protocols reduces the introduction of pathogens such as *Staphylococcus aureus* and coliforms into the product (Robinson, 2002).

In traditional units, the absence of these practices often results in rapid spoilage, off-flavors, and discoloration. Environmental conditions, including open-air cooling and exposure to dust or insects, further exacerbate microbial proliferation and degradation of texture. Implementation of Good Manufacturing Practices and Good Hygienic Practices has been shown to significantly reduce contamination risk, maintain consistent moisture and fat levels, and preserve the sensory attributes of khoa (Aneja et al., 2002; Singh & Gandhi, 2015).

Additionally, adoption of Hazard Analysis and Critical Control Points systems helps identify critical stages in production, such as milk reception, heating, cooling, and packaging, where contamination is most likely, enabling targeted interventions. Research indicates that khoa produced under hygienic conditions with proper cooling and storage at 4°C exhibits a prolonged shelf life of 10–14 days compared to 2–3 days for unhygienically produced products stored at ambient temperatures (Walstra et al., 2006; Singh & Gandhi, 2015).

Furthermore, hygienic packaging practices, including vacuum sealing or food-grade wrapping, prevent post-production contamination and moisture absorption, thereby enhancing durability. Regulatory compliance with standards prescribed by the Food Safety and Standards Authority of India, such as monitoring microbial counts and ensuring sanitary premises, further ensures that khoa meets consumer safety and quality expectations. Overall, hygiene practices, encompassing raw material selection, equipment sanitation, personal hygiene, environmental control, and appropriate packaging and storage, collectively determine the microbial, physicochemical, and sensory quality of khoa.

Strengthening hygiene awareness, training personnel, modernizing equipment, and adhering to standardized procedures are essential strategies for maintaining quality, extending shelf life, and enhancing market competitiveness in both domestic and international markets (Aneja et al., 2002; Robinson, 2002; Jay et al., 2005; Singh & Gandhi, 2015).

GOOD MANUFACTURING PRACTICES

Implementation of GMP includes:

- Use of stainless-steel equipment
- Controlled heating temperature
- Clean water supply
- Regular sanitation schedules

These practices reduce total plate count and coliform presence, enhancing product safety (Aneja et al., 2002).

GOOD HYGIENIC PRACTICES

Personal hygiene measures such as gloves, hairnets, clean uniforms, and periodic health check-ups of workers significantly reduce contamination risks.

HACCP IMPLEMENTATION

HACCP identifies critical control points such as:

- Milk reception
- Heating temperature control
- Cooling stage
- Packaging

Systematic monitoring prevents microbial hazards and ensures compliance with regulatory standards.



EFFECT OF HYGIENE ON SHELF LIFE

Microbial growth is the primary factor limiting shelf life. High moisture (30–40%) and nutrient availability make khoa an ideal medium for bacteria, yeast, and mold growth (Walstra et al., 2006). The shelf life of khoa, a heat-desiccated dairy product, is highly sensitive to hygiene practices adopted during its production, handling, and storage. Khoa is rich in moisture (typically 30–40%), proteins, and fats, which provide an ideal environment for microbial proliferation, making it highly perishable (Walstra, Wouters, & Geurts, 2006).

Contamination can occur at multiple stages, beginning with the raw milk. Milk with a high initial microbial load or poor-quality milk containing coliforms and pathogenic bacteria directly affects the shelf stability of the final product (De, 2005). During processing, manual stirring and open pan heating without proper sanitation further expose the product to environmental contaminants, including airborne microbes, dust, and insects. Studies have shown that traditional small-scale manufacturing units that do not follow structured hygiene protocols often produce khoa with high total plate counts, leading to rapid spoilage within 2–3 days at ambient temperature (Aneja, Mathur, Chandan, & Banerjee, 2002).

Conversely, organized dairy units implementing Good Manufacturing Practices Good Hygienic Practices and Hazard Analysis and Critical Control Points achieve a significantly lower microbial load, thereby extending shelf life up to 10–14 days under refrigerated conditions (Singh & Gandhi, 2015). Personal hygiene of workers, including hand washing, use of gloves, hairnets, and clean uniforms, plays a crucial role in reducing contamination with *Staphylococcus aureus* and other pathogenic organisms, which are otherwise responsible for spoilage and health risks (Robinson, 2002).

Equipment hygiene is equally critical; stainless-steel utensils, regular cleaning, and sanitation prevent cross-contamination and support microbial control. Packaging and storage conditions also strongly influence shelf life. Open-air cooling and ambient storage accelerate microbial growth, whereas rapid cooling followed by refrigeration at 4°C significantly slows spoilage (Jay, Loessner, & Golden, 2005). Vacuum or hygienic sealed packaging further prolongs shelf life by minimizing exposure to environmental contaminants.

The impact of hygiene on shelf life is quantifiable: poorly sanitized traditional units typically yield a shelf life of 2–3 days, hygienic production with proper cooling extends it to 10–14 days, and advanced processing with vacuum packaging can increase durability up to 21 days (Singh & Gandhi, 2015). Despite regulatory guidelines provided by the Food Safety and Standards Authority of India under the Food Safety and Standards Act, 2006, small-scale units often struggle with enforcement due to lack of infrastructure and awareness.

Therefore, improving hygiene practices from milk procurement to final packaging—is essential not only for enhancing shelf life but also for ensuring microbiological safety, maintaining sensory quality, and increasing market competitiveness. Modernization of equipment, worker training, adoption of standardized sanitation protocols, and integration of cold chain logistics are necessary strategies to minimize spoilage and maintain consistent quality. Overall, hygiene practices are the single most influential factor determining the shelf stability of khoa, and their systematic implementation can substantially improve both the economic and safety aspects of traditional dairy production.

Hygienic practices combined with refrigeration (4°C) slow microbial growth. Studies report that:

Unhygienic ambient storage → Shelf life 2–3 days

Hygienic production + refrigeration → Shelf life 10–14 days

Vacuum packaging + cold storage → Shelf life up to 21 days (Singh & Gandhi, 2015)

Thus, sanitation and storage practices significantly extend product durability.

COMPARATIVE IMPACT OF HYGIENE PRACTICES

Hygiene Practice	Traditional Units	Hygienic/Organized Units	Impact on Shelf Life	Impact on Quality
Raw Milk Testing	Rare	Mandatory quality testing	Increases by 2–4 days	Improved compositional stability
Equipment	Irregular manual	CIP & sanitization	Reduces spoilage	Lower microbial load



Cleaning	washing	systems	rate	
Personal Hygiene	Minimal protection	Gloves, hairnets, uniforms	Extends by 3–5 days	Reduced pathogen risk
Cooling Method	Open-air cooling	Rapid cooling in clean area	Slows microbial growth	Better texture retention
Packaging	Loose sale	Vacuum/Sealed packs	Extends up to 21 days	Prevents contamination
Storage	Ambient (25–35°C)	Refrigerated (4°C)	Doubles/triples shelf life	Maintains sensory quality

REGULATORY PERSPECTIVE

The Food Safety and Standards Authority of India mandates hygienic processing conditions under the Food Safety and Standards Act (2006). Compliance includes sanitary premises, pest control, potable water use, and periodic microbial testing. However, enforcement in the unorganized sector remains limited due to lack of awareness and infrastructure. The regulation of hygiene practices in khoa manufacturing is crucial for ensuring both product safety and extended shelf life. Khoa, being a highly perishable dairy product, is susceptible to microbial contamination due to its high moisture content, nutrient density, and the predominance of manual processing methods in small-scale units (De, 2005). Recognizing this vulnerability, the Food Safety and Standards Authority of India has established comprehensive guidelines under the Food Safety and Standards Act (FSSA), 2006, emphasizing the adoption of Good Manufacturing Practices and Good Hygienic Practices for traditional dairy products, including khoa. These regulatory standards cover critical aspects such as the quality of raw milk, cleanliness of processing equipment, personal hygiene of handlers, sanitary conditions of processing areas, and safe storage and transportation. By mandating hygienic handling at each stage of production, the regulatory framework aims to minimize microbial load, prevent adulteration, and enhance consumer safety (Aneja et al., 2002).

Specifically, the FSSA requires that raw milk used in khoa production must meet defined quality parameters, including fat content, total solids, and microbial limits. Non-compliance, such as the use of contaminated milk, can significantly reduce the product's shelf life and compromise its organoleptic and nutritional properties (Walstra et al., 2006). Moreover, the regulatory guidelines emphasize equipment sanitation through regular cleaning schedules, use of food-grade materials such as stainless steel, and maintenance of proper heating temperatures during khoa preparation. These measures reduce contamination by coliforms, yeast, molds, and pathogenic bacteria, which are commonly implicated in spoilage and safety hazards (Jay et al., 2005). The enforcement of personal hygiene practices, such as hand washing, use of gloves, hairnets, and clean clothing, is also highlighted, as human handling remains a major vector for microbial introduction in traditional processing setups (Robinson, 2002).

Another key regulatory aspect is post-production handling and storage. The Food Safety and Standards Authority of India mandates rapid cooling, hygienic packaging, and maintenance of cold chain infrastructure wherever feasible. Scientific studies have demonstrated that proper refrigeration (around 4°C) and hygienic packaging can extend the shelf life of khoa from 2–3 days under ambient conditions to 10–14 days or more, while maintaining desirable sensory and nutritional qualities (Singh & Gandhi, 2015). Additionally, HACCP systems are encouraged to systematically identify critical control points such as milk reception, heating, cooling, and packaging stages, enabling proactive mitigation of contamination risks.

Despite clear regulatory frameworks, enforcement remains a challenge in unorganized sectors, which constitute a significant portion of khoa production in India. Small-scale producers often lack awareness, financial capacity, or access to certified laboratories for routine microbial testing. As a result, regulatory interventions must be coupled with capacity-building programs, training initiatives, and cooperative models to ensure compliance and sustainable quality improvement. Strengthening regulatory oversight, promoting mechanization, and integrating hygiene awareness campaigns are critical strategies to enhance the overall quality, safety, and shelf life of khoa in both domestic and export markets.



II. CONCLUSION

Hygiene practices are a decisive factor influencing the quality and shelf life of khoa. Contamination during milk procurement, processing, and post-production handling significantly reduces product stability and safety. Adoption of GMP, GHP, and HACCP systems, along with regulatory compliance under the Food Safety and Standards Authority of India, can substantially enhance microbial quality and extend shelf life. Strengthening hygiene infrastructure, training workers, and modernizing processing units are critical for ensuring sustainable and safe khoa production in India.

REFERENCES

- [1]. Aneja, R. P. (1992). Advances in processing and preservation of khoa. *Indian Dairyman*, 44(12), 567–573.
- [2]. Aneja, R. P., Mathur, B. N., Chandan, R. C., & Banerjee, A. K. (2002). *Technology of Indian milk products*. Dairy India Publication.
- [3]. Arora, K. L., & Srinivasan, M. R. (1972). Studies on the chemical composition and shelf life of khoa. *Indian Journal of Dairy Science*, 25(2), 86–90.
- [4]. Chawla, R., & Balachandran, R. (1994). Technological innovations and hygiene in khoa manufacture. *Dairy Foods International*, 23(6), 34–38.
- [5]. De, S. (2005). *Outlines of dairy technology*. Oxford University Press.
- [6]. Food Safety and Standards Authority of India (2006). *Food Safety and Standards Act*. Government of India.
- [7]. FSSAI. (2006). *Food Safety and Standards Act, 2006*. Government of India.
- [8]. Gupta, S. K., & Reuter, H. (1993). Effect of sanitation on microbial load in traditional khoa. *Indian Dairyman*, 45(8), 345–352.
- [9]. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). *Modern food microbiology* (7th ed.). Springer.
- [10]. Kumar, P., & Sharma, A. (2018). Food safety and quality assurance in traditional dairy products: A review. *International Journal of Dairy Technology*, 71(3), 543–556.
- [11]. Mahajan, P., & Riar, C. S. (2012). Effect of hygienic practices on shelf life of khoa and its derivatives. *Asian Journal of Dairy and Food Research*, 31(2), 123–130.
- [12]. Patel, R. S., & Upadhyay, K. G. (1998). Microbiological quality of market khoa and its improvement strategies. *Indian Journal of Dairy Science*, 51(3), 178–182.
- [13]. Robinson, R. K. (2002). *Dairy microbiology handbook*. Wiley-Interscience.
- [14]. Singh, S., & Gandhi, N. (2015). Quality evaluation and shelf-life studies of khoa. *Journal of Food Science and Technology*, 52(4), 2345–2352.
- [15]. Tamime, A. Y. (2009). *Dairy powders and concentrated products*. Wiley-Blackwell.
- [16]. Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006). *Dairy science and technology*. CRC Press.

