Journal Pre-proof



Optimization of Microwave-Assisted Drying Methods for Optimizing Quality, Nutrient Retention, and Color Stability of Sweet Cherries

Tunahan ERDEM, Sevil N. KARAASLAN, Muhammad WASEEM, Nurten YILMAZ, Kamil EKİNCİ, Ayşe Gül ÖZAYDIN, Handan ÇULAL KILIÇ, Hürkan Tayfun VAROL, Anıl ALBAYRAK

PII: S0023-6438(25)01160-0

DOI: https://doi.org/10.1016/j.lwt.2025.118476

Reference: YFSTL 118476

To appear in: *LWT*

Received Date: 24 June 2025

Revised Date: 20 August 2025

Accepted Date: 8 September 2025

Please cite this article as: ERDEM, T., KARAASLAN, S.N., WASEEM, M., YILMAZ, N., EKİNCİ, K., ÖZAYDIN, A.G., ÇULAL KILIÇ, H., VAROL, H.T., ALBAYRAK, A., Optimization of Microwave-Assisted Drying Methods for Optimizing Quality, Nutrient Retention, and Color Stability of Sweet Cherries, *LWT*, https://doi.org/10.1016/j.lwt.2025.118476.

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2025 Published by Elsevier Ltd.

Journal Pre-proof

Research Article

Optimization of Microwave-Assisted Drying Methods for Optimizing Quality, Nutrient Retention, and Color Stability of Sweet Cherries

Tunahan ERDEM[1], Sevil N. KARAASLAN[2], Muhammad WASEEM[6], Nurten YILMAZ[3], Kamil EKİNCİ[2], Ayşe Gül ÖZAYDIN[4], Handan ÇULAL KILIÇ[5], Hürkan Tayfun VAROL[1], Anıl ALBAYRAK[1]

[1]Department of Agricultural Machinery and Technologies Eng., Cukurova University Faculty of Agriculture, Adana, Türkiye

[2]Department of Agricultural Machinery and Technologies Eng., Isparta University of Applied Sciences, Türkiye

[3]Department of Medicinal and Aromatic Plants, Cukurova University, Adana, Türkiye

[4]YETEM, Innovative Technology Application and Research Center, Suleyman Demirel University, Isparta, Türkiye

[5]Department of Plant Protection, Isparta University of Applied Sciences, Isparta, Türkiye

[6]Department of Food Science & Technology, Faculty of Agriculture & Environment, The Islamia University of Bahawalpur, 63100, Bahawalpur, Pakistan

Correspondence:

Tunahan ERDEM (terdem@cu.edu.tr)

Journal Pre-proof

Abstract

The aim of this study was to optimise drying methods for sweet cherries (Prunus avium) in order to extend their shelf life while preserving their nutritional and bioactive compounds. Cherries are highly perishable due to their high moisture content, requiring effective drying techniques. Three methods were evaluated: microwave drying (MWD), microwave-assisted hot air drying (MWHAD) and solar tunnel drying (STD). Key parameters included drying time, drying rate, colour stability, and the retention of sugars, organic acids, and phenolic compounds. MWD was tested at 180, 360 and 540 W; meanwhile, MWHAD involved combining microwave treatment with hot air at temperatures of 100, 180 and 230 °C. Drying time decreased with increasing microwave power; MWHAD reduced drying time by ~25% compared to MWD. Although STD was cost-effective, it took 126 hours, reduced to 82 hours with solution pre-treatment. Colour stability was best preserved in the MWHAD process at 180 W and 160 °C without a solution, closely resembling fresh cherries. The highest sugar content (glucose: 259.37 mg/100 g; fructose: 229.68 mg/100 g) was achieved at 180 W and 160 °C with a solution. Meanwhile, organic acids (malic acid: 28,431.56 mg/kg) were best retained at 540 W without pretreatment. Phenolic compounds were maximally preserved under MWHAD at low power (180 W) and a moderate temperature (up to 160 °C) when using a solution. Overall, MWHAD under optimised conditions effectively balanced drying efficiency with the retention of biochemical integrity, colour and nutritional quality. These findings support MWHAD as a scalable, efficient approach for producing high-quality dried cherries.

Keywords: Drying, Pre-treatment, Cherry, Phenolic Compounds, Stability

1. Introduction

The sweet cherry (*Prunus avium* L.), a member of the Rosaceae family, originated from Europe, South Asia, and the Western Himalayas (Hu et al., 2021). The main producers were Türkiye, the United States, and Iran, with an annual yield of nearly 2.2 million tonnes (Vignati et al., 2022). Global production reached 4.35 million tonnes in 2022, of which Türkiye accounted for more than 19%. Sweet cherries were rich in phenolic acids (e.g., caffeic and p-coumaric acids), flavonoids, anthocyanins, melatonin, and vitamins (C, A, B6, D), as well as minerals such as potassium, iron, and manganese (Gonçalves et al., 2024). These compounds provided strong antioxidant, anti-inflammatory, anti-diabetic, and metabolic regulatory properties, with anthocyanins being the main contributors to the high antioxidant capacity (Liu

et al., 2020; Gonçalves et al., 2024; Deng et al., 2019; Bland & Oomah, 2019). Despite their nutritional richness, cherries were highly perishable, with a shelf life of only 7–10 days in cold storage, necessitating effective preservation strategies (Madalina & Mihai, 2020).

Drying was a widely used preservation method that extended shelf life, reduced postharvest losses, and concentrated health-promoting compounds by removing water (Salehi, 2023; Göztepe et al., 2022). It also reduced packaging and transportation costs while maintaining sensory and nutritional attributes, making dried cherries a convenient, functional food (Salehi, 2023). However, the effectiveness of drying largely depended on the method and parameters applied, which determined nutrient retention and product quality, particularly color, bioactives, and structure (Radojčin et al., 2021; Pateiro et al., 2022).

The STD was low-cost but limited by long processing times, weather dependency, and potential degradation of bioactives such as anthocyanins and organic acids. The MWD accelerated dehydration but could generate uneven heating and localized overheating. The MWHAD emerged as a promising technique that combined rapid moisture removal with more uniform energy distribution, thereby better preserving the biochemical integrity of the fruit (Belwal et al., 2022; Khan et al., 2024).

In addition to temperature and microwave power, pretreatment solutions significantly influenced drying performance and quality retention by modulating enzymatic activity, color stability, and nutrient preservation (Kandasamy & Naveen, 2022; Pateiro et al., 2022). Therefore, optimizing these combined parameters was essential to prevent quality deterioration and ensure maximum retention of sugars, organic acids, phenolics, and color in dried cherries. This study aimed to evaluate and compare STD, MWD, and MWHAD, while investigating the effects of pretreatment solution type, and duration. The findings provided insights into developing efficient, scalable, and sustainable drying methods for high-quality dried cherries (*Prunus avium* L., cv. 0900 Ziraat).

2. Material and Methods

2.1.Raw Materials

The 0900 Ziraat cherries were purchased from a local market in Isparta, Turkey, and were selected at commercial maturity. Sweet cherries (*Prunus avium* L., cv. 0900 Ziraat) were harvested at commercial maturity, which is characterized by uniform dark-red skin color, a

firmness of 3.2–3.5 N, a soluble solids content of 16–18 °Brix, and titratable acidity of 0.7–0.9 g malic acid/100 g fresh weight. The experiments were only performed using fruit that was free from defects, mechanical damage and fungal contamination. Prior to drying, they were stored in a refrigerator at 4 ± 1 °C for one day. The cherries, removed from the refrigerator, were maintained at ambient conditions (1 ATM, 25 °C) for 2 h to achieve moisture equilibrium with the environment and to ensure uniform distribution of their internal moisture content. Subsequently, the cherries were cleansed with water and dried using paper towels. The initial meaning moisture content of fresh cherry fruits was ascertained by drying the samples in an oven at 105 °C (Izli & Polat, 2019). The moisture content values recorded for cherry fruits were 75.36 g water per g of wet weight. Prior to initiating the drying process, the whole cherry fruits (with stones) were categorized into two groups. A potassium carbonate solution was administered to the first group as a pretreatment. The remaining cherries constitute the untreated group (control).

2.2. Reagents and Chemicals

Cherry samples (1.03 kg) were immersed in a 1 L 5% potassium carbonate (K_2CO_3) solution for 3 minutes to eliminate bacterial contamination prior to drying (Dipersio et al, 2004; Ölmez and Akbaş, 2009).

2.3. Drying treatments of cherries

2.3.1. Solar tunnel drying

The STD comprised a 150 W solar cell module and a flat plate solar collector positioned in an east–west orientation, with the drying area directed southward. In each trial, 500 g of cherry samples were arranged in a single layer on trays within the solar tunnel dryer. STD occurred from dawn to dusk, and the fruit weight loss was recorded using a digital precision scale (Sartorius GP3202, Göttingen, Germany) with an accuracy of 0.01 g at two-hour intervals throughout the drying period (Karaaslan and Ekinci, 2021). The cherry samples were not weighed overnight, and the drying process continued until no variation was detected between two successive weighings. The experiments were conducted from July 16 to July 22, 2024. Solar radiation was measured hourly from dawn to dusk using a pyranometer on a horizontal plane. STD parameters, including the air velocity at the tunnel exit, the internal temperature of the cherries, and the relative humidity of the air, were recorded using a hotwire anemometer, K-type thermocouples (DT-10, Shenzhen, China), and a K-type hygrometer (PCE-THD 50,

Shenzhen, China).

2.3.2. Microwave Drying

The MWD experiments with three replicates were conducted utilizing an Arçelik MD 594 (Turkey) domestic microwave oven, which has a maximum output of 800 W work at 2450 MHz The microwave oven has a rotating base made by glass and stable magnetron. The STD procedure involved subjecting 100 g cherry samples to microwave power levels of 180, 360, and 540 W, with weight losses quantified using a digital balance (Sartorius GP3202 Göttingen, Germany).

2.3.3. Combined Fan Assisted Convection and Microwave Drying

TheMWHAD Experiments utilizing a combination of hot air and microwave energy were performed at fixed microwave power levels of 180 and 540 W, with hot air applied at temperatures of 100, 180, and 230 °C. Moisture loss was quantified and documented every minute until equilibrium moisture was attained.

2.3.4. Pre-Treatment with Potassium Carbonate

Twenty grams (20 g) of potassium carbonate (K_2CO_3) powder was measured using a precision balance (Sartorius GP3202, Göttingen, Germany) and transferred to a 500 mL beaker, to which 5 g of olive oil was subsequently added. The beaker was filled with distilled water until it attained a total mass of 500 g, comprising 470 g of distilled water. The prepared solution was agitated, and the mixture containing 5% potassium carbonate and 1% olive oil was prepared for pretreatment (Karaaslan & Ekinci 2022)

2.4.Drying kinetics

2.4.1. Moisture Content

Cherry fruit samples were desiccated in a hot air oven at 105 °C for 24 hours to determine the moisture content of the fruits. The measurement was conducted thrice for each experiment and subsequently averaged. The moisture content of the cherry fruits was 75.36% wet basis.

2.4.2. Moisture Ratio

A moisture ratio (MR) of the cherry fruits was determined by using the following equation (I).

$$Moisture\ Ratio\ (MR) = \frac{M_t - M_e}{M_0 - M_e} \quad \text{(I)}$$

Where MR was the moisture ratio (dimensionless), Mt was the moisture content of the sample at any time t (kg water/kg dry solids), Me was the equilibrium moisture content (kg water/kg dry solids), and M0 was the initial moisture (kg water/kg dry solids). Me was relatively small for long drying times compared to Mt or M0; therefore, Me was considered numerically zero in this study. Thus, MR was simplified as MR = Mt/M0 (Tunckal & Doymaz, 2020).

2.4.3. Drying Rate

The drying rate was a critically significant factor in drying kinetics. To elucidate the correlation between the drying duration of cherries and the drying rate, the drying rate of cherry samples was assessed as follows (II):

$$Drying\ Rate\ (DR) = \frac{M_{t1} - M_{t2}}{t_2 - t_1} \quad \text{(II)}$$

Where the drying rate was g water g dry matter^{-1} min^{-1}; Mt1 and Mt2 were the moisture contents of the dry mass at the times of drying up to t1 and t2, respectively, in g/g; t1 and t2 were the drying times in minutes (Safarov et al., 2024).

2.4.4. Mathematical Modelling

Continuous data on moisture content, acquired under varying microwave power densities and size characteristics, were converted into moisture content measurements. Table 1 presented thirteen distinct mathematical models previously employed in the literature for the moisture ratio of cherry samples. Non-linear regression analysis of the equations was conducted using Sigma Plot 12.0 statistical software, and the drying parameters and coefficients (a, b, c, k, k1, k2, n) were computed. The selection of the optimal mathematical model relied on three statistical metrics: the correlation coefficient R^2 derived from non-linear analysis across various drying conditions, the chi-square statistic χ^2, and the root mean square error (RMSE) (Izli & Polat, 2019; Tunckal & Doymaz, 2020). These metrics were used as standards for goodness of fit. The equations for R^2, χ^2, and RMSE were presented in (III), (IV), and (V), respectively.

$$\text{Correlation Coefficient } R^2 = 1 - \frac{\sum_{i=1}^{N}\left(MR_{exp,i} - MR_{pre,i}\right)^2}{\sum_{i=1}^{N}\left(\overline{MR}_{exp} - MR_{pre,i}\right)^2} \quad \text{(III)}$$

$$\text{Chi} - \text{square statistic } \chi^2 = \frac{\sum_{i=1}^{N}\left(MR_{exp,i} - MR_{pre,i}\right)^2}{N - z} \quad \text{(IV)}$$

$$Root\ Mean\ Square\ Error\ (RMSE) = \sqrt{\frac{\sum_{i=1}^{N}\left(MR_{pre,i} - MR_{exp,i}\right)^2}{N}} \quad \text{(V)}$$

Where MRexp and MRpre were the experimental and predicted values of the moisture ratio, respectively; z was the number of constants in the model, and N was the total number of observations.

2.4.5. Colour Determination

Colour measurements of fresh and dried cherry samples, both with and without pretreatment, were conducted by assessing L^* (whiteness or brightness/darkness), a* (redness/greenness), and b* (yellowness/blueness) values utilizing the Minolta Chroma CR-100 colour measurement device (Konica, Minolta, Tokyo, Japan). The measurements were conducted five times, and the average of the resulting values was calculated for evaluation. The equations employed for calculating the parameters Chroma (C), alpha, delta E, and BI are presented below (Erdem et al, 2018; Lopez-Ortiz et al, 2024) (Eq. VI-Eq. X).

$$Chroma\ (C) = \sqrt{(a^2 + b^2)} \quad \text{(VI)}$$

$$Hue\ angle\ (\alpha^{\circ}) = \tan^{-1}\left(\frac{b}{a}\right) \quad \text{(VII)}$$

$$\text{Delta E } (\Delta E) = \sqrt{(L^* - {L_0}^*)^2 + (a^* - {a_0}^*)^2 + (b^* - {b_0}^*)^2} \quad \text{(VIII)}$$

$$Browning\ index\ (BI) = \frac{[100(x - 0{,}31)]}{0{,}17} \quad \text{(IX)}$$

$$x = \frac{(a^* + 1{,}75L^*)}{(5{,}645L^* + a^* - 3{,}012b^*)} \quad \text{(X)}$$

2.5. Bio-Chemical Characterization

A precise analysis of the chemical composition of food products was crucial for understanding their nutritional value and potential health benefits. This study aimed to analyze the compounds in crushed dried cherries using high-performance liquid chromatography (HPLC). The analyses specifically focused on quantifying the sugar content, organic acids, and phenolic compounds in pulverized dried cherries. The Duncan multiple comparison test was applied at a significance level of $p < 0.05$.

2.5.1. Determination of Sugar Content in Dried Cherries Using High Performance Liquid Chromatography (HPLC)

The sugar content (sucrose, glucose, fructose) was quantified using the HPLC system in accordance with the method outlined by Ma et al, 2015, with minor adjustments. Approximately 2 grams of crushed dried cherries were weighed and homogenized in 8 mL of 6% meta-phosphoric acid for 1 min using a rotor-stator homogenizer. The resulting extracts were then centrifuged at 10000 rpm for 10 minutes at 4 °C and filtered through filter paper. The filtrate was subsequently passed through a 0.45 µm filter, and 20 µL of the resultant supernatant was injected into the HPLC system. The HPLC analyses were performed utilizing a Shimadzu system featuring a RID 10A detector, LC-10ADvp pump, DGU-14A degasser, and CTO-10ACvp column oven. The chromatographic separation was conducted using an Aminex HPX-87C carbohydrate column (300 x 7.8 mm). The mobile phase comprised ultrapure water. The flow rate was established at 0.6 mL/min, and the column temperature was sustained at 80 °C.

2.5.2. Determination of Organic Acids in Dried Cherries Using HPLC

A Supelco C-18 cartridge was conditioned using 3 ml of methanol followed by 10 ml of ultrapure water. The sample (10 g) was homogenized with 10 mL of 2% H_3PO_4, filtered, and 1 mL of the filtrate was diluted with 1 mL of 0.01 M KH_2PO_4 (pH 8). The combined eluate was passed through the cartridge, and 20 µL was injected into an HPLC system comprising a SPD-10Avp detector, an LC-20AT system, a SIL-20AC autosampler, and a CTO-10AS column oven. The separation was performed using a Teknokroma TRACER EXTRASIL ODS(2) column (250 × 4.6 mm, 5 µm) at 30 °C with a flow rate of 0.8 mL/min using a mobile phase of H_3PO_4/H_2O (pH 2.2). Results are expressed as mg/g.

2.5.3. Determination of Phenolics in Dried Cherries Using HPLC

The HPLC process began after the initial extraction and filtration by redissolving the dried extract in methanol and injecting a tiny amount into the machine for analysis. The HPLC analysis (Veberic, & Stampar, 2005) was performed on a Shimadzu system with a DAD detector (λmax = 278 nm), utilizing a SIL–10AD vp autosampler, SCL-10Avp system controller, LC-10ADvp pump, DGU-14A degasser, and CTO-10Avp column oven. Chromatographic separation was carried out using an Agilent Eclipse XDB-C18 column (250 x 4.60 mm, 5 µm). The mobile phase consisted of (A) 3% acetic acid and (B) methanol, with a flow rate of 0.8 mL/min, and the column temperature was maintained at 30 °C. An injection volume of 20 µL was used, and the results are expressed in milligrams per gram (mg/g).

3. Results and Discussion

3.1. Drying Parameters

Drying was essential for food safety, security, and value enhancement, and most fruits and vegetables were dried for preservation. MWD and its combinations were widely applied to achieve high-quality products. In this study, cherry fruits were dried using MWD at 180, 360, and 540 W, MWHAD at 100, 180, and 230 °C, and were compared with STD.

As shown in Figures 1–2, microwave drying at 1.8 W/g lasted over 80 minutes, whereas 5.4 W/g required only 13 minutes, indicating that increasing microwave power significantly reduced drying time. These findings were consistent with previous studies (Wiset et al., 2021; Karaaslan et al., 2013). The drying rate (DR) increased with higher microwave power. However, solution pretreatment prolonged drying by 11 minutes at 1.8 W/g and 7 minutes at 5.4 W/g. This extension was attributed to vapor pressure depression caused by solutes and surface crust formation that hindered mass transfer. At higher power densities (e.g., 5.4 W/g), this retarding effect diminished because greater thermal energy overcame these barriers (Khampakool et al., 2019).

During the experiments, a two-stage drying rate was observed in MWD at 3.6 and 5.4 W/g, both with and without solution, while three-stage drying occurred only at 1.8 W/g (Fig. 3).

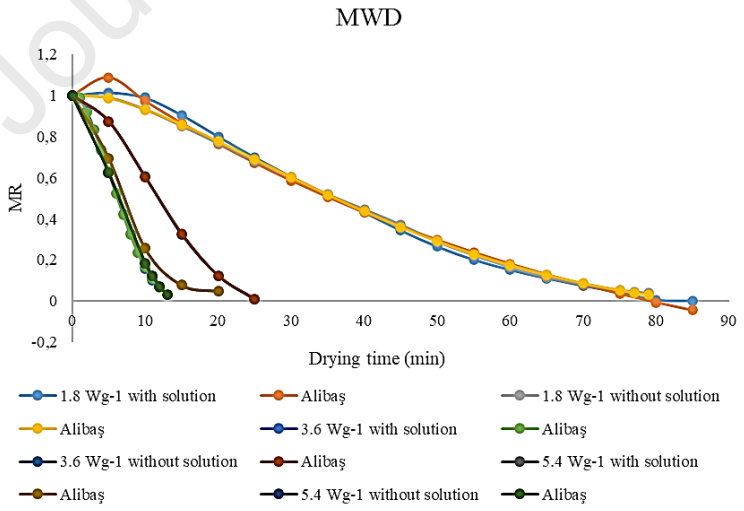


Fig. 1. MR Curves of cherry fruits under MWD.

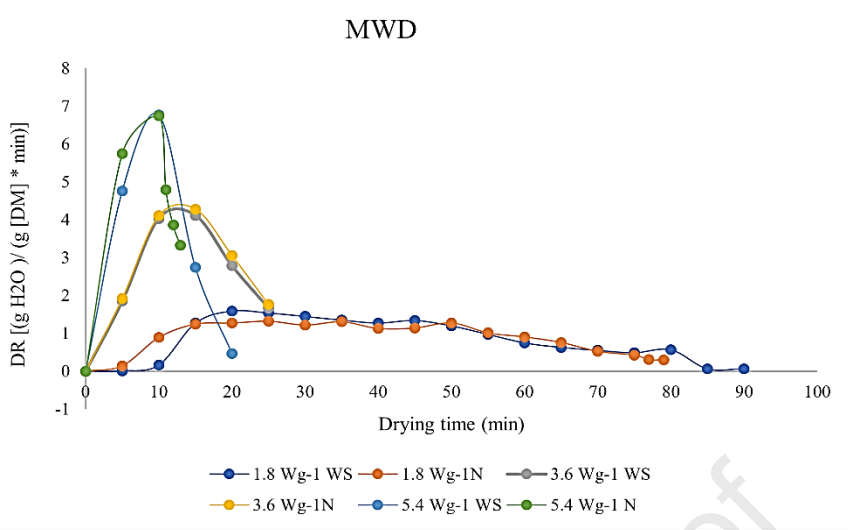


Fig. 2. DR Curves of cherry fruits under MWD

Hot air drying expeditiously extracted moisture from the food surface; however, the drying process was challenging due to extended heat transfer and the formation of an impermeable surface layer. Consequently, combining these two techniques expedited the drying rate. The simulated outcomes of the drying parameters for the combined fan-assisted convection and microwave application were illustrated in Figures 3-4. The drying time was reduced by 25% compared to microwave drying alone due to the integration of MWD with hot air. The drying rate was 8% higher than that of microwave drying. Furthermore, the combination of heated air negated the solution's impact on drying duration.

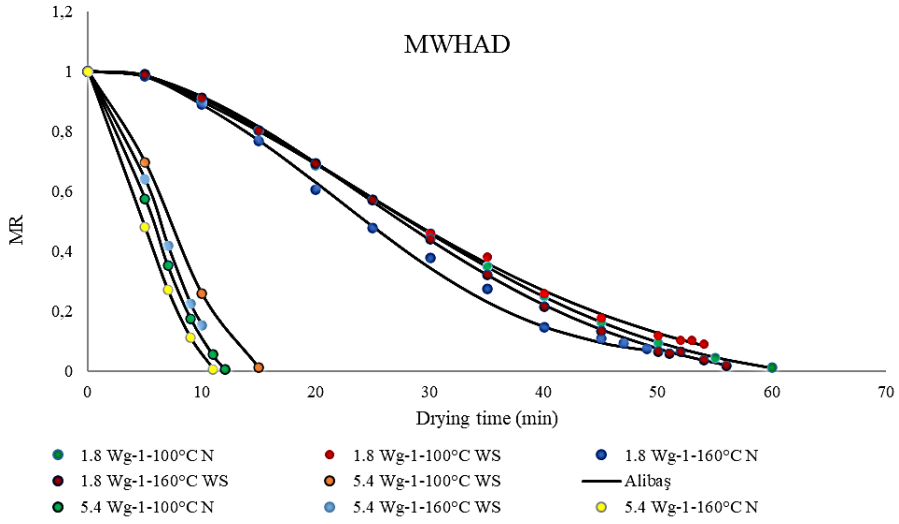


Fig. 3. MR Curves of cherry fruits under MWHAD.

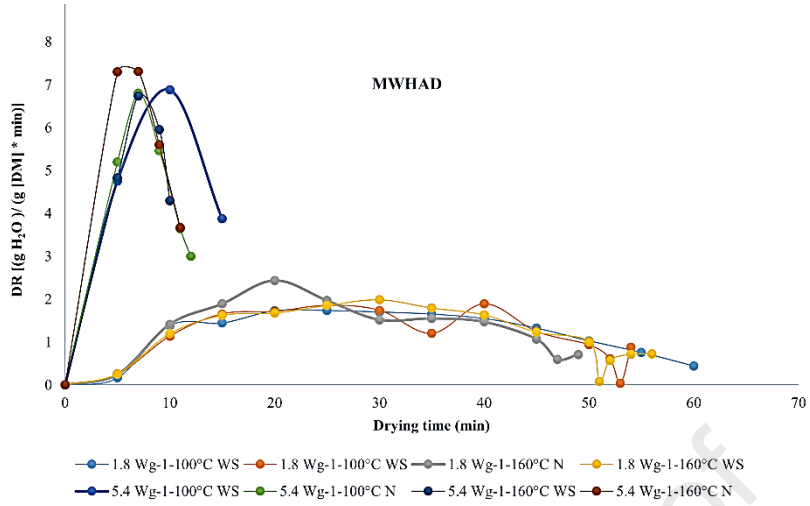


Fig. 4. DR Curves of cherry fruits under MWHAD.

Numerous studies report that STD of cherry fruits is a cost-effective, practical method to reduce postharvest losses, extend shelf life, and maintain fruit quality (Ouaabou et al., 2018; Doymaz & İsmail, 2011). In our trials, STD lasted 126 hours without solution, achieving a drying rate of 7.24 g H_2O/(g [DM]·min), whereas solution-treated fruits dried in 82 hours with a drying rate of 12 g H_2O/(g [DM]·min) (Fig. 5–6).

Drying data were analyzed using regression techniques. The most commonly used models were fitted to the experimental curves (Table 1). For MWD, RMSE values ranged from 0.0064 to 0.1251, and R^2 values ranged from 0.99756 to 1.0000 across all methods, indicating excellent model fit.

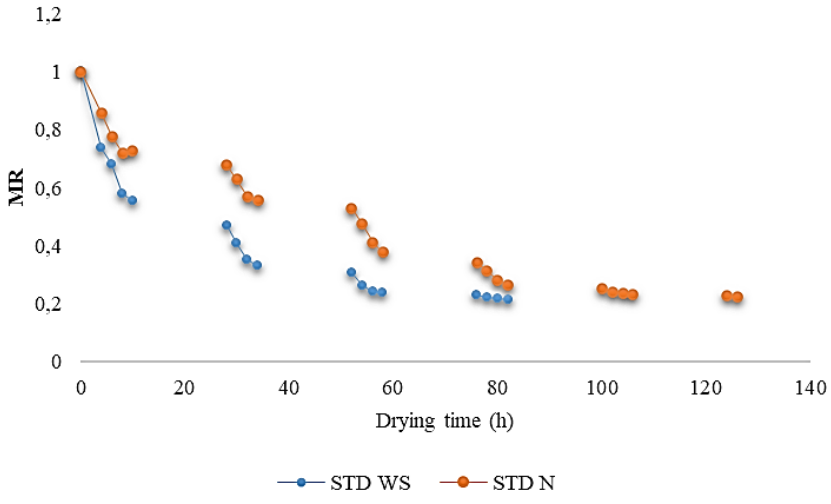


Fig. 5. MR Curves of cherry fruits under STD.

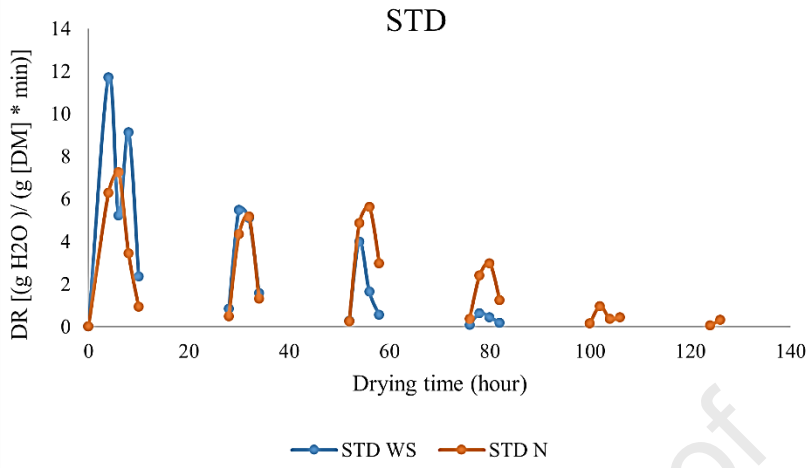


Fig. 6. DR Curves of cherry fruits under STD.

The Alibas model provided the best fit for microwave and hot air-assisted drying, yielding the highest R^2 and the lowest χ^2 and RMSE values, with RMSE ranging from 0.0000 to 0.1308 and R^2 from 0.9465 to 1.0000 across all models. For solar tunnel drying, RMSE and R^2 values ranged from 0.0274 to 0.1139 and 0.9412 to 0.9736, respectively, where the Midilli model showed the best performance. Similar findings have been reported for other food products: Karaaslan and Ekinci (2022) identified the Alibas model as most suitable for apple slices pretreated with citric acid; Horuz et al. (2017) demonstrated that the Verma and modified Logistic models best described sour cherry drying under conventional and hybrid (conventional–microwave) conditions; and Nukulwara and Tungikara (2020) found the Page model appropriate for turmeric drying using both indirect natural convection solar dryers (INCSD) and open STD.

3.2. Color Stability of Dried Cherry

Color was a key quality parameter that directly influenced consumer preference and market value. Thermal treatments could induce discoloration; therefore, drying conditions such as temperature, oxygen, and moisture had to be carefully controlled (Simsek & Sufer, 2021; Qing-Guo et al., 2006).

The MWHAD without solution pretreatment preserved brightness values close to fresh cherries ($L^* \approx 25.05$ vs. 25.76 ± 4.14) and reduced drying time compared to solution-based drying. Similar values were obtained with MWD without solution. Higher microwave power combined with elevated air temperature shortened drying time, reduced non-enzymatic browning, and

limited pigment oxidation, resulting in lighter color and higher chroma values. However, at very high temperatures (e.g., 5.4 W/g at 160 °C), L*, a*, b*, and chroma values declined compared to 5.4 W/g at 100 °C, indicating increased pigment degradation.

Delta E was measured on a 0–100 scale, where 0 indicated no perceptible difference and 100 represented complete contrast. According to Schuessler (2025), the perception thresholds were as follows: 1.0, imperceptible to the human eye; 1-2, detectable with close inspection; 2-10, noticeable at a glance; 11-49, colors appeared more similar than different; and 100, completely opposite. In this study, Delta E values reached levels at which color differences were immediately recognizable. The BI index was comparable to new samples at 5.4 g/W MWHAD in other applications (Fig. 7) at 100 °C and 1.8 g/W MWHAD at 160 °C in pre-treatment applications, while showing higher values under certain conditions.

Journal Pre-proof

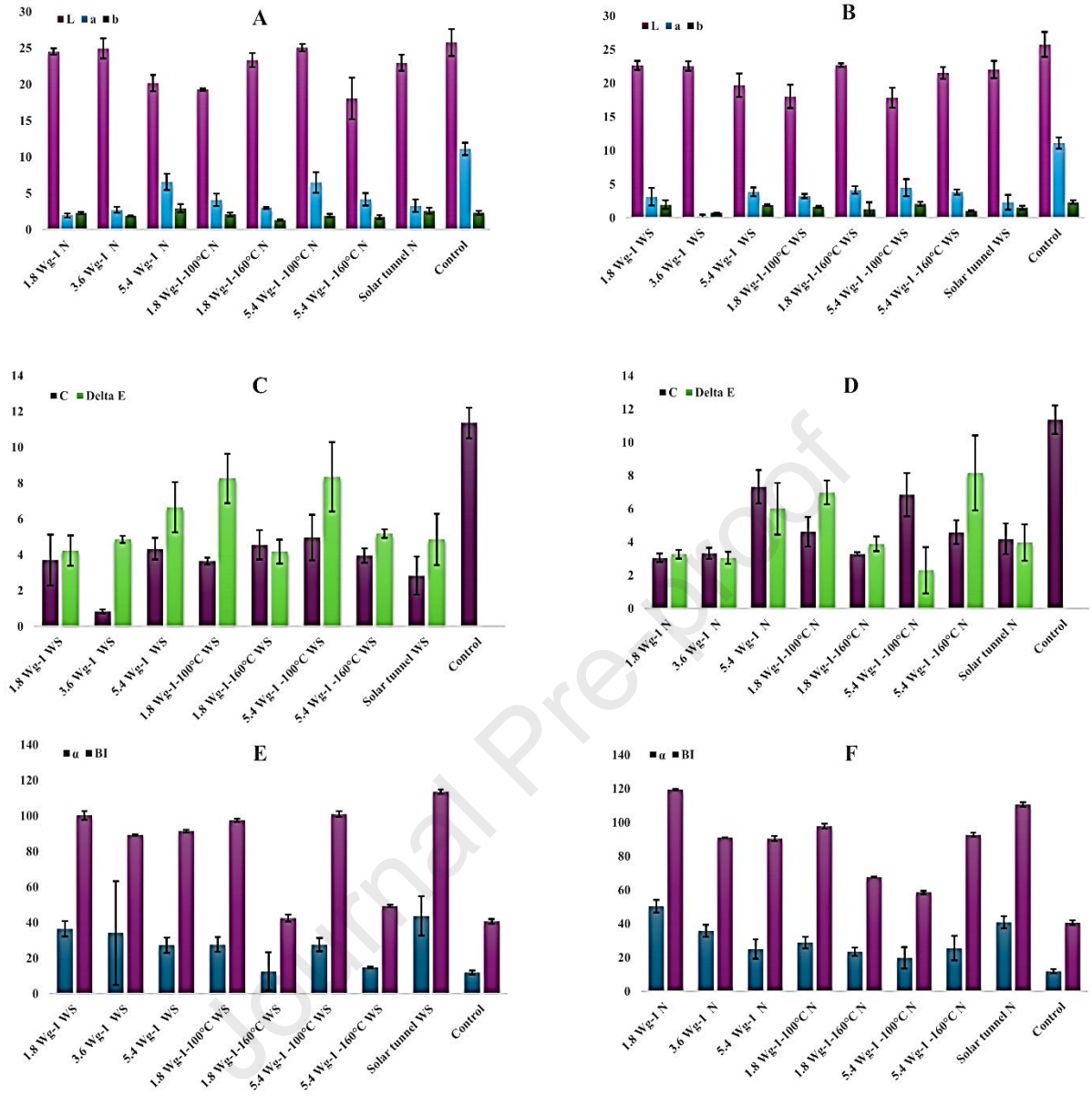


Figure 7. Colour parameters of sweet cherry under different drying applications.

The distinctive red color of cherries was mainly due to anthocyanins, which were highly sensitive to heat and oxygen. Excessive temperatures accelerated their degradation through hydrolysis, cleavage, and polymerization, diminishing color intensity (Enaru et al., 2021; Tan et al., 2023). These changes were reflected in ΔE and BI values, which directly indicated processing-induced pigment loss. Optimal drying conditions preserved BI values comparable to fresh cherries (Fig. 7). Since anthocyanins were the primary source of red color, their thermal and oxidative degradation explained the observed differences in ΔE and BI (Oancea, 2021).

3.3. Effects of Drying Techniques on The Biochemical Components Contained in Cherries

Drying fresh cherries primarily yielded glucose and fructose as the main monosaccharides and sucrose as the main disaccharide (see Table 2). Tables 2–4 showed the changes in sugars, organic acids, and phenolic compounds during the drying process. Vitamin C, which is essential for immune and cardiovascular health (Szczepaniak et al., 2019), was largely retained. The effectiveness of MWHAD in preserving sugars, phenolic compounds, and color depended on the type, concentration, and duration of the pretreatment solution (Wani et al., 2024; Smith et al., 2023), highlighting the importance of optimisation. Cherries contained high levels of malic acid (Zhou et al., 2023) and phenolic compounds with potent bioactivity (Baicu et al., 2024; Bayram et al., 2024).

Glucose was the predominant sugar, followed by fructose, with sucrose present at the lowest concentrations. The highest levels of glucose (259.37 ± 4.44 mg/100 g) and fructose (229.68 ± 2.52 mg/100 g) were observed in cherries pretreated with a potassium carbonate solution and dried using 180 W MWHAD at 160 °C hot air. High microwave power reduced sucrose due to thermal degradation and microwave-specific effects. Elevated temperatures accelerated sucrose hydrolysis into glucose and fructose (Liu et al., 2025), while microwave heating created localized hotspots, increasing reaction rates (Zhao et al., 2009). Fructose degraded thermally to form HMF (hydroxymethylfurfural) and Maillard reaction products, contributing to browning (Agcam, 2022; Nath et al., 2022). These factors explain the pronounced sucrose loss and confirm that MWHAD at 180 W and 160 °C with solution pretreatment was the most effective method.

As shown in Table 3, cherries contained oxalic, tartaric, malic, ascorbic, lactic, citric, and fumaric acids, which were essential for fruit quality and human health (Çelik et al., 2019). The acid-to-sugar ratio reflected ripeness and taste, as lower acid levels corresponded to sweetness and higher levels caused sourness (Cemeroğlu et al., 2004). Drying without solar support resulted in the lowest acid retention. Malic acid reached 28,431.56 ± 109.78 mg/kg at 540 W without solution, tartaric acid peaked at 15,842.40 ± 161.28 mg/kg at 100 °C without solution, and ascorbic acid reached 942.54 ± 8.41 mg/kg at 180 W with solution pretreatment. Retention depended on drying power and pretreatment, with the best balance observed at 540 W without solution and 180 W with solution at 160 °C. These differences were attributed to the thermal stability and intracellular localisation of the acids (Lu et al., 2024). Heat-labile acids such as

ascorbic acid degraded more rapidly at higher temperatures, whereas heat-stable acids including malic and tartaric benefited from enhanced membrane permeability and the protective effects of the solution (Smith et al., 2023). The interaction of microwave power, temperature, and solution pretreatment significantly influenced acid retention. High power (540 W) without solution facilitated rapid moisture removal and partial cell disruption, favoring heat-stable acids, whereas medium power (180 W) with solution minimised oxidative losses and preserved heat-labile acids, particularly ascorbic acid (Lee et al., 2024; Zhou et al., 2023).

Phenolic compounds identified in dried cherries included gallic acid, protocatechuic acid, catechin hydrate, p-hydroxybenzoic acid, chlorogenic acid, caffeic acid, epicatechin, vanillin, p-coumaric acid, o-coumaric acid, rutin, quercetin dihydrate, and apigenin (Table 4). STD consistently resulted in the lowest phenolic concentrations, regardless of solution pretreatment. The lowest values were recorded in MWD without solution at 540 W and 160 °C. In contrast, the highest phenolic content was observed in cherries pretreated with potassium carbonate solution and dried at 180 W without additional heat. High microwave power and elevated temperature markedly degraded phenolic compounds, reducing the antioxidant capacity and nutritional value of the dried cherries. During STD, prolonged exposure to heat and oxygen disrupted the fruit's outer skin, increasing susceptibility to degradation of bioactive compounds, including phenolics and anthocyanins. Slow water removal promoted enzymatic oxidation, as reported by Radojčin et al. (2021) and Salehi (2023). Microwave-assisted drying accelerated water removal through volumetric heating, rupturing cell walls and releasing intracellular compounds, which enhanced the extraction of phenolics and sugars (Belwal et al., 2022; Kandasamy & Naveen, 2022). However, excessive microwave power or prolonged exposure generated thermal hotspots, leading to the degradation of heat-sensitive compounds, similar to effects observed with ultrasonic pretreatment in berries (Radojčin et al., 2021).

Collectively, these results demonstrated that drying at high power and temperature, whether by solar or microwave methods, reduced key biochemical compounds essential for health. Optimal preservation of sugars, organic acids, and phenolics was achieved when cherries were pretreated with potassium carbonate and dried at low microwave power (180 W) combined with moderate hot air temperature (up to 160 °C). This drying regime effectively balanced drying efficiency with the retention of bioactive and nutritional quality in the dried cherries.

4. Conclusion

Drying is an effective way to preserve fruit, as it reduces water content, limits spoilage and extends shelf life. This study compared three drying methods STD, MWD, and MWHAD and demonstrated that MWHAD at 180 W and 160 °C, combined with an optimised pretreatment solution (type, concentration, and soaking duration), resulted in the fastest drying time and the best retention of glucose, fructose, phenolic compounds, anthocyanins, organic acids, and colour in sweet cherries. Although STD was cost-effective, it took longer and resulted in lower retention of bioactive compounds. It is crucial to optimise drying parameters, including microwave power, air temperature, and pretreatment conditions, to maximise nutrient retention and overall quality. These results highlight the potential of MWHAD as an efficient, scalable, and sustainable method for producing high-quality dried fruit. Future research should explore its application to other fruits and vegetables, evaluate energy efficiency, and assess consumer acceptance in order to support the development of optimised, sustainable postharvest drying strategies.

References

Agcam, E. (2022). A kinetic approach to explain hydroxymethylfurfural and furfural formations induced by Maillard, caramelization, and ascorbic acid degradation reactions in fruit juice-based mediums. *Food Analytical Methods*, *15*(5), 1286-1299.

Baicu, Ș., Jigău, R., Zoican, C., & Pașcalău, R. (2024). Benefits of cherries manufacturing for human health. *Research Journal of Agricultural Science, 56*(4).

Bayram, H. M., Özkan, K., Öztürkcan, A., et al. (2024). Effect of drying methods on free and bound phenolic compounds, antioxidant capacities, and bioaccessibility of Cornelian cherry. *European Food Research and Technology, 250,* 2461–2478. https://doi.org/10.1007/s00217-024-04552-6

Belwal, T., Cravotto, C., Prieto, M. A., Venskutonis, P. R., Daglia, M., Devkota, H. P., Baldi, A., Ezzat, S. M., Gómez-Gómez, L., Salama, M. M., & Campone, L. (2022). Effects of different drying techniques on the quality and bioactive compounds of plant-based products: A critical review on current trends. *Drying Technology, 40*(8), 1539–1561. https://doi.org/10.1080/07373937.2022.2037645

Blando, F., & Oomah, B. D. (2019). Sweet and sour cherries: Origin, distribution, nutritional composition and health benefits. *Trends in Food Science & Technology, 86,* 517–529.

Çelik, F., Gündoğdu, M., & Zenginbal, H. (2019). Bazı nar genotiplerine ait meyvelerin organik asit ve C vitamini profili. *Yuzuncu Yıl University Journal of Agricultural Sciences, 29*(3), 489–495.

Deng, L. Z.; Mujumdar, A. S.; Zhang, Q.; Yang, X. H.; Wang, J.; Zheng, Z. A.; Gao, Z. J.; Xiao, H. W. Chemical and Physical Pretreatments of Fruits and Vegetables: Effects on

Drying Characteristics and Quality Attributes - A Comprehensive Review. *Crit. Rev. Food Sci. Nutr.* 2019, *59*, 1408–1432. DOI: 10.1080/10408398.2017.1409192.

Cemeroglu, B., & Ozkan, M. (2004). *Drying technology, fruit and vegetable processing technology.* Ankara, Turkey: Bizim Büro Publisher.

DiPersio, P. A., Kendall, P. A., & Sofos, J. N. (2004). Inactivation of Listeria monocytogenes during drying and storage of peach slices treated with acidic or sodium metabisulfite solutions. *Food Microbiology, 21*(6), 641–648. https://doi.org/10.1016/j.fm.2004.03.011

Doymaz, İ., & İsmail, O. (2011). Drying characteristics of sweet cherry. *Food and Bioproducts Processing, 89*(1), 31–38.

Erdem, T., Ozluoymak, O. B., & Kizildag, N. (2018). Color change analysis of dried orange slices during hot air drying. *Fresenius Environmental Bulletin, 27*(9), 6064–6072.

Enaru, B., Drețcanu, G., Pop, T. D., Stănilă, A., & Diaconeasa, Z. (2021). Anthocyanins: Factors Affecting Their Stability and Degradation. *Antioxidants (Basel), 10*(12), 1967. https://doi.org/10.3390/antiox10121967

Gonçalves, B., Aires, A., Oliveira, I., Baltazar, M., Cosme, F., Afonso, S., Pinto, T., Anjos, M. R., Inês, A., & Morais, M. C. (2024). From orchard to wellness: Unveiling the health effects of sweet cherry nutrients. *Nutrients, 16*(21), 3660. https://doi.org/10.3390/nu16213660

Göztepe, B., Kayacan, S., Bozkurt, F., Tomas, M., Sagdic, O., & Karasu, S. (2022). Drying kinetics, total bioactive compounds, antioxidant activity, phenolic profile, lycopene and β-carotene content and color quality of rosehip dehydrated by different methods. *LWT, 153*, 112476. https://doi.org/10.1016/j.lwt.2021.112476

Horuz, E., Bozkurt, H., Karataş, H., & Maskan, M. (2017). Effects of hybrid (microwave-convectional) and convectional drying on drying kinetics, total phenolics, antioxidant capacity, vitamin C, color and rehydration capacity of sour cherries. *Food Chemistry, 230*, 469–477. https://doi.org/10.1016/j.foodchem.2017.03.046

Hu, T., Subbiah, V., Wu, H., BK, A., Rauf, A., Alhumaydhi, F. A., & Suleria, H. A. R. (2021). Determination and characterization of phenolic compounds from Australia-grown sweet cherries (Prunus avium L.) and their potential antioxidant properties. *ACS Omega, 6*(50), 34115–34126. https://doi.org/10.1021/acsomega.1c05112

Izli, N., & Polat, A. (2019). Effect of convective and microwave methods on drying characteristics, color, rehydration and microstructure properties of ginger. *Food Sci. Technology* Vol.39 No.3.

Kandasamy, S., & Naveen, R. (2022a). A review on the encapsulation of bioactive components using spray-drying and freeze-drying techniques. *Journal of Food Process Engineering, 45*(8), e14059. https://doi.org/10.1111/jfpe.14059

Karaaslan, S., Ekinci, K., Ertekin, C., & Kumbul, B. S. (2021). Thin layer peach drying in solar tunnel drier. *Erwerbs-obstbau, 63*(1), 65-73.

Karaaslan, S., & Ekinci, K. (2022). Effect of pretreatments on solar dehydration of different varieties of apple (Malus domestica). *Czech Journal of Food Sciences, 40*(2), 93–101.

Karaaslan, S., Erdem, T., & Oztekin, S. (2013). Mathematical modelling and color characteristics of purslane (*Portulaca oleracea* L.) leaves using different drying methods. *Philippine Agricultural Scientist, 96*(3), 267–274.

Khampakool, A., Soisungwan, S., & Park, S. H. (2019). Effect of osmotic pretreatment on shrinkage, textural properties, and aroma of microwave-vacuum dried mango. *Journal of Food Engineering, 263*, 120–128. https://doi.org/10.1016/j.jfoodeng.2019.05.004

Khan, S. A., Chakraborty, S., Dash, K. K., Dar, A. H., Shawl, F., Dash, S. K., ... & Barik, D. (2024). Review of solar greenhouse drying systems in conjunction with hybrid technological features, designs, operations, and economic implications for agro-food product processing application. *Energy Technology*, *12*(8), 2400176.

Lee, S., Park, M., & Kim, H. (2024). Effects of microwave and thermal pretreatment on ascorbic acid degradation kinetics in fruit drying. *Journal of Food Engineering, 350*, 112650. https://doi.org/10.1016/j.jfoodeng.2023.112650

Liu, X., Ji, D., Cui, X., Zhang, Z., Li, B., Xu, Y., Chen, T., & Tian, S. (2020). p-Coumaric acid induces antioxidant capacity and defense responses of sweet cherry fruit to fungal pathogens. *Postharvest Biology and Technology, 169*, 111297. https://doi.org/10.1016/j.postharvbio.2020.111297

Liu, C., Bai, C., Zhang, Y., Zhu, H., Dong, Z., & Zheng, X. (2025). Combined effect of ultrasonic pretreatment and drying temperature on the quality characteristics of honeysucks puree under microwave vacuum drying. *Drying Technology*, 1-1

López-Ortiz, A., Salgado, M. N., Nair, P. K., Ortega, A. B., Méndez-Lagunas, L. L., Hernández-Díaz, W. N., & Guerrero, L. (2024). Improved preservation of the color and bioactive compounds in strawberry pulp dried under UV-Blue blocked solar radiation. *Cleaner and Circular Bioeconomy, 9*, 100112. https://doi.org/10.1016/j.clcb.2024.100112

Lu, H., Huang, X., Ma, G., Xu, Y., Zang, Z., Zhang, K., Ma, W., & Wan, F. (2024). Evaluation of the effect of ultrasound-assisted hot air drying on the drying characteristics and physicochemical properties of cherries based on the entropy-weighted TOPSIS method. *Journal of Food Science, 89*(11), 7157–7171.

Ma, X., Zheng, J., Wang, W., Wang, Y., & Wang, X. (2015). A simple and rapid HPLC method for simultaneous determination of sucrose, glucose, and fructose from the fruits of *Lycium barbarum* L. for its quality control. *Pharmacognosy Magazine*, *11*(Suppl 2), S295–S299.

Mădălina, B., & Mihai, C. (2020). The influence of different storage methods on fruits quality of some sweet cherry cultivars. Fruit Growing Research. 2020, Vol. 36, 106-111

Nath, P., Pandey, N., Samota, M., Sharma, K., Kale, S., Kannaujia, P., Sethi s., and Chauhan, O. P. (2022). Browning reactions in foods. In *Advances in food chemistry: Food components, processing and preservation* (pp. 117-159). Singapore: Springer Nature Singapore.

Nukulwar, M. R., & Tungikar, V. B. (2020). Evaluation of drying model and quality analysis of turmeric using solar thermal system. *Applied Solar Energy, 56*(4), 292–300. https://doi.org/10.3103/S0003701X20040088

Ölmez, H., & Akbas, M. Y. (2009). Optimization of hurdle technology for minimally processed

carrots. *Food and Bioproducts Processing*, *87*(1), 25–31. https://doi.org/10.1016/j.fbp.2008.06.003

Oancea, S. (2021). A review of the current knowledge of thermal stability of anthocyanins and approaches to their stabilization to heat. *Antioxidants*, *10*(9), 1337.

Ouaabou, R., Nabil, B., Hidar, N., Lahnine, L., Idlimam, A., Lamharrar, A., Hanine, H., & Mahrouz, M. (2018). Valorization of solar drying process in the production of dried Moroccan sweet cherries. *Solar Energy*, *172*, 993–1003. https://doi.org/10.1016/j.solener.2018.05.079

Pateiro, M., Vargas-Ramella, M., Franco, D., Cruz, A. G. d., Zengin, G., Kumar, M., Dhama, K., & Lorenzo, J. M. (2022). The role of emerging technologies in the dehydration of berries: Quality, bioactive compounds, and shelf life. *Food Chemistry: X*, *16*, 100465. https://doi.org/10.1016/j.fochx.2022.100465

Qing-guo, H., Min, Z., Mujumdar, A. S., Wei-hua, D., & Jin-cai, S. (2006). Effects of different drying methods on the quality changes of granular edamame. *Drying Technology*, *24*(5), 639–647. https://doi.org/10.1080/07373930600776217

Radojčin, M., Pavkov, I., Kovačević, D. B., Putnik, P., Wiktor, A., Stamenković, Z., Kešelj, K., & Gere, A. (2021). Effect of selected drying methods and emerging drying intensification technologies on the quality of dried fruit: A review. *Processes*, *9*(1), 132. https://doi.org/10.3390/pr9010132

Safarov, J. E., Imanova, G. T., Sultanova, S. A., Samandarov, D. I., Gurbuz, G., & Azimov, T. D. (2024). Mathematical modelling of infrared drying characteristics. *Materials Research Innovations*, *28*(6), 562–574. https://doi.org/10.1080/14328917.2024.2366582

Salehi, F. (2023). Recent progress and application of freeze dryers for agricultural product drying. *ChemBioEng Reviews*, *10*(5), 1–16. https://doi.org/10.1002/cben.202300003

Schuessler, Z. (2025). What is delta E? And why is it important for color accuracy. *Viewsonic Library*. Retrieved August 19, 2025, from https://zschuessler.github.io/DeltaE/learn/

Simsek, M., & Süfer, Ö. (2021). Influence of different pretreatments on hot air and microwave-hot air combined drying of white sweet cherry. *Turkish Journal of Agriculture - Food Science and Technology*, *9*(6), 1172–1179. https://doi.org/10.24925/turjaf.v9i6.1172-1179.4455

Smith, J., Millar, J., & González, R. (2023). Influence of osmotic pretreatment and microwave drying on organic acid preservation in berries. *LWT – Food Science and Technology*, *162*, 113621. https://doi.org/10.1016/j.lwt.2022.113621

Szczepaniak, O. M., Kobus-Cisowska, J., Kusek, W., & Przeor, M. (2019). Functional properties of Cornelian cherry (Cornus mas L.): A comprehensive review. *European Food Research and Technology*, *245*(10), 2067–2082. https://doi.org/10.1007/s00217-019-03313-0

Tan, W., Wen, X., Xu, Z., Zong, L., Sun, X., Wei, Y., & Wei, (2023). High temperature inhibited the accumulation of anthocyanin by promoting ABA catabolism in sweet cherry fruits. *[Journal/Source]*. PubMed

Tunckal, C., & Doymaz, İ. (2020). Performance analysis and mathematical modelling of

banana slices in a heat pump drying system. *Renewable Energy, 150*, 183–193. https://doi.org/10.1016/j.renene.2020.01.040

Veberic, R., & Stampar, F. (2005). Quality of apple fruits (Malus domestica) from organic versus integrated production. *Information and Technology for Sustainable Fruit and Vegetable Production, Frutic, 5*, 12–16.

Vignati, E., Lipska, M., Dunwell, J. M., Caccamo, M., & Simkin, A. J. (2022). Fruit development in sweet cherry. *Plants*, *11*(12), 1531. https://doi.org/10.3390/plants11121531

Wani, S. M., Rizwan, D., Khanday, F. A., Mir, S. A., & Masoodi, F. A. (2024). Effect of pullulan and pullulan-chitosan composite coating on the antioxidant activity, texture, color and shelf-life of a local cultivar of sweet cherry. *Food and Humanity, 3.* https://doi.org/10.1016/j.foohum.2024.100432

Wiset, L., Poomsa-ad, N., & Onsaard, W. (2021). Drying characteristics and quality evaluation in microwave-assisted hot air drying of cherry tomato. *Engineering & Applied Science Research*, *48*(6).

Zhao, X., Huang, K., Yan, L. et al. A preliminary study on numerical simulation of microwave heating process for chemical reaction and discussion of hotspot and thermal runaway phenomenon. Sci. China Ser. G-Phys. Mech. Astron. 52, 551–562 (2009). https://doi.org/10.1007/s11433-009-0081-6

Zhou, J., Yang, S., Ma, Y., Liu, Z., Tu, H., Wang, H., Zhang, J., Chen, Q., He, W., Li, M., & Lin, Y. (2023). Soluble sugar and organic acid composition and flavor evaluation of Chinese cherry fruits. *Food Chemistry: X*, *20*, 100953.

Journal Pre-proof

1 Table1. Drying Kinetics of sweet cherry

	Initial MC	Final MC	Model Selected	RMSE	X2	R2
T1	75.36%	10.02%	Alibaş	0.0064	5,83 x 10-5	0.9997
T2	75.36%	10.56%	Alibaş	0.0071	7,10 x 10-5	0.9995
T3	75.36%	14.56%	Alibaş	0.0025	***	0.9999
T4	75.36%	2.42%	Alibaş	0.0004	***	1.0000
T5	75.36%	12.9%	Alibaş	8×10^{-06}	***	1.0000
T6	75.36%	8.19%	Alibaş	0.0002	***	1.0000
T7	75.36%	22.39%	Alibaş	0.0084	1.14 x 10-4	0.9993
T8	75.36%	4.19%	Alibaş	0.0025	1.08×10^{-5}	0.9999
T9	75.36%	5.99%	Alibaş	0.0038	6.07 x 10-5	0.9997
T10	75.36%	19.01%	Alibaş	0.0357	0.0023	0.9881
T11	75.36%	3.71%	Alibaş	3.46×10^{-6}	***	1.0000
T12	75.36%	1.75%	Alibaş	0.0017	***	0.9999
T13	75.36%	27.72%	Alibaş	1.31×10^{-5}	***	1.0000
T14	75.36%	2.10%	Alibaş	2.55×10^{-5}	***	1.0000
T15	75.36%	20.08%	Midilli	0.0274	0.0010	0.9736
T16	75.36%	21.86%	Midilli	0.0326	0.0013	0.9743
T17						

2

3

Journal Pre-proof

Journal Pre-proof

Table 2. Sugar content of dried fresh cherries

App. No	Sucrose	Glucose	Fructose
T1	6.68^{h} (±0.03)	164.8^{g} (±0.42)	95.70^{ij} (±2.07)
T2	6.68^{h} (±0.03)	164.8^{g} (±0.42)	95.70^{ij} (±2.07)
T3	18.66^{de} (±0.56)	207.74^{e} (±4.26)	167.46^{gh} (±4.03)
T4	21.73^{cd} (±5.47)	226.05^{d} (±4.56)	183.61^{ef} (±3.48)
T5	18.66^{de} (±0.32)	196.70^{ef} (±4.97)	163.86^{h} (±3.69)
T6	18.07^{e} (±0.41)	194.45^{ef} (±2.11)	178.42^{fg} (±1.03)
T7	22.18^{c} (±0.21)	202.75^{ef} (±5.36)	192.64^{de} (±9.27)
T8	14.56^{f} (±0.37)	114.58^{h} (±17.26)	99.37^{i} (±11.73)
T9	34.53^{a} (±0.39)	243.57^{bc} (±4.54)	200.69^{cd} (±3.88)
T10	14.78^{f} (±0.33)	259.37^{a} (±4.44)	229.68^{a} (±2.52)
T11	19.01^{cde} (±0.16)	237.67^{bcd} (±1.14)	210.32^{bc} (±1.22)
T12	11.31^{g} (±0.17)	233.43^{cd} (±3.47)	181.695^{ef} (±1.57)
T13	13.43^{fg} (±0.34)	195.78^{ef} (±6.41)	180.26^{ef} (±5.3)
T14	31.13^{b} (±0.16)	82.095^{i} (±4.60)	85.385^{j} (±2.53)
T15	18.05e (±0.27)	189.305f (±9.90)	180.27^{ef} (±10.50)
T16	20.86^{cde} (±0.09)	250.265^{ab} (±2.59)	214.96^{b} (±3.97)
T17	*	258.56^{a} (±0.31)	213.81^{b} (±6.80)

Journal Pre-proof

Table 3. Organic acid content of dried fresh cherries

App. No	Oxalic acid	Tartaric acid	Malic acid	Ascorbic acid	Lactic acid	Sitric acid	Fumaric acid
T1	52.77^{k} (±0.29)	1416.85^{r} (±61.44)	8888.36^{m} (±30.52)	295.20^{i} (±41.38)	*	592.91^{b} (±35.70)	0.905^{n} (±0.1)
T2	110.18^{g} (±2.47)	7018.29^{n} (±29.94)	9267.53^{l} (±11.41)	227.66^{j} (±13.32)	*	563.76^{b} (±10.45)	6.2^{m} (±0.02)
T3	173.33d (±2.7)	15349.31^{c} (±3.33)	22121.77^{g} (±2.24)	632.35^{d} (±12.85)	*	1599.28^{a} (±28.56)	16.59^{k} (±0.04)
T4	128.06^{f} (±0.52)	10898.85^{h} (±46.73)	24629.69^{f} (±194.73)	613.54^{d} (±2.77)	*	*	58.5^{c} (±0.42)
T5	143.23^{e} (±0.62)	15842.40^{a} (±161.28)	26439.17^{d} (±49.02)	773.06^{b} (±3.18)	*	*	34.6^{f} (±0.14)
T6	319.73^{a} (±8.34)	7814.41^{l} (±58.04)	14397.61^{j} (±193.81)	460.08^{f} (±25.03)	9587.38^{c} (±39.08)	*	32.73^{g} (±1.52)
T7	96.25^{i} (±0.22)	15533.02^{b} (±69.92)	28431.56^{a} (±109.78)	709.83^{c} (±9.55)	*	*	37.39^{e} (±0.17)
T8	231.89^{b} (±3.93)	7418.93^{m} (±7.62)	14539.16^{j} (±104.51)	498.30^{e} (±0.84)	10843.84^{b} (±168.80)	*	42.62^{d} (±0.03)
T9	196.52^{c} (±1.14)	9038.97^{j} (±95.21)	25623.53^{e} (±362.08)	699.22^{c} (±2.99)	14628.64^{a} (±144.15)	*	61.02^{b} (±1.73)
T10	131.89^{f} (±0.28)	14187.08^{d} (±39.61)	27162.36^{b} (±192.73)	695.96^{c} (±22.62)	*	*	27.18^{i} (±2.31)
T11	196.52^{c} (±1.14)	9038.97^{j} (±95.21)	25623.53^{e} (±362.08)	699.22^{c} (±2.99)	14628.64^{a} (±144.15)	*	61.02^{b} (±1.73)
T12	102.40^{h} (±3.2)	8324.94^{k} (±69.19)	10393.87^{k} (±118.33)	258^{j} (±14.8)	*	*	9.98^{l} (±0.02)
T13	84.04^{j} (±1.54)	9641.59^{i} (±80.76)	15683.63^{i} (±89.51)	372.64^{h} (±16.71)	*	*	22.66^{j} (±0.16)
T14	94.26^{i} (±1.28)	*	26909.92^{bc} (±202.23)	942.54^{a} (±8.41)	*	*	91.07^{a} (±0.33)
T15	88.25j (±0.12)	12661.28^{e} (±30.93)	26702.53^{cd} (±110.74)	918.51^{a} (±3.45)	*	*	29.09^{h} (±0.7)
T16	132.6^{f} (±0.028)	5662.52^{o} (±1.17)	3956.23^{o} (±23.43)	181.11^{k} (±0.21)	*	*	26.01^{i} (±0.68)
T17	107.48^{gh} (±1.43)	5110.82^{p} (±9.79)	6078.14^{n} (±79.13)	219.31^{j} (±6.95)	*	*	21.19^{j} (±0.02)

Journal Pre-proof

8 Table 4. Phenol content of dried fresh cherries

App. No	Gallic Acid	Protocatechic Acid	Catechin Hydrate	P-Hydroxy Benzoic Acid	Chlorogenic Acid	Caffeic Acid	Epicatechin	Vanilin	P-Coum Acid	O-Coum	Rutin	Quercetin.2H2O	Apigenin
T1	0.055^{j} (±0.005)	2.585^{h} (±0.09)	36.78^{b} (±1.47)	20.505^{a} (±0.44)	14.765^{ı} (±0.09)	9.74^{k} (±0.19)	50.82^{d} (±1.21)	2.865^{h} (±0.007)	1.02^{fgh} (±0.05)	*	13.63^{jk} (±0.09)	0.725^{d} (±0.09)	*
T2	0.41^{hı} (±0.02)	15.24^{c} (±0.08)	*	8.95^{d} (±0.41)	47.84^{f} (±1.59)	44.985^{d} (±1.54)	33.12^{f} (±0.86)	3.04^{h} (±0.02)	*	3.715^{f} (±0.1)	27.16^{h} (±0.14)	*	4.16^{a} (±0.01)
T3	0.565^{gh} (±0.04)	4.22^{g} (±0.08)	25.235^{c} (±0.07)	2.67^{f} (±0.24)	21.07^{h} (±0.12)	14.685^{ıj} (±0.23)	4.685^{j} (±0.6)	0.88^{ı} (±0.05)	0.365^{ı} (±0.02)	2.215^{g} (±0.03)	12.985^{k} (±0.04)	3.955^{c} (±0.007)	3.21^{b} (±0.07)
T4	3.175^{c} (±0.14)	15.145^{c} (±0.2)	23.195^{c} (±4.51)	10.235^{c} (±0.1)	125.05^{b} (±1.58)	36.99^{e} (±2.12)	40.65^{e} (±0.22)	10.07^{d} (±0.08)	6.665^{b} (±0.36)	15.015^{a} (±1.5)	84.66^{a} (±0.01)	*	*
T5	0.715^{fg} (±0.42)	11.545^{e} (±0.17)	*	*	102.61^{c} (±0.15)	53.96^{b} (±0.5)	22.49^{gh} (±0.77)	4.49^{g} (±0)	1.585^{ef} (±0.2)	12.845^{b} (±0.14)	67.345^{c} (±2.69)	*	*
T6	4.615^{b} (±1.52)	14.08^{cd} (±0.93)	59.05^{a} (±6.03)	*	70.56^{d} (±5.62)	27.505^{f} (±2.07)	88.89^{b} (±0.57)	40.29^{a} (±0.01)	*	14.95^{a} (±0.77)	63.2^{d} (±2.33)	*	*
T7	0.875^{ef} (±0.17)	15.165^{c} (±1.08)	*	*	76.08^{d} (±2.23)	48.59^{c} (±0.57)	11.275^{ıj} (±0.54)	6.905^{e} (±1.11)	2.81^{d} (±0.79)	11.085^{c} (±0.26)	60.19^{d} (±3.5)	*	*
T8	3.27^{c} (±0.03)	11.83^{e} (±0.27)	*	20.66^{a} (±0.19)	51.66^{f} (±4.25)	22.955^{g} (±0.13)	71.22^{c} (±0.82)	14.175^{c} (±0.43)	0.27^{ı} (±0.01)	3.25^{f} (±0.05)	16.48^{j} (±0.02)	*	*

Journal Pre-proof

T9	1.48^{d} (±1.73)	12.675^{de} (±0.07)	18.43^{c} (±1.79)	3.305^{f} (±0.37)	63.47^{e} (±1.08)	11.95^{jk} (±0.7)	20.19^{gh} (±0.66)	5.825^{f} (±0.72)	4.65^{c} (±0.08)	10.81^{c} (±0.15)	50.55^{f} (±1.25)	*	*
T10	0.605^{gh} (±2.31)	15.755^{c} (±0.12)	*	*	76.305^{d} (±3.51)	46.38^{cd} (±3.64)	7.18^{j} (±0.52)	5.565^{f} (±0.07)	3.205^{d} (±0.03)	8.79^{d} (±0.05)	54.65^{e} (±1.4)	*	*
T11	0.89^{ef} (±0.28)	9.785^{f} (±0.4)	*	*	59.485^{e} (±2.38)	36.29^{e} (±1.41)	3.905^{j} (±0.67)	2.36^{h} (±0)	1.725^{e} (±0.007)	5.35^{e} (±0.31)	45.205^{g} (±2.01)	*	*
T12	0(±)	13.23^{de} (±0.38)	*	6.475^{e} (±0.5)	35.7^{g} (±1.66)	47.165^{cd} (±3.21)	7.645^{j} (±0.48)	2.55^{h} (±0.04)	0.775^{ghı} (±0.02)	3.315^{f} (±0.03)	24.345^{hı} (±0.07)	*	*
T13	0.685^{fg} (±0.065)	8.43^{b} (±1.49)	*	10.365^{c} (±0.89)	61.505^{e} (±0.62)	59.925^{a} (±1.43)	14.83^{hı} (±0.33)	6.715^{e} (±0.3)	1.275^{efg} (±0.37)	5.625^{e} (±0.14)	26.1^{h} (±0.11)	*	*
T14	5.77^{a} (±0.33)	25.155^{a} (±2.18)	*	*	145.45^{a} (±5.54)	24.555^{fg} (±0.34)	253.865^{a} (±12.49)	33.71^{b} (±0.29)	20.34^{a} (±0.39)	15.805^{a} (±0.09)	78.035^{b} (±0.85)	*	*
T15	1.08^{e} (±0.7)	18.77^{b} (±0.32)	*	10.765^{c} (±0.16)	72.345^{d} (±3.45)	17.44^{hı} (±0.91)	4.085^{j} (±0.1)	2.795^{h} (±0.13)	3.09^{d} (±0.14)	5.66^{e} (±0.07)	22.125^{ı} (±1.37)	*	*
T16	0.07^{j} (±0.01)	4.9^{g} (±0.042)	*	8.85^{d} (±0.12)	9.185^{ıj} (±0.13)	11.055^{k} (±0.007)	6.99^{j} (±0.56)	0.9^{ı} (±0.05)	0.48^{hı} (±0.05)	0.695^{g} (±0.007)	15.92^{jk} (±0.29)	7.08^{b} (±0.52)	*
T17	0.22^{ıj} (±0.01)	13.065^{de} (±0.33)	*	17.03^{b} (±0.02)	8.49^{j} (±0.29)	18.745^{h} (±0.19)	21.995^{g} (±1.73)	2.99^{h} (±0.028)	1.68^{e} (±0)	0.745^{g} (±0.02)	14.625^{jk} (±0.12)	9.48^{a} (±0.14)	*

9

10

5

Journal Pre-proof

Journal Pre-proof

Highlights*

1. Optimized cherry drying methods extend shelf-life while preserving bioactive compounds.
2. MWHAD efficiently preserves color and bioactive compounds in dried cherries.
3. Microwave power and hot air temperature in MWHAD strongly affect drying efficiency.
4. Solution pre-treatment enhances sugar and phenolic compound retention
5. Optimized MWHAD offers scalable, high-quality dried cherries for industrial application.

Journal Pre-proof

Journal Pre-proof

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Journal Pre-proof