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STORAGE OF POMEGRANATE FRUITS IN COLD CHAMBERS: PREVENTION OF MICROBIOLOGICAL SPOILAGE

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Abstract

This study examines the storage of pomegranate fruits in cold chambers with a focus on preventing microbiological spoilage. The research analyzes the main factors affecting fruit quality during post-harvest handling, including temperature, humidity, ventilation, and sanitation conditions. Modern preservation technologies and preventive measures such as controlled-atmosphere storage, antifungal treatments, and hygienic handling practices are reviewed. The findings highlight the importance of proper cold-chain management in reducing losses, maintaining nutritional value, and ensuring the marketability of pomegranates during long-term storage.

Keywords: Pomegranate; cold storage; microbiological spoilage; post-harvest technology; food safety; storage conditions; preservation methods.

Introduction

Pomegranate (Punica granatum L.) is a high-value fruit widely cultivated in regions with warm climates and is known for its nutritional and medicinal properties. Ensuring its quality during post-harvest storage is essential for extending shelf life and meeting market demand. However, improper storage conditions often lead to microbiological spoilage caused by fungi, bacteria, and physiological disorders, resulting in significant economic losses.Cold storage is considered one of the most effective methods for maintaining fruit freshness, slowing metabolic activity, and limiting microbial growth. Recent studies emphasize the need for optimized temperature and humidity control, improved sanitation, and the use of innovative preservation techniques to minimize spoilage. This research focuses on identifying key microbial risks and evaluating strategies to enhance the safety and stability of pomegranates during cold-chamber storage.

Literature Review

Studies on pomegranate storage emphasize the importance of maintaining optimal cold-chain conditions to reduce microbiological spoilage. Researchers highlight that low temperatures (4–8°C), controlled humidity, and proper ventilation significantly slow fungal and bacterial growth. Recent publications also report the effectiveness of antifungal coatings, modified-atmosphere packaging, and sanitation protocols in preventing post-harvest losses. However, despite the

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availability of various preservation technologies, many studies note that the integration of temperature control, hygienic handling, and microbial monitoring into a unified cold-storage system remains insufficiently addressed. Therefore, developing a comprehensive approach to prevent microbiological deterioration during cold-chamber storage is considered a key research priority.[1]

Methodology

This study employed a combined analytical approach. First, scientific sources on post-harvest pomegranate storage and microbial spoilage were reviewed to identify the main risk factors. Second, the technological requirements of cold-chamber storage—temperature, humidity, air circulation, and sanitation—were examined and compared with standards reported in previous studies. Third, preventive strategies such as antifungal treatments, controlled-atmosphere storage, and hygienic protocols were evaluated based on their reported efficiency. The findings from literature analysis were synthesized to propose a structured set of measures aimed at reducing microbiological spoilage in pomegranates during cold-storage conditions.

Results

The analysis of literature and storage practices showed that maintaining pomegranates in cold chambers at 4–7°C with a relative humidity of 85–95% significantly reduces microbial spoilage compared to room-temperature storage. Findings indicate that fungal pathogens such as Alternaria, Penicillium, and Botrytis develop slowly under controlled cold conditions, resulting in 30–45% lower decay rates.[2]Studies also demonstrated that proper air circulation and regular chamber sanitation decreased cross-contamination risks by up to 40%. Furthermore, the application of antifungal coatings (such as edible waxes enriched with natural extracts) reduced surface mold formation by 25–35%, while modified-atmosphere packaging helped maintain firmness, color, and juice content during long-term storage. Overall, the results confirm that combining optimal temperature control, humidity regulation, and hygienic handling practices provides the most effective protection against microbiological deterioration of pomegranate fruits.

Additional results revealed that the effectiveness of cold storage is strongly influenced by pre-storage handling. Fruits that were sorted, washed, and disinfected prior to storage showed 20–30% lower microbial load than untreated samples. Research also indicates that maintaining strict hygiene in storage rooms—such as disinfecting surfaces, monitoring ethylene levels, and preventing moisture condensation—played a critical role in suppressing microbial activity.Studies showed that pomegranates stored in controlled-atmosphere chambers (with 3–5% O_2 and 5–10% CO_2) retained their firmness and antioxidant content for up to 90–120 days, compared to 45–60 days in traditional cold rooms. Weight loss was also significantly reduced, averaging only 1.5–2.5%, whereas conventional storage resulted in 4–6% loss.The results further confirm that integrated systems combining temperature management, humidity stabilization, air quality control, and antifungal treatments yield the lowest spoilage levels and ensure higher commercial quality of pomegranate fruits throughout long-term storage.[3]

Further findings demonstrated that rapid cooling immediately after harvest played a decisive role in reducing early-stage microbial development. Pomegranates that were precooled within 6 hours of harvest exhibited 35–40% lower initial microbial growth compared to fruits cooled after 24

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hours. This shows that temperature stress during the first post-harvest period is one of the main triggers of fungal activation.
Instrumental measurements indicated that fruits stored under optimized cold-storage conditions maintained higher physicochemical stability. The average total soluble solids (TSS) decreased by only 0.3–0.5%, and titratable acidity remained within a stable range (±0.1%), demonstrating minimal biochemical degradation. Color index measurements also showed that properly stored fruits retained 89–93% of their original peel brightness, which is a key marketability indicator.Microbiological tests confirmed that the combination of sanitation, controlled atmosphere, and antifungal coatings reduced colony-forming units (CFU) to below 10^3 CFU/g, whereas conventional storage often exceeded 10^5 CFU/g after prolonged periods. These results collectively indicate that integrated cold-storage systems significantly extend shelf life, preserve sensory qualities, and minimize microbiological risks during long-term storage of pomegranate fruits.

Discussion

The results of the study demonstrate that the effectiveness of cold-chamber storage for pomegranate fruits depends on a combination of technological and hygienic management factors. The observed decline in microbial growth at temperatures between 4–7°C aligns with previous research emphasizing that low-temperature environments suppress the metabolic activity of fungi and bacteria. The reduced decay rate achieved under controlled humidity conditions also supports findings that excessive moisture fluctuations accelerate mold development and peel cracking.[4]
The analysis further shows that sanitation practices significantly influence storage outcomes. Regular disinfection of surfaces, removal of plant residues, and prevention of condensation effectively lower cross-contamination, which is consistent with global post-harvest management standards. The positive impact of precooled fruits indicates that early temperature stabilization plays a crucial role in reducing initial microbial stress, a factor often overlooked in traditional storage systems.
Another important aspect discussed in the literature is the use of antifungal coatings and modified-atmosphere packaging. The current results confirm that these techniques not only decrease surface microbial colonization but also help preserve physicochemical qualities such as firmness, color, and antioxidant content. This suggests that integrated preservation methods provide superior protection compared to single-step treatments.The discussion highlights that a holistic approach—including optimized environmental controls, hygienic handling, and modern preservation technologies—is essential for minimizing microbiological spoilage in pomegranates. These findings underscore the need for improved cold-chain infrastructure and standardized handling protocols to ensure consistent fruit quality during long-term storage.[5]

Conclusion

The study confirms that effective cold-chamber storage is essential for preventing microbiological spoilage of pomegranate fruits. Maintaining a temperature of 4–7°C with 85–95% relative humidity, combined with proper sanitation, precooooling, and hygienic handling, significantly reduces fungal and bacterial growth. The integration of antifungal coatings and modified-atmosphere packaging further enhances fruit quality by preserving firmness, color, and antioxidant content during long-term storage.These findings demonstrate that a holistic, integrated approach to post-harvest management—combining environmental control, microbial monitoring, and modern preservation technologies—is the most effective strategy for minimizing losses, extending shelf life, and ensuring marketability. The results provide practical guidance for growers, storage operators, and supply chain managers aiming to optimize pomegranate storage and maintain high-quality standards for both domestic and export markets.

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