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SCIENTIFIC TECHNOLOGY OF CONVECTIVE DRYING OF PLUM FRUITS

Gulistan State University
Head of the Department of
Production Technologies,
Associate Professor
To'raqulov Mamaraym
Gulistan State University
2nd year Master's student
Eshquvvatov Jasur
jasureshquvvatov11@gmail.com

Annotation. This article presents a comprehensive scientific analysis of the technology of convective drying of plum (Prunus domestica L.) fruits. Convective drying is considered one of the most widely used and economically feasible dehydration methods in the agro-processing industry due to its relative simplicity, scalability, and adaptability to various climatic and production conditions. The study focuses on the physicochemical, thermodynamic, and kinetic principles underlying convective drying, with particular emphasis on moisture migration mechanisms, heat and mass transfer phenomena, quality preservation, and energy efficiency. The relevance of convective drying technology for extending the shelf life of plums, reducing post-harvest losses, and producing high-value dried products is critically evaluated. Existing challenges in conventional drying practices are identified, and scientifically grounded solutions are proposed. The article provides methodological approaches, analytical discussion, and practical recommendations aimed at optimizing drying parameters to ensure high nutritional, sensory, and technological quality of dried plum products.

Keywords: plum fruit, convective drying, dehydration technology, heat and mass transfer, moisture diffusion, drying kinetics, food quality, energy efficiency.

Introduction. Plum fruit (Prunus domestica L.) is one of the most important stone fruits cultivated in temperate regions and widely consumed in both fresh and processed forms. Due to its high moisture content, typically ranging from 78 to 88 percent depending on cultivar and maturity stage, fresh plums are highly perishable and susceptible to rapid microbial spoilage and physiological degradation after harvest.[1] Drying represents one of the oldest and most effective preservation methods, allowing significant extension of shelf life while maintaining nutritional value and sensory attributes. Among various drying techniques, convective drying remains the most commonly applied method in industrial and semi-industrial food processing. Convective drying involves the removal of moisture from biological materials through the application of heated air flowing over the product surface. The driving force of the process is the difference in vapor pressure between the wet material and the surrounding air. For plums, convective drying is particularly relevant due to their structural characteristics, sugar content, organic acids, and bioactive compounds such as phenolics and antioxidants. Understanding the scientific and technological foundations of convective drying is essential for improving product quality, minimizing energy consumption, and enhancing process efficiency.

Relevance of the topic. The relevance of convective drying of plum fruits is closely linked to global challenges in food security, sustainable agriculture, and reduction of post-harvest losses. In many plum-producing countries, including Uzbekistan, a significant

[1] Ganiev, S., & Rahmonov, A. (2015). Technology of Drying Agricultural Products. Tashkent: Fan Publishing House.

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proportion of harvested fruit is lost due to insufficient processing and storage infrastructure. Convective drying provides an accessible and cost-effective solution that can be implemented at different scales, from small farms to industrial enterprises. Furthermore, consumer demand for natural, minimally processed, and shelf-stable fruit products is increasing worldwide. Dried plums, commonly known as prunes, are valued for their high dietary fiber content, antioxidant activity, and functional health benefits. Optimizing convective drying technology contributes to the production of high-quality dried plums that meet international standards and market requirements.[2]

Problem statement. Despite the widespread use of convective drying, several technological and scientific problems remain unresolved. Traditional drying practices often lead to uneven moisture removal, excessive shrinkage, surface hardening, color darkening, and degradation of heat-sensitive nutrients such as vitamin C and phenolic compounds. Inadequate control of drying parameters, including air temperature, velocity, and relative humidity, results in low energy efficiency and inconsistent product quality. Another major problem is the lack of scientifically optimized drying regimes tailored to specific plum varieties and their physicochemical properties. Many producers rely on empirical methods without sufficient understanding of drying kinetics and internal moisture diffusion mechanisms. This limits the potential for process optimization and innovation.

Methodology. The methodological framework of this study is based on a comprehensive analysis of scientific literature, experimental data, and theoretical models related to convective drying of fruits. The methodology includes the evaluation of heat and mass transfer principles, drying kinetics modeling, and quality assessment parameters. Theoretical approaches such as Fick's second law of diffusion, thin-layer drying models, and empirical kinetic equations are considered to describe moisture removal behavior in plum tissues. In addition, the article integrates findings from experimental studies conducted under controlled convective drying conditions, focusing on the influence of air temperature (40–80 °C), air velocity (0.5–3.0 m/s), and relative humidity on drying rate, energy consumption, and product quality. Quality indicators such as moisture content, water activity, color parameters, texture, and retention of bioactive compounds are analyzed.

Scientific basis of convective drying. The convective drying process of plums is governed by simultaneous heat and mass transfer between the drying medium and the product. Initially, heat is transferred from hot air to the plum surface through convection, increasing surface temperature and causing moisture evaporation. Subsequently, internal moisture migrates toward the surface due to concentration gradients, capillary forces, and diffusion mechanisms. The drying process typically consists of a short constant-rate period followed by a longer falling-rate period. For plums, the falling-rate period dominates due to the presence of a waxy skin and high sugar content, which increase resistance to moisture diffusion. Understanding this behavior is crucial for designing effective drying strategies. Convective drying relies on the principles of heat and mass transfer to remove moisture. The transfer of heat via the hot air stream causes water to evaporate, while air velocity helps carry away the humid air.

Technological aspects of convective drying. From a technological perspective, convective dryers used for plums include cabinet dryers, tunnel dryers, belt dryers, and tray

[2] Ismoilov, J. (2016). Drying Processes of Agricultural Raw Materials. Samarkand: Zarafshon Publishing.

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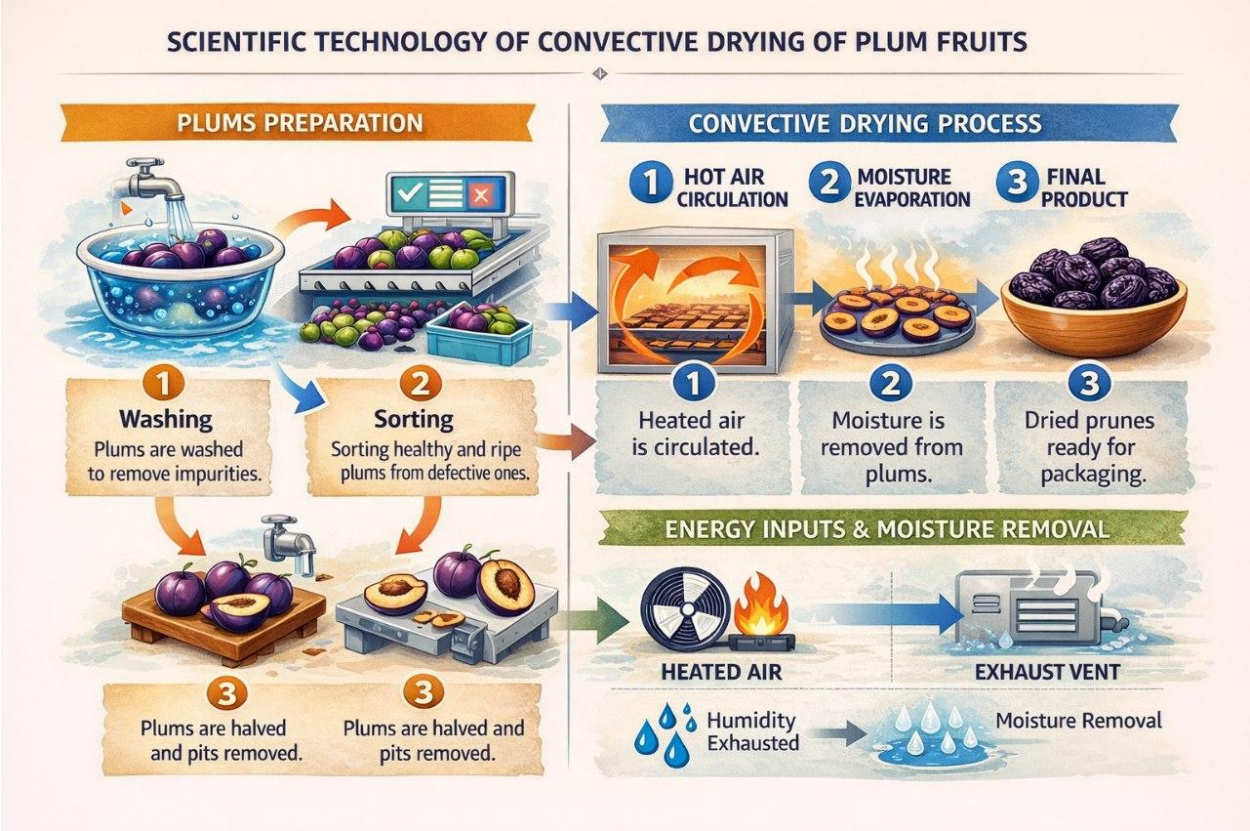
dryers. The choice of equipment depends on production scale, desired product quality, and available energy resources. Pre-treatment methods such as blanching, chemical dipping, or mechanical skin perforation are often applied to enhance drying efficiency by reducing skin resistance and accelerating moisture removal. Temperature control is one of the most critical technological parameters. Low drying temperatures preserve quality but prolong drying time, while high temperatures increase drying rate but risk thermal damage.[3] Therefore, multi-stage or variable-temperature drying regimes are increasingly recommended to balance efficiency and quality preservation. The plums are placed in a single layer on trays and moved into the convective dryer. The drying process occurs in stages over a total time of 12 to 24 hours for plum halves, which may be longer or shorter depending on the drying temperature and the specific pretreatment applied.

Solutions and optimization strategies. To address the identified problems, several scientifically grounded solutions are proposed. These include the application of optimized drying schedules based on drying kinetics modeling, the use of pre-treatment techniques to improve moisture diffusivity, and the integration of real-time monitoring and control systems. Advanced modeling tools and simulation software can be used to predict drying behavior and optimize process parameters. Additionally, hybrid drying systems combining convective drying with infrared or heat pump technologies offer promising opportunities for improving energy efficiency and product quality.



Scientific recommendations and practical suggestions. Based on the analysis, it is recommended to adopt cultivar-specific drying protocols that consider the unique physicochemical properties of different plum varieties. Drying air temperature should be

[3] Karimov, B. (2018). Food Processing Technologies. Tashkent: Economics and Finance Publishing.

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maintained within an optimal range to minimize nutrient loss while ensuring microbiological safety. The use of moderate air velocities and controlled humidity levels can significantly improve drying uniformity. Furthermore, training programs for producers and processors should be implemented to disseminate scientific knowledge and best practices in convective drying technology. Investment in modern drying equipment and quality control systems is also essential for enhancing competitiveness in international markets.

Conclusion. Convective drying remains a cornerstone technology for the preservation and value addition of plum fruits. A scientific understanding of heat and mass transfer processes, drying kinetics, and quality changes is essential for optimizing this technology. By addressing existing challenges and implementing scientifically based solutions, it is possible to produce high-quality dried plums with improved nutritional, sensory, and economic value. The findings and recommendations presented in this article contribute to the advancement of convective drying technology and its sustainable application in the agro-food sector.

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