

# Quality Control Measures and Standardization Challenges in Khoa Manufacturing

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**Abstract:** *Khoa is a heat-desiccated traditional dairy product widely used in the preparation of Indian sweets. Despite its economic and cultural importance, khoa manufacturing remains largely unorganized and lacks uniform quality control and standardization practices. Variations in raw milk quality, heating techniques, hygiene practices, storage conditions, and adulteration significantly influence product safety, shelf life, and consumer acceptability. This review examines existing quality control measures in khoa manufacturing, regulatory frameworks, physicochemical and microbiological standards, and the major challenges in standardization.*

*The study highlights the need for technological interventions, adoption of Hazard Analysis and Critical Control Points Good Manufacturing Practices and strict adherence to food safety standards issued by Food Safety and Standards Authority of India. The review further discusses issues related to small-scale production, lack of cold chain infrastructure, adulteration risks, and variability in composition. Strengthening laboratory testing, training of producers, mechanization, and policy support are essential to ensure quality consistency and market competitiveness of khoa in both domestic and international markets*

**Keywords:** Khoa, Quality Control, Standardization, Dairy Processing, Food Safety

## I. INTRODUCTION

Khoa is produced by continuous heating of milk in open pans until it reaches a semi-solid consistency. It serves as a base ingredient for several traditional dairy sweets such as peda, burfi, and gulab jamun. Due to its high moisture and nutrient content, khoa is highly perishable and susceptible to microbial contamination (De, 2005). The absence of standardized manufacturing practices in small-scale and cottage industries leads to significant variations in composition, texture, and microbiological quality (Aneja et al., 2002). With increasing consumer awareness and regulatory scrutiny, quality control and standardization have become critical for ensuring food safety and expanding market potential.

Khoa, also known as mawa, is a heat-desiccated milk product widely used as a base material for numerous traditional Indian sweets such as peda, burfi, and gulab jamun. It is prepared by continuously heating whole milk in open pans until most of the moisture evaporates, resulting in a semi-solid mass rich in fat, protein, lactose, and minerals (De, 2005). Due to its high nutrient density and moisture content, khoa is highly perishable and susceptible to rapid microbial spoilage, making quality control a critical concern in its production and distribution (Jay, 2000). Despite its significant economic contribution to the dairy and sweet-making industries, khoa manufacturing in India remains largely unorganized, characterized by small-scale operations, traditional processing techniques, and limited adherence to standardized quality parameters (Aneja et al., 2002).

Quality control in khoa manufacturing involves monitoring physicochemical, microbiological, and sensory attributes to ensure product safety, uniformity, and consumer acceptability. Physicochemical parameters such as moisture content, fat percentage, titratable acidity, and total solids directly influence texture, shelf life, and overall quality (Walstra, Wouters, & Geurts, 2006). Variations in raw milk composition due to seasonal fluctuations, breed differences, and feeding practices further complicate standardization efforts. In traditional units, manual heating and stirring result in

inconsistent moisture reduction and uneven caramelization, leading to batch-to-batch variability. Moreover, improper hygiene practices, open handling, and lack of temperature control create opportunities for contamination by coliforms, yeasts, molds, and pathogenic bacteria (Jay, 2000).

Regulatory oversight plays a crucial role in ensuring safety and standardization. In India, khoa falls under the compositional and safety standards prescribed by the Food Safety and Standards Authority of India under the Food Safety and Standards Act, 2006. These regulations specify minimum milk fat requirements and prohibit adulteration with non-milk fats, starch, or synthetic substances. However, enforcement remains challenging in the unorganized sector due to limited awareness, inadequate infrastructure, and insufficient laboratory testing facilities. Adulteration practices aimed at economic gain not only compromise nutritional quality but also pose significant health risks (Singh & Gandhi, 2015).

Standardization challenges are further intensified by inadequate cold chain facilities and improper storage conditions. Since khoa has a short shelf life at ambient temperature, lack of refrigeration during transportation and marketing leads to rapid spoilage and economic losses. While organized dairy plants have introduced mechanized khoa-making equipment, steam-jacketed kettles, hygienic stainless-steel processing systems, and Hazard Analysis and Critical Control Points (HACCP)-based monitoring, such technologies are not widely adopted in small-scale units (Aneja et al., 2002). The gap between traditional practices and modern quality assurance systems creates inconsistencies in product quality and limits export potential.

Therefore, ensuring robust quality control measures and overcoming standardization challenges in khoa manufacturing is essential for protecting consumer health, enhancing market competitiveness, and supporting sustainable growth of the dairy sector. Strengthening regulatory compliance, promoting Good Manufacturing Practices and encouraging technological modernization are key strategies to achieve uniformity and safety in khoa production.

### **PHYSICOCHEMICAL QUALITY PARAMETERS**

Quality assessment of khoa primarily involves physicochemical parameters such as moisture, fat content, protein, acidity, and total solids. According to dairy science standards, moisture content typically ranges between 30–40%, depending on the type of khoa (pindi, danedar, dhap). Excess moisture reduces shelf life and promotes microbial growth (Walstra et al., 2006). Adulteration with starch, synthetic milk, or non-milk fats alters the nutritional composition and compromises safety (Singh & Gandhi, 2015). Routine laboratory analysis including titratable acidity, fat estimation (Gerber method), and total plate count is recommended for maintaining quality consistency.

Physicochemical quality parameters play a central role in ensuring consistency, safety, and consumer acceptability in khoa manufacturing. Khoa is obtained by continuous heating of milk until partial desiccation, resulting in a semi-solid mass rich in milk solids. The primary physicochemical attributes evaluated in khoa include moisture content, fat percentage, protein composition, titratable acidity, pH, lactose content, ash, and total solids. Among these, moisture content is the most critical determinant of texture, shelf life, and microbial stability.

Typically, khoa contains approximately 30–40% moisture depending on the variety such as pindi, danedar, or dhap. Higher moisture levels accelerate microbial growth and enzymatic spoilage, whereas excessively low moisture may result in hard texture and reduced palatability (De, 2005). Therefore, precise control of heating temperature and duration is essential to achieve optimal moisture balance and standardization across batches.

Fat content significantly influences the body, texture, and flavor profile of khoa. Since khoa is a concentrated milk product, fat content usually ranges between 20–25%, depending on the quality of milk used. Variability in raw milk fat percentage, seasonal fluctuations, and improper standardization practices often lead to inconsistent product characteristics (Aneja et al., 2002). Standardization of milk prior to heating by adjusting fat and solids-not-fat levels is a recommended quality control measure to maintain uniformity.

Protein concentration, particularly casein and whey proteins, contributes to the structural matrix of khoa. Excessive heat treatment may cause protein denaturation and Maillard browning reactions, altering color and flavor (Walstra, Wouters, & Geurts, 2006). Hence, temperature regulation through steam-jacketed kettles or mechanized khoa-making machines improves physicochemical stability compared to traditional open-pan systems.

Titrate acidity and pH are additional indicators of product freshness and microbial quality. Fresh khoa generally exhibits a slightly acidic pH around 6.3–6.5. An increase in acidity indicates lactose fermentation and microbial activity, leading to sourness and reduced shelf life (Jay, 2000). Routine acidity testing through titration methods serves as a rapid and economical quality control tool, particularly in organized dairy units.

Ash content reflects the mineral composition and helps detect dilution or adulteration. One of the major standardization challenges in khoa manufacturing is adulteration with starch, synthetic milk, or non-milk fats to increase bulk and profitability. Such adulteration alters carbohydrate and fat composition and can be detected through physicochemical tests including iodine test for starch and butyro-refractometer readings for fat purity (Singh & Gandhi, 2015).

The regulatory framework provided by the Food Safety and Standards Authority of India prescribes compositional standards for milk fat and prohibits the use of non-permitted additives in khoa. However, implementation remains inconsistent in the unorganized sector due to limited laboratory access and lack of technical awareness. Moreover, absence of uniform heating protocols, variability in milk quality, and non-standardized packaging practices further complicate physicochemical consistency. Modern analytical techniques such as infrared spectroscopy, texture profile analysis, and moisture analyzers offer improved precision but are often inaccessible to small-scale producers.

Maintaining physicochemical quality parameters is fundamental to quality control and standardization in khoa manufacturing. Effective milk standardization, controlled heating, routine laboratory testing, and strict adherence to regulatory standards are essential to overcome variability and adulteration challenges. Strengthening infrastructure and promoting technological adoption can significantly enhance uniformity, safety, and market competitiveness of khoa products.

#### **MICROBIOLOGICAL QUALITY CONTROL**

Microbial contamination is a major concern due to open pan heating and manual handling practices. Common contaminants include coliforms, yeast, molds, and pathogenic bacteria such as *Salmonella* and *Staphylococcus aureus* (Jay, 2000). Implementation of Microbiological quality control is a critical component of quality assurance in khoa manufacturing because khoa is a high-moisture, nutrient-dense dairy product that provides an ideal medium for microbial growth.

Although the traditional preparation process involves prolonged heating of milk, which destroys many vegetative microorganisms, post-processing contamination frequently occurs due to manual handling, open pan heating, and exposure to ambient environments (De, 2005). The microbial quality of khoa is generally assessed through total plate count coliform count, yeast and mold count, and detection of pathogenic organisms such as *Staphylococcus aureus*, *Salmonella* spp., and *Escherichia coli* (Jay, 2000). High microbial loads not only reduce shelf life but also pose significant public health risks, particularly when khoa is used as a base material for sweets that may not undergo further heat treatment.

In traditional and small-scale production units, lack of hygienic infrastructure and absence of systematic sanitation protocols contribute significantly to microbial contamination (Aneja et al., 2002). The use of unpasteurized milk, contaminated water, improperly cleaned utensils, and direct hand contact during stirring and shaping increase the risk of bacterial proliferation. Furthermore, ambient storage conditions in warm climates accelerate microbial growth, making refrigeration essential for maintaining safety and extending shelf life. Studies indicate that storing khoa at 4°C significantly reduces microbial multiplication compared to storage at room temperature (Walstra et al., 2006).

To address these concerns, microbiological quality control must begin at the raw milk stage. Standardization of milk through pasteurization, filtration, and quality testing for initial microbial load is a fundamental preventive measure. Implementation of Good Manufacturing Practices and Good Hygienic Practices ensures sanitation of equipment, proper personal hygiene of workers, and controlled processing environments. Adoption of Hazard Analysis and Critical Control Points (HACCP) systems helps identify critical contamination points such as milk reception, heating temperature control, cooling phase, and packaging operations. By monitoring these critical control points, producers can significantly minimize contamination risks and ensure product consistency (Jay, 2000).

Regulatory oversight by the Food Safety and Standards Authority of India under the Food Safety and Standards Act, 2006, mandates adherence to microbiological safety criteria and prohibits the sale of contaminated dairy products.

However, effective enforcement remains challenging in the unorganized sector, where laboratory testing facilities are limited and awareness regarding microbial standards is inadequate. Routine microbial analysis, including TPC and pathogen screening in accredited laboratories, is essential for ensuring compliance and maintaining consumer confidence.

Despite technological advancements in organized dairy plants, standardization challenges persist due to variability in processing methods and inconsistent hygiene practices across regions. Continuous khoa-making machines and closed processing systems reduce environmental exposure and improve microbiological quality, yet their adoption remains limited due to financial constraints. Therefore, strengthening microbiological quality control in khoa manufacturing requires integrated efforts involving technological modernization, capacity building of small producers, expansion of cold chain infrastructure, and strict regulatory implementation. Enhanced surveillance, training programs, and affordable testing mechanisms can bridge the gap between traditional practices and standardized food safety requirements, ultimately improving product safety, shelf life, and market acceptability.

### **REGULATORY STANDARDS AND COMPLIANCE**

In India, khoa quality and safety are regulated by the Food Safety and Standards Authority of India under the Food Safety and Standards Act, 2006. The authority prescribes compositional standards for milk fat and prohibits adulteration.

However, enforcement challenges persist in unorganized sectors due to:

Lack of licensing

Limited laboratory testing facilities

Poor awareness among small producers

Standardization efforts also include ISO certification and FSSAI licensing for organized dairy units.

### **STANDARDIZATION CHALLENGES IN KHOA MANUFACTURING**

Standardization in khoa manufacturing remains a significant challenge due to the predominance of small-scale, unorganized production systems and the inherent variability in traditional processing methods. Khoa is produced by continuous open-pan heating of milk until semi-solid consistency is achieved, but the absence of precise temperature control and standardized time-temperature combinations leads to batch-to-batch variation in moisture, fat concentration, texture, and color (De, 2005).

Seasonal fluctuations in milk composition particularly fat and solids-not-fat content further contribute to inconsistency in the final product, making it difficult to maintain uniform physicochemical standards (Walstra, Wouters, & Geurts, 2006). Unlike organized dairy sectors that adopt steam-jacketed kettles and mechanized stirring systems, many traditional units rely on manual heating and subjective judgment to determine end-point consistency, which compromises reproducibility and product uniformity (Aneja et al., 2002).

Another major standardization challenge lies in ensuring microbiological safety. Although khoa is subjected to high heat during preparation, post-processing contamination frequently occurs due to poor hygienic handling, exposure to open environments, and inadequate packaging practices. The lack of implementation of Good Manufacturing Practices Good Hygienic Practices and Hazard Analysis and Critical Control Points systems increases the risk of contamination by coliforms, yeasts, molds, and pathogenic bacteria (Jay, 2000). In the unorganized sector, limited access to microbiological testing facilities further weakens routine quality monitoring. Consequently, maintaining standardized microbial limits across production units becomes difficult, affecting shelf life and consumer safety.

Adulteration also poses a serious obstacle to standardization. Economic incentives often drive producers or intermediaries to add starch, non-milk fats, or synthetic milk components to increase volume and profit margins. Such practices alter compositional standards and undermine consumer trust (Singh & Gandhi, 2015). Although regulatory oversight is provided by the Food Safety and Standards Authority of India under the Food Safety and Standards Act, enforcement remains inconsistent, especially in rural and semi-urban markets where informal trade dominates. Limited awareness among small producers regarding regulatory norms, licensing requirements, and quality specifications further exacerbates the problem.

Storage and distribution infrastructure add another layer of complexity. Khoa has high moisture content and is highly perishable, yet it is frequently transported and marketed without refrigeration. The absence of an efficient cold chain system leads to rapid microbial growth, fat oxidation, and texture deterioration, making it difficult to maintain standardized quality from production to retail (Aneja et al., 2002). In addition, variations in packaging from loose bulk sale to vacuum-sealed packs result in differing exposure to environmental contaminants and shelf-life variability.

Financial and technological constraints also limit modernization efforts. Small producers often lack capital to invest in automated equipment, quality testing laboratories, or standardized packaging systems. As a result, achieving uniform compliance with compositional, microbiological, and safety standards across the sector remains a persistent challenge. Addressing these issues requires integrated interventions including mechanization, training programs, strengthened regulatory enforcement, and the adoption of quality assurance systems. Without systematic standardization measures, maintaining consistent quality control in khoa manufacturing will continue to be difficult despite its strong market demand and cultural significance.

### **VARIABILITY IN RAW MILK**

Seasonal variations in milk composition affect final product consistency (Walstra et al., 2006). Variability in raw milk is one of the most critical factors influencing quality control and standardization in khoa manufacturing. Since khoa is produced by concentrating milk through continuous heating, the physicochemical composition of raw milk particularly fat, solids-not-fat protein, lactose, and mineral content directly determines the yield, texture, flavor, and shelf life of the final product.

Seasonal fluctuations, breed differences, feeding practices, stage of lactation, and regional climatic conditions significantly affect milk composition (Walstra, Wouters, & Geurts, 2006). For instance, milk obtained during winter generally contains higher fat and total solids compared to summer milk, resulting in higher khoa yield and improved body and texture. In contrast, milk with lower fat or diluted solids produces softer, less cohesive khoa with inferior sensory attributes. Such inherent variability poses a major challenge in achieving consistent quality, particularly in small-scale and unorganized manufacturing units where milk standardization is rarely practiced (Aneja et al., 2002).

From a quality control perspective, inconsistent fat-to-SNF ratios can lead to variations in moisture retention and caramelization during heating. Since khoa preparation involves prolonged heat treatment, even minor differences in lactose concentration can influence Maillard browning reactions, affecting color and flavor development (De, 2005). Excess acidity in raw milk, often caused by delayed collection or inadequate chilling at the farm level, accelerates protein coagulation and may result in grainy or coarse texture in khoa. Moreover, microbial load in raw milk is another crucial variable. High initial bacterial counts due to poor hygienic milking practices increase the risk of spoilage and reduce product shelf life, even after heat concentration (Jay, 2000). Although heating reduces microbial populations, heat-resistant spores and post-processing contamination remain concerns, particularly when raw milk quality is substandard.

Standardization challenges are further intensified by the fragmented milk procurement system in India, where milk is sourced from multiple smallholders with varying quality standards. In many traditional khoa-producing clusters, milk is purchased based on volume rather than compositional quality, and systematic testing for fat and SNF is often absent. The lack of chilling infrastructure during transportation allows microbial proliferation, increasing titratable acidity and compromising heat stability. According to guidelines prescribed by the Food Safety and Standards Authority of India, milk used for manufacturing dairy products must comply with defined compositional and microbiological standards; however, enforcement remains inconsistent in unorganized sectors. Without proper raw milk grading and standardization such as adjusting fat content through cream separation or blending maintaining uniformity in khoa texture, color, and yield becomes difficult.

Modern quality control systems recommend routine platform tests, including lactometer reading, fat estimation (Gerber method), clot-on-boiling test, and acidity measurement before processing (Aneja et al., 2002). Adoption of bulk milk coolers and rapid microbial detection methods can significantly reduce variability-related risks. Mechanized khoa production units often standardize milk to predetermined fat levels to ensure uniform concentration and consistent final solids.

However, the cost of equipment and lack of technical awareness limit widespread adoption among small producers. Thus, variability in raw milk composition and quality remains a fundamental constraint in achieving standardization in khoa manufacturing. Strengthening farm-level hygiene, implementing cold chain systems, and enforcing regulatory compliance are essential measures to minimize variability and enhance overall product quality and safety.

**1. Traditional Processing Techniques**

Manual stirring and open heating cause uneven moisture reduction and caramelization variability.

**2. Lack of Mechanization**

Most khoa is produced in small-scale units without automated temperature control systems.

**3. Adulteration Practices**

Economic adulteration with starch or low-quality milk reduces product authenticity and consumer trust (Singh & Gandhi, 2015).

**4. Inadequate Cold Chain Infrastructure**

Improper storage and transportation accelerate spoilage.

**QUALITY CONTROL MEASURES IN ORGANIZED SECTOR**

Modern dairy plants adopt:

Steam-jacketed kettles

Continuous khoa-making machines

Automated temperature regulation

Hygienic stainless-steel equipment

Vacuum packaging

Such technological interventions improve consistency, reduce contamination, and enhance shelf life.

**COMPARATIVE OVERVIEW OF QUALITY CONTROL MEASURES**

Quality Parameter	Traditional Units	Organized Dairy Units	Recommended Standard
Milk Source	Unstandardized	Quality-tested milk	Standardized fat & SNF
Heating Method	Open pan	Steam-jacketed kettle	Controlled temperature
Hygiene Level	Manual handling	GMP & HACCP	FSSAI compliance
Microbial Testing	Rare	Regular lab testing	TPC within safe limits
Packaging	Loose sale	Vacuum/Sealed packs	Hygienic packaging
Storage	Ambient	Refrigerated (4°C)	Cold chain required

**STRATEGIES FOR IMPROVING STANDARDIZATION**

Training and capacity building of small producers

Establishment of regional quality testing laboratories

Financial support for mechanization

Strengthening regulatory inspections

Promotion of cooperative dairy models

Integration of digital traceability systems can also enhance transparency and consumer confidence.

**II. CONCLUSION**

Quality control and standardization in khoa manufacturing are essential to ensure product safety, uniformity, and market competitiveness. While organized dairy units have adopted advanced technologies and regulatory compliance measures, the unorganized sector continues to face significant challenges related to hygiene, adulteration, and lack of standardization. Effective implementation of GMP, HACCP, and regulatory guidelines by the Food Safety and Standards Authority of India is crucial. Policy support, technological modernization, and awareness programs can

significantly enhance the quality profile of khoa production in India. Future research should focus on extending shelf life, developing rapid adulteration detection methods, and improving cold chain logistics.

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