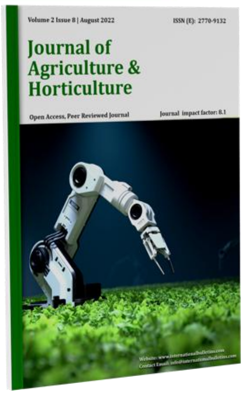

COMPARATIVE ANALYSIS OF CONVECTIVE, INFRARED, AND MICROWAVE DEHYDRATION TECHNIQUES ON THE DRYING KINETICS, PRODUCT YIELD, AND ORGANOLEPTIC QUALITY OF SWEET CHERRY CULTIVARS IN UZBEKISTAN

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Abstract. This study investigates the technological feasibility and qualitative outcomes of processing two commercially significant sweet cherry cultivars, 'Volovye Serdse' and 'Drogana Jeltaya' in Uzbekistan, utilizing three distinct drying methodologies: convective, infrared, and microwave dehydration. The experiment analyzed the impact of fruit morphology – specifically comparing whole fruits versus fruits with stones removed – on drying duration, final product yield, and organoleptic quality. Results indicate that the convective drying of stoneless 'Drogana Jeltaya' samples exhibited the most favorable balance of processing efficiency (43.7 hours) and sensory quality (4.8/5.0 points). Conversely, microwave drying of whole fruits necessitated the most prolonged processing times (up to 89.4 hours), negatively correlating with quality scores in the 'Volovye Serdse' variety. This paper discusses the thermodynamic and physiochemical implications of these findings for industrial fruit processing.

Key words: sweet cherry, Convective, Infrared, Microwave dryers, yield of dried products.

1. Introduction. The preservation of sweet cherries (*Prunus avium* L.) represents a significant challenge in the post-harvest sector due to the fruit's high moisture content, intense respiration rate, and susceptibility to fungal pathogens and mechanical damage immediately following harvest. While fresh market distribution remains the primary avenue for monetization, the development of value-added dried products offers a strategic solution for utilizing surplus harvest and extending shelf life. However, the selection of an appropriate dehydration technique is critical, as the application of heat can induce detrimental changes in the phytochemical profile, textural integrity, and chromatic characteristics of the sensitive fruit tissue.

Traditional convective drying, while widely adopted, is often criticized for its high energy consumption and long duration, potentially leading to oxidative degradation. Emerging technologies, such as infrared radiation—which transfers energy directly to the water molecules within the product—and microwave drying—which relies on volumetric heating through ionic conduction and dipole rotation—have been proposed as alternatives to accelerate mass transfer. This study aims to provide a comparative evaluation of these three drying kinetics, focusing specifically on how the interaction between the drying method and the cultivar's biological structure (specifically the presence of the endocarp) influences the final yield and consumer acceptability of the dried product.

2. Materials and Methods. Plant Material. Fresh sweet cherry fruits of the varieties 'Volovye Serdse' (characterized by a deep red hue and heart-shaped morphology) and 'Drogana

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Jeltaya' (a yellow-fruited variety noted for its firmness) were harvested at commercial maturity. The fruits were sorted to ensure uniformity in size and freedom from physical defects.

Sample Preparation. The raw material was divided into two experimental groups based on mechanical pre-treatment: pitted (whole/stone-in) – fruits processed intact, retaining the endocarp (stone), ostensibly to study the resistance to moisture diffusion presented by the fruit skin and stone. Stoneless (stone-removed) – fruits subjected to mechanical de-stoning, thereby exposing the internal mesocarp directly to the drying medium and increasing the surface area for evaporation.

Drying Protocols. The prepared samples were subjected to three drying treatments until a stable moisture content was achieved: Convective Drying – carried out in a forced-air tunnel dryer with controlled temperature and airflow velocity, Infrared Drying – utilized ceramic infrared emitters designed to penetrate the fruit surface; Microwave Drying – conducted in a variable-power microwave unit designed for dehydration applications.

Statistical Analysis. Data regarding the duration of the drying cycle (hours), the final yield of the dried product (calculated as a percentage of the initial fresh weight), and organoleptic quality (assessed by a sensory panel on a 5-point scale) were recorded and analyzed to determine significant variances between treatments.

3. Results and Discussion. Analysis of Drying Kinetics and Temporal Efficiency The experimental data reveals a profound disparity in drying times heavily influenced by both the physical state of the raw material and the dehydration mechanism employed. Consistently, across all three drying modalities, the removal of the stone significantly accelerated the dehydration process.

In the case of the 'Volovye Serdse' variety, the transition from the whole form to the stoneless form resulted in a reduction of drying time by 26% in the convective dryer (falling from 71.4 to 52.8 hours), 26.4% in the infrared dryer, and 27.6% in the microwave dryer. This kinetic behavior suggests that the waxy cuticle of the cherry skin, combined with the dense endocarp, acts as a significant barrier to moisture diffusion; disrupting this integrity through de-stoning facilitates rapid water removal.

Surprisingly, the Microwave Dryer exhibited the least efficient temporal performance in this specific experimental setup. For the 'Drogana Jeltaya' variety (stone-in), the microwave process required 89.4 hours, which is 33% longer than the convective method (67.2 hours) and 23% longer than the infrared method (72.6 hours). This anomaly might be attributed to the specific power density settings used; lower power settings may have been mandatory to prevent the "popping" or thermal runaway effects often associated with microwave heating of sugar-rich fruits, thereby necessitating a prolonged, gentle drying cycle that ultimately exceeded the duration of conventional convection.

Evaluation of Product Yield Characteristics. The yield of the dried product serves as a crucial economic indicator, reflecting both moisture loss and the retention of soluble solids. The data demonstrates a predictable stratification where "Pitted" (whole) samples retained a higher percentage of their initial mass compared to "Stoneless" samples, a mathematical inevitability given that the stone contributes to the weight but does not lose moisture.

However, examining the Infrared Dryer reveals a distinct trend in mass retention. For the 'Drogana Jeltaya' variety, the infrared method yielded 38.5% for whole fruits, which is notably higher than the 35.3% achieved by convective drying and 36.8% by microwave drying. This suggests that the infrared radiation, by heating the surface rapidly, may have induced a phenomenon known as "case hardening" – the formation of a rigid outer crust that traps residual moisture within the center of the fruit – or conversely, it may have preserved the solid fruit structure better, preventing the leakage of sugary exudates that can occur during the prolonged tumbling or airflow of convective systems.

Organoleptic Quality Assessment. The qualitative assessment, quantified on a 5-point scale, highlights the 'Drogana Jeltaya' variety as technologically superior for dried fruit production, consistently outscoring 'Volovye Serdse'.

The highest quality score of the entire study (4.8 points) was achieved by the Stoneless 'Drogana Jeltaya' processed in the Convective Dryer. This indicates that despite being the oldest technology among the three, convective drying provided the most uniform heat distribution for the open-flesh structure of the stoneless cherry, likely resulting in a product with superior texture and color retention (Table-1).

Conversely, the microwave drying of 'Volovye Serdse' yielded the lowest quality scores (3.8 points for stone-in samples). The extended duration required for the microwave treatment (85.9 hours) likely contributed to Maillard reaction browning or caramelization of sugars, negatively impacting the visual appeal and flavor profile of the dark-colored 'Volovye Serdse'. Furthermore, the data suggests a general positive correlation between de-stoning and quality; in every pairwise comparison, the stoneless variant scored higher than its whole counterpart, implying that the uniform drying permitted by stone removal prevents the internal fermentation or "cooking" effects that degrade quality in whole dried drupes.

Table-1

Effect of drying time of sweet cherries in convective, infrared and microwave dryers on the yield of dried products

Sweet cherryvarieties / Drying parameters		Volovye serdse		Drogana jeltaya	
		pitted	stoneless	pitted	stoneless
Convective dryer	drying period, hours	71.4	52.8	67.2	43.7
	dried product yield, %	33.1	24.8	35.3	26.6
	quality, point	4.0	4.5	4.2	4.8
Infrared dryer	drying period, hours	77.9	57.3	72.6	50.8
	dried product yield, %	37.6	23.1	38.5	25.4
	quality, point	3.8	4.2	4.3	4.6
Microwave dryer	drying period, hours	85.9	62.2	89.4	59.3
	dried product yield, %	34.4	25.6	36.8	24.1
	quality, point	3.8	4.0	4.1	4.5

4. Conclusion. The comprehensive analysis of the drying parameters for 'Volovye Serdse' and 'Drogana Jeltaya' sweet cherries leads to the following conclusions: morphological influence – the removal of the stone is the single most effective pre-treatment for enhancing drying efficiency and product quality, reducing processing time by approximately 26-35% depending on the variety and method.

Varietal Suitability: 'Drogana Jeltaya' exhibited superior aptitude for processing, maintaining better structural integrity and receiving higher sensory scores compared to 'Volovye Serdse'.

Technological Recommendation: While advanced methods like microwave drying offer theoretical advantages, in this specific regime, they proved less efficient than traditional methods. The Convective drying of stoneless 'Drogana Jeltaya' is identified as the optimal protocol, achieving the rapidest dehydration (43.7 hours) and the highest organoleptic quality (4.8 points). Future research should focus on optimizing microwave power density and combined methods (e.g., convective-microwave) to potentially overcome the temporal inefficiencies observed in this study.

References:

1.Doymaz, I., & Ismail, O. (2011). Drying characteristics of sweet cherry (Prunus avium L.) using different drying methods. Journal of Food Processing and Preservation, 35(4), 546-552.
2.Ginzburg, A. S. (1969). Application of Infra-Red Radiation in Food Processing. Chemical and Process Engineering Series. London: Leonard Hill Books.
3.Mujumdar, A. S. (Ed.). (2014). Handbook of Industrial Drying (4th ed.). CRC Press.
4.Nowak, D., & Lewicki, P. P. (2004). Infrared drying of apple slices. Innovative Food Science & Emerging Technologies, 5(3), 353-360.
5.Özkan, G., Vural, H., & Dikbas, N. (2020). Determination of the effects of different drying methods on the mineral content, color, and sensory properties of sweet cherry. Journal of Food Measurement and Characterization, 14, 212-221.
6.Schiffmann, R. F. (2006). Microwave and Dielectric Drying. In Handbook of Industrial Drying (pp. 345-372). CRC Press.
7.Wojdyło, A., Figiel, A., Lech, K., Nowicka, P., & Oszmiański, J. (2014). Effect of convective and vacuum-microwave drying on the bioactive compounds, color, and antioxidant capacity of sour cherries. Food and Bioprocess Technology, 7(5), 1299-1310.
8.Yilmaz, F. M., & Alibas, I. (2017). The effect of microwave, convective, and hybrid drying methods on the drying kinetics and color of sweet cherry. Heat and Mass Transfer, 53(9), 2841-2851.