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Evaluation of drying kinetics, energy consumption, thermo-physical characteristics, and color quality of sweet cherries dried in an active-passive indirect dryer

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Since cherries are a seasonal product, it is not possible to obtain them at all times of the year. Due to their high moisture content, they cannot be stored for long periods of time. For these reasons, the drying of sweet cherries is of great importance in preventing product losses and preserving market value. In this study, cherries were dried with different solar energy using passive (without fan; P1), active (with three fan speed; F1, F2, F3) and open (exposed to the sun) methods in order to extend the shelf life and provide access in all seasons. The kinetics of the drying processes, energy consumption parameters, thermophysical properties and their effects on color parameters were investigated. Drying rate in drying processes changed in the range of 6.09–13.98 × 10^{-4} g moisture/g dry matter min. It was determined that effective moisture diffusion values ranged between 1.43 × 10^{-8}–9.62 × 10^{-9} m^2/s. The highest average specific heat, thermal conductivity, thermal diffusivity and specific mass of the dried samples were obtained at activated type-F1 fan speed. The dry product closest to fresh according to all color values was determined in the open drying method. According to the results, it is recommended that solar drying at a single fan speed (F1) be prioritized as a promising approach for sweet cherry drying in future applications and studies, while further optimization of active systems can improve specific moisture extraction rate (SMER) and specific energy consumption (SEC) performance.

KEYWORDS
drying kinetics, energy analysis, solar drying, sustainability-improvement, sweet cherry

1 Introduction

Sweet cherry (*Prunus avium* L.) is a seasonal and very popular fruit that is widely consumed worldwide, especially in fresh form. Cherries are known for their high antioxidant levels and the richness and diversity of their anthocyanin content (Serra et al., 2011; Grigoras et al., 2012; Ballistreri et al., 2013; Ouaabou et al., 2020). The cultivation and consumption of sweet cherry have increased due to consumer awareness of their health benefits, as they are rich in polyphenolics (anthocyanins, phenolic acids, flavonoids, and hydroxycinnamic acid) (Wani et al., 2014; Gonçalves et al., 2018; Salehi et al., 2023a; Salehi et al., 2023b). Cherry production has increased by 37% since the 2000 (Vignati et al., 2022; Chezanoglou et al., 2024). In 2020, 2.6 million tons of cherries were produced being Turkey (724,000 tons), the United States

(294,000 tons) and Chile (255,000 tons) the main producing countries (Mateus et al., 2023; Chezanoglou et al., 2024). Although cherries are mainly consumed fresh, the fruits are also dried to intensify their nutritional value and increase their shelf life. Drying is a widely used processing method of fruit and vegetable allowing reducing the moisture content and the water activity of products, thus extending their shelf life, facilitating storage, handling, packaging and transportation while preserving the organoleptic characteristics of products (Subramanyam et al., 2017; Salehi et al., 2023a; Nguyen et al., 2018). Drying is an energy intensive process, thus, to increase its sustainability, especially when applied to agricultural products, alternative drying systems need to be envisaged. For this reason, it is necessary to minimize energy costs in order to increase profitability. In this context, defining the amount of energy consumed with energy analysis is one of the basic components of the production stages. Energy analysis explains the thermal performance of a solar dryer based on the first law of thermodynamics. It provides information about the types of energy of a process and the amounts of energy input and output. In energy analysis, the quality of energy, losses due to irreversibility and environmental conditions are not taken into account (Suleman et al., 2014). The oldest known drying method is the open field solar drying, characterized by very long processing time, very large surface area for drying, and very high labor requirements (Karaaslan and Ekinci, 2023). In alternative the use of solar dryers has been suggested, utilizing solar energy indirectly. The use of these systems avoid the use of auxiliary energy contributing to decrease the environmental impact due to CO_2 production (Chen et al., 2020). In the past few years, solar dryers (Gupta et al., 2021; Gupta et al., 2022) have been proposed in the agricultural sector due to their cost-effectiveness and use of a clean energy source (Kumar et al., 2020). Solar dryers are generally classified as direct type, indirect type, mixed type and heat storage dryers (Akamphon et al., 2018). This classification primarily considers the drying of a product under direct/indirect exposure to sunlight (Mohana et al., 2020). Some of the advantages of indirect dryers are better control of the drying process, and a better quality of products compared to solar drying, particularly their color since the exposure to ultraviolet radiation is avoided (Lingayat et al., 2020).

There are many studies on the drying of various fruits and vegetables in indirect air flow dryers. Mugi and Chandramohan (2021), in their study on okra, found the specific moisture absorption ratio (SMER) and specific energy consumption (SEC) values as 0.674 kg/(kWh) and 1.484 (kWh)/kg in artificial air convection drying, and as 0.554 kg/(kWh) and 1.805 kg/(kWh) in natural air convection drying, respectively. Ouaabou et al. (2020), in their study on sweet cherries in an active indirect type dryer, found that the effective moisture diffusivity varied between 2.85–6.51 × 10^{-9} m^2/s, and the activation energy value reached 2388.67 kJ/kg. The total energy consumption and specific electrical energy of dried cherries showed a decreasing trend with increasing temperature. Wang et al. (2018), obtained the average thermal efficiency of mango in an active indirect type dryer as 30.9–33.8% and the specific moisture absorption rate as 1.67 kg water/kWh at 52 °C drying temperature. In previous studies on cherries, different drying techniques such as air, freezing and vacuum were applied (Doymaz and Ismail, 2011; Pirone et al., 2014; Franceschinis et al., 2015; Vakula et al., 2020). In addition to these, indirect driers have been proposed for drying different fruits and vegetables such as banana, strawberry, potato, red pepper and mint leaf (Lingayat et al., 2017; El-Beltagy et al., 2007; Nasri and Belhamri, 2018; Fudholi et al., 2014; Akpinar, 2010) and the drying behavior as well as energy consumption were discussed. Previous studies on air drying, vacuum drying, and freeze-drying of sweet cherries are reported in the literature. However, to the best of our knowledge, the use of indirect dryers to dry sweet cherries has not been proposed. This study aims to investigate the drying kinetics, energy consumption, thermophysical and organoleptic properties during drying of sweet cherries in active-passive and solar (open) dryers.

2 Materials and methods

2.1 Sweet cherry samples

The sweet cherry fruit (0900 Ziraat cultivar) used in this study was harvested by hand from a local producer's garden in Ereğli district of Konya province. Before the moisture determination and drying processes; inhomogeneity in color were sorted out and the remaining fruits were thoroughly washed with chlorinated tap water. The washed fruits were cut in half, the kernels were removed, and the drying process was started.

2.2 Moisture determination and drying processes

To determine the initial moisture of sweet cherry fruits, which were split in half in a hot air oven (NÜVE brand FN 400 model, Türkiye) set at 70 °C (Pixton and Warburton, 1973) until constant weight was reached. The initial moisture content (wb) of the samples was determined as 83.46 ± 0.61% on average. The samples were dried to an average of 0.10 ± 0.019 g moisture/g dry matter. The weight change of the dried samples was determined with (AND brand EK-300i model) precision balance (0.01 g). Fresh and dried sweet cherry samples were stored at 4 ± 0.5 °C in refrigerated conditions throughout the study. The manufactured solar cabinet type dryer was used to dry the samples with the solar cabinet dryer used during the experiments, was a self-designed system manufactured by a local company in Türkiye (Figure 1). The drying cabinet has a surface area of 8 m^2, and the volume of the opaque drying chamber is approximately 1 m^3. The system is equipped with three axial fans, each with a nominal power of 50 W and a diameter of 250 mm. These fans facilitate the transfer of air from the collector surface to the drying chamber.

Within the scope of the study, sweet cherry fruits were dried using passive (without fan), active (with fan) and open (exposed to the sun) methods (Table 1).

In addition, the effect of three fans used to direct the drying air to the drying chamber in the active drying method was studied. The effect on the drying processes when one fan was operated (F1), two fans were operated (F2) and three fans were operated together (F3) in the active drying method was investigated.

2.3 Calculation of moisture content

Equation 1 was used to determine the initial moisture content of the cherry fruit on wet basis (wb) (Pixton and Warburton, 1973).

$$N_{\mathrm{wb}} = \frac{M_{\mathrm{i}} - M_{\mathrm{l}}}{M_{\mathrm{i}}} \times 100 \tag{1}$$

M_{i}, the initial weight of the sample (g), M_{l}, the last weight of the sample (g), N_{wb}, the initial moisture content.

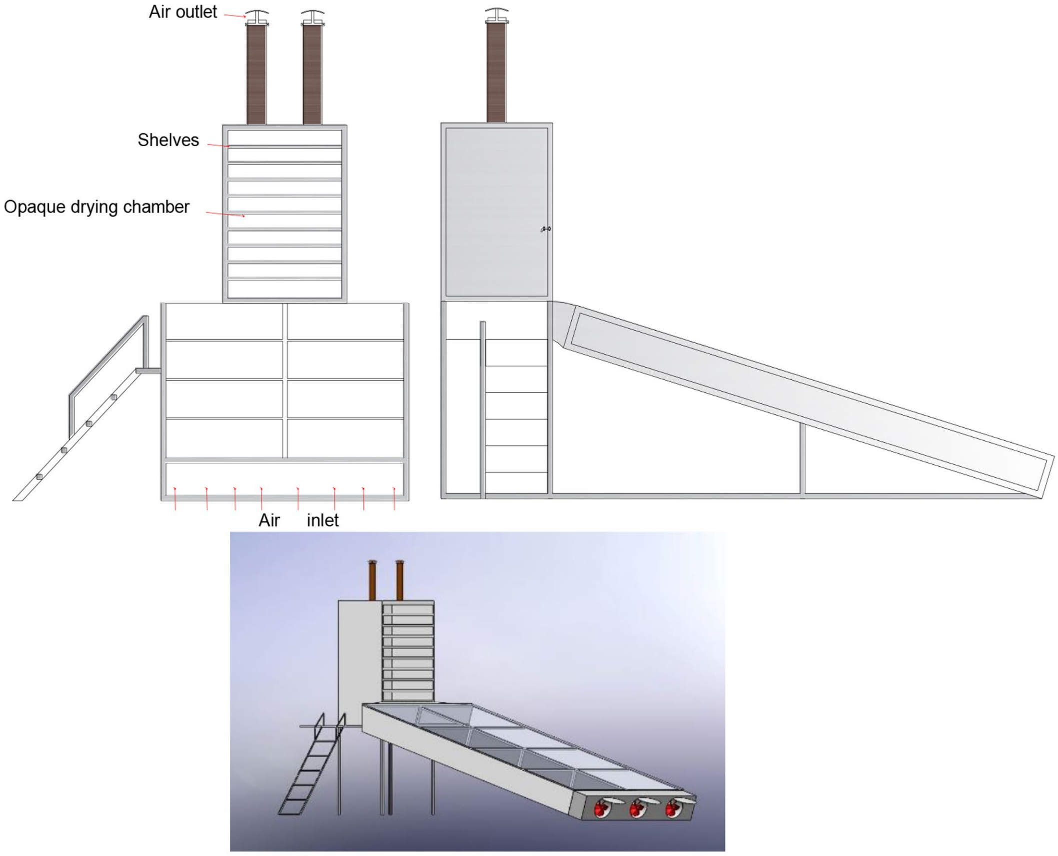

FIGURE 1
Solar powered cabinet dryer.

TABLE 1 Drying processes.

No.	Drying processes
1	Passive (P)
2	Active (F1)
3	Active (F2)
4	Active (F3)
5	Open

2.4 Determination of drying and moisture rates

Equation 2 was used to determine the drying rates of the samples.

$$\mathrm{DR} = \frac{M_t - M_{(t+dt)}}{dt} \tag{2}$$

M_t, the moisture content at time t (g water g drying matter $^{-1}$), dt, the minute, DR, the drying rate (g water g drying matter minute^{-1}).

Equation 3 was used to determine the moisture content of the drying processes.

$$\mathrm{MR} = \frac{M - M_e}{M_0 - M_e} \tag{3}$$

MR, the moisture ratio, M, the instantaneous moisture content of the product (g moisture/g dry matter), M_e, equilibrium moisture content of the product (g moisture/g dry matter), M_o, initial moisture content of the product (g moisture/g dry matter).

2.5 Effective diffusion value

Equation 4 was used to calculate the effective moisture diffusion values of the drying processes (Corzo et al., 2008).

$$\ln \mathrm{MR} = \ln \frac{8}{\pi^2} - \frac{\pi^2 . D_{\mathrm{eff}.t}}{4L^2} \tag{4}$$

D_{eff}, the effective moisture diffusion value (m^2/s), L, the thickness value (m) of the product.

2.6 Energy consumption values

A power meter (Polaxtor brand PLX-15366 model, China) (±0.02 kWh) was used to measure the energy values consumed in the drying processes.

2.7 Specific moisture extraction rate

Equation 5 was used to calculate the amount of moisture removed per unit energy value (SMER) in drying processes (Surendhar et al., 2019).

$$\text{SMER} = \frac{\text{Moisture removed in drying process (kg)}}{\text{Total energy supplied to the dryer (kWh)}} \quad (5)$$

SMER, the specific moisture removal rate (kg/kWh).

2.8 Specific energy consumption

Equation 6 was used to calculate the specific energy consumption value of drying processes (Motevali et al., 2012).

$$\text{SEC} = \frac{E_t}{m_w} \quad (6)$$

SEC, the specific energy consumption (kWh/kg water), E_t, total energy consumed (kWh), m_w, amount of moisture removed (kg).

2.9 Thermophysical properties

Specific heat, thermal conductivity, thermal diffusivity and specific mass values were calculated as a function of moisture content of cherry fruit on a dry basis. Specific heat value evaluated using Equation 7 (Huang et al., 2013; Taşova and Polatcı, 2021).

$$C_p = 837 + 3348\left(\frac{X}{1+X}\right) \quad (7)$$

C_p, is the specific heat (J kg K^{-1}), X, the moisture content on dry basis (kg water kg dry matter^{-1}).

The thermal conductivity was calculated using Equation8 (Ruiz-López et al., 2004; Taşova and Polatcı, 2021).

$$k = 0.49 - 0.44\exp(-0.206X) \quad (8)$$

k, where k is the thermal conductivity (W mK^{-1}) and X the moisture content on dry basis.

The thermal diffusivity was calculated using Equation 9 (Ruiz-López et al., 2004; Taşova and Polatcı, 2021).

$$\propto = \frac{k}{pC_p} \quad (9)$$

$\propto$, where the thermal diffusivity (m^2 s^{-1}), p, is the specific gravity (kg m^{-3}) value.

The specific gravity was calculated using Equation 10 (Perussello et al., 2013; Tzempelikos et al., 2015; Taşova and Polatcı, 2021).

$$P_p = 147.95\frac{X}{X_0} + 691.46 \quad (10)$$

P_p, the specific gravity (kg m^{-3}), X_0, the initial moisture content of the sample (kg water kg dry matter^{-1}) to the dry basis.

2.10 Color values

A CR400 colorimeter (Konica Minolta, Japan) was used to determine the color of fresh and dried sweet cherries. In this context, "L" value slices of fresh and dried sweet cherries took values between 0–100, the "a" value was measured as red (+)/green (−) and "b" value as yellow (+)/blue (−) values. Using the measured values, chroma (C), hue angle ($h°$), total color change (ΔE) and browning index (BI) values were calculated. Chroma shows the saturation value of the products. The hue value expresses a color radiant calculated using the measured redness and yellowness values. The total color change shows how much the color of the samples changed as a result of the drying processes. These values were calculated using equations 11–15 (Palou et al., 1999; Tan et al., 2001; Ramallo and Mascheroni, 2012; Çelen et al., 2015).

$$C = \left(a^2 + b^2\right)^{1/2} \quad (11)$$

$$h^\circ = \tan^{-1}\left(\frac{b^*}{a^*}\right) \quad (12)$$

$$\Delta E = \sqrt{\left(L - L^*\right)^2 + \left(a - a^*\right)^2 + \left(b - b^*\right)^2} \quad (13)$$

$$BI = \frac{\left[100(x - 0.31)\right]}{0.17} \quad (14)$$

$$X = \frac{a + (1.75 \text{ x } L)}{\left[(5.645 \times L) + \left(a - (3.012 \times b)\right)\right]} \quad (15)$$

2.11 Statistical analysis

The results obtained were analyzed using SPSS 23.0 software. SigmaPlot 10.0 program was used in the creation of curves. Reliability values were calculated according to ($p < 0.05$).

3 Results and discussion

3.1 Drying values

Moisture content and drying rate as a function of drying time in the different drying processes investigated, namely sun drying (Open), natural air flow drying (passive drying), one fan active solar drying (F1), two fans active solar drying (F2), three fans active solar drying (F3) are reported in Figure 2.

According to Figure 2, drying processes affected the moisture content and drying rates of sweet cherries. The average drying rates determined for P, F1, F2, F3 and open drying processes were 0.001077, 0.001398, 0.000845, 0.000843 and 0.000609 g moisture/g dry matter, respectively. It was observed that 50% of the moisture content of sweet cherries was removed in the first 33% of the process during the drying process. Data reported in the paper by Salehi et al. (2023b) show a similar trend. While the shortest drying times were determined in F1 and F3 drying processes (3,360 and 4,320 min), respectively, the longest drying time was determined in the open drying process (6,000 min). Bajoub et al. (2023) dried Moroccan strawberry fruit in a solar dryer at temperatures of 60, 70 and 80 °C and reported that the drying time of the samples varied between 60–240 min. It is thought that the reason why the drying times reported in the study are shorter than the drying times

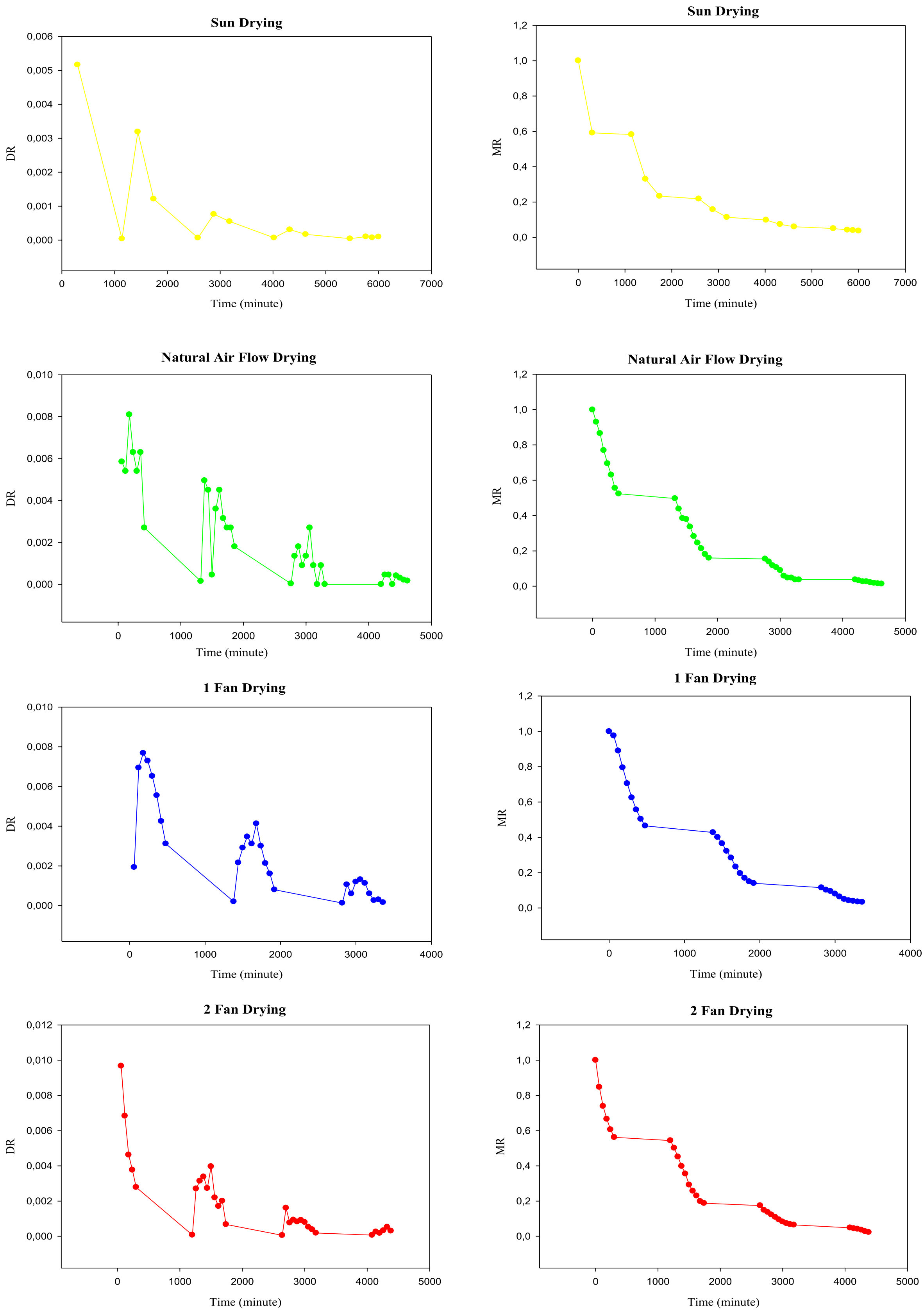

FIGURE 2 (Continued)

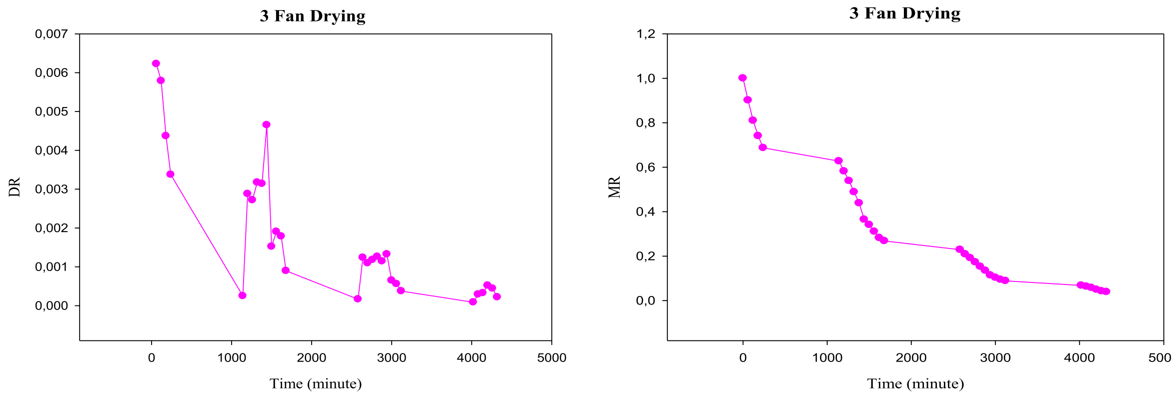

FIGURE 2
Drying kinetics of sweet cherry. P: passive drying, F1: one fan active drying, F2: two fans active drying, F3: three fans active drying, Open: drying by laying out in the sun.

obtained in our study is that the drying temperature was controlled and constant. Mohammed et al. (2020) was found that the average drying times determined in the open natural and mixed mode drying processes were more than 1,200 and 1,800 min, respectively. It was observed that the findings were consistent with the data obtained within the scope of the study.

3.2 Effective diffusion

Effective diffusion values for drying processes are given in Table 2. According to Table 2, drying processes affected the effective moisture diffusion values of sweet cherry fruit. Within the scope of the study, the effective moisture diffusion values of red cherries varied between 1.43×10^{-8}–9.62×10^{-9} m^2/s. The effective moisture diffusion value of the open drying process was found to be higher compared to other drying methods. It is estimated that the slower drying process in this method causes the moisture released outside the product to spread to a larger area (aerosol). Similarly, Aksüt et al. (2023) determined that the effective diffusion values were significantly affected after the drying study they conducted by applying pretreatment. Ouaabou et al. (2020) determined the effective moisture diffusion value of their cherry drying study conducted with a solar dryer as 2.85–6.51×10^{-9} m^2/s. Essalhi et al. (2018), dried grapes using open and indirect type solar drying processes. They determined it as 2.34–4.08×10^{-11} m^2/s for open and indirect type solar drying processes, respectively.

TABLE 2 Effective moisture diffusion values.

Drying method	Factors	Effective moisture diffusion (m^2/s)	R^2
Solar dryer	P	1.65×10^{-8}	0.956
	F1	1.47×10^{-8}	0.944
	F2	1.59×10^{-8}	0.962
	F3	1.43×10^{-8}	0.996
Open drying	—	9.62×10^{-9}	0.975

P: passive drying, F1: one fan active drying, F2: two fans active drying, F3: three fans active drying and Open: drying by laying out in the sun.

3.3 Energy consumption

SMER and SEC energy consumption values of drying processes are given in Figure 3. When Figure 3 is examined, it is seen that the number of fans affects the energy consumption values of the drying processes (Mohammed et al., 2020). Increasing the number of fans did not show a significant difference on the drying kinetics but increased the energy consumption values. Gilago and Chandramohan (2022) discussed the results obtained carrying out drying experiments in passive and active (fan) drying. As expected, the energy consumption increased in active drying.

In this study, the average SMER values determined for F1, F2 and F3 were 3.4×10^{-3}, 8.1×10^{-4} and 3.6×10^{-4} kg/kWh, respectively. Vijayan et al. (2016), in their study observed that the SMER values in the solar drying processes carried out in the air flow rate range of 0.0353–0.0872 kg/s continuously increased in the range of 0.0353–0.0636 kg/s and then decreased. In this study, it was determined that the SMER values decreased when two fans (F1 + F2) were operating together. It was observed that the relationship between the data determined in the literature and the data obtained within the scope of this study was similar. SEC energy consumption values of sweet cherry fruit in F1, F2 and F3 drying processes were determined as 298.42, 1233.77 and 2760.62 kWh/kg, respectively. It is estimated that the reason for this is that an increase in the number of fans causes an increase in the total energy consumption values.

3.4 Thermophysical properties

The effects of temperature values on the average specific heat, thermal conductivity, thermal diffusivity and specific mass values of sweet cherry fruit samples dried in active and passive type indirect dryers and sun dried are given in Table 3. Drying methods affected the thermo-physical properties of sweet cherries. It was determined that the final thermo-physical properties of the dried samples had very close values. The highest average specific heat, thermal conductivity, thermal diffusivity and specific mass of the dried samples were obtained in the indirect dryer and at F1 fan speed. Polatoğlu and Aral (2022) determined the thermal conductivity and thermal diffusivity values of the dried cornelian cherries as 0.06–0.11 Wm K^{-1} 6.46×10^{-8} and 7.18×10^{-8} m^2 s^{-1}, respectively, while they determined the specific heat values as

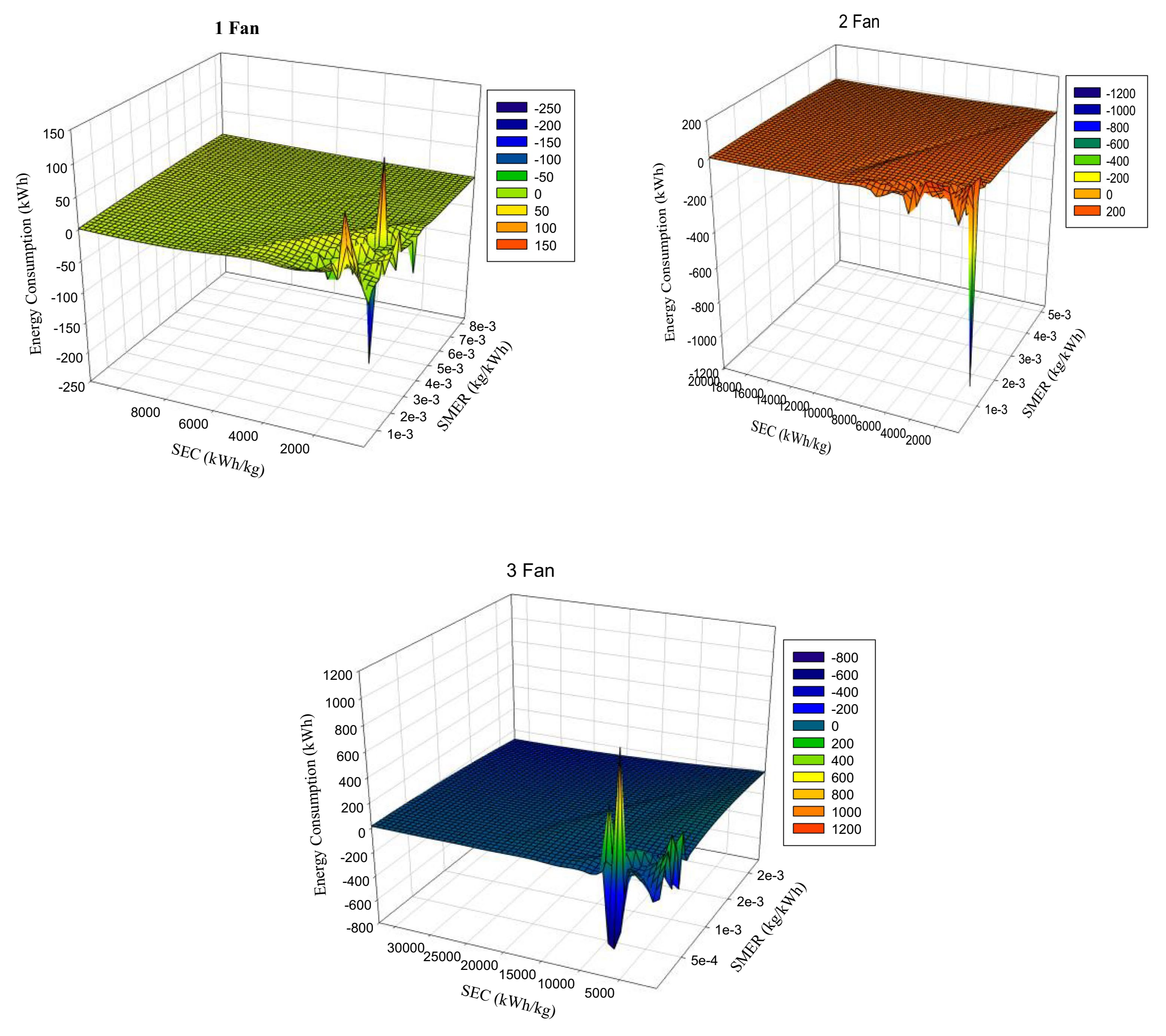

FIGURE 3
Distribution of SMER and SEC values.

1263.50–2062.27 J kg K^{-1}. In this study, while the thermal conductivity and thermal diffusivity values were found to be lower than those reported in the literature, the opposite was determined for the specific heat values. This might be due to the fact that the temperature and air flow rate could be controlled in the dryer used in the study in the literature. Yagua and Moreira (2011) found that the specific gravity change of potato slices dried in a hot air oven at 120, 130 and 140 °C gradually decreased and varied between 1,100–420 kg m^{-3} on average. The data obtained in this study in agreement with the findings reported in the literature.

3.5 Color values

Color, which is one of the most important quality characteristics for dried fruits, is a parameter giving indications of quality losses caused by heat treatments (Mateus et al., 2023). The measured and calculated color values of fresh and dried cherry samples are given in Table 4. Drying methods affected the color of sweet cherry fruit. Cherry fruits dried with F1 method retain their brightness (L) to greater extent at a significant ($p < 0.05$) level. Zia and Alibas (2021) found that the brightness (L) value of cornelian cherries dried with different drying techniques varied between 20.80–27.46. The brightness (L) values obtained in this study were determined to be higher than those found in the literature. It was determined that the redness (a) value of dried cherries decreased compared to fresh fruit. This is due to the negative effects of increasing temperatures on color pigments in solar dryer and open drying methods. Wojdyło et al. (2014) determined that the a value varied between 3.48–16.39 by drying sour cherries with different dryers. This can be explained considering the different driers and raw materials used. Data on yellowness allowed us to conclude that cherry samples dried with F2, F3 and open drier methods show similar characteristics as fresh fruits at statistically significant degree. Horuz et al. (2017) determined that the b values of the dried sour cherry samples varied between −0.24 to 1.26. In this study, colors closer to blue were obtained. Color intensity (chroma value) was better preserved when sweet cherries were dried with F1 and open drying methods ($p < 0.05$). Zia and Alibas (2021) similarly to this study determined the chroma (C) values of cornelian cherries in the range of 3.66–20.96. The hue angle of cherries dried in open drier is better preserved compared to fresh fruits while the highest hue angle was measured in sun dried samples, due to the highest values of the parameter b. The lowest total color change values were determined in the F3 method. Yi et al. (2016) stated that it was closer to fresh for the lower ΔE values. As far as the browning index is concerned, no

TABLE 3 Thermophysical properties of sweet cherries.

Drying method	Factors	Specific heat (J kg K^{-1})	Thermal conductivity (Wm K^{-1})	Thermal diffusivity (m^2 s^{-1})	Specific gravity (kg m^{-3})
Solar dryer	P	Min: 837.00	Min: 0.06	Min: 9.66×10^{-8}	Min: 694.24
		Max: 853.81	Max: 0.33	Max: 4.46×10^{-7}	Max: 896.55
		Avg: 841.73	Avg: 0.15	Avg: 2.25×10^{-7}	Avg: 749.12
	F1	Min: 837.00	Min: 0.06	Min: 1.10×10^{-7}	Min: 697.99
		Max: 853.18	Max: 0.33	Max: 4.41×10^{-7}	Max: 888.85
		Avg: 842.49	Avg: 0.16	Avg: 2.48×10^{-7}	Avg: 758.56
	F2	Min: 837.00	Min: 0.06	Min: 9.95×10^{-8}	Min: 695.04
		Max: 849.65	Max: 0.29	Max: 4.08×10^{-7}	Max: 845.56
		Avg: 840.61	Avg: 0.13	Avg: 2.06×10^{-7}	Avg: 735.44
	F3	Min: 837.00	Min: 0.06	Min: 1.08×10^{-7}	Min: 697.54
		Max: 849.64	Max: 0.29	Max: 4.08×10^{-7}	Max: 845.54
		Avg: 841.15	Avg: 0.14	Avg: 2.22×10^{-7}	Avg: 742.15
Open dryer	—	Min: 837.00	Min: 0.06	Min: 1.07×10^{-7}	Min: 697.04
		Max: 849.64	Max: 0.29	Max: 4.08×10^{-7}	Max: 845.54
		Avg: 840.03	Avg: 0.12	Avg: 1.88×10^{-7}	Avg: 728.68

P: passive drying, F1: one fan active drying, F2: two fans active drying, F3: three fans active drying and Open: drying by laying out in the sun.

TABLE 4 Color values.

Drying method	Factors	*L*	*a*	*b*	*C*	*h*°	Δ*E*	*BI*
Fresh	—	33.38^{ab}	5.92^{a}	4.73^{b}	7.69^{ab}	41.27^{ab}	—	—
Solar dryer	P	34.85^{a}	3.95^{ab}	9.18^{a}	10.06^{a}	70.13^{a}	28.08^{a}	38.44^{a}
	F1	34.44^{ab}	2.97^{ab}	6.80^{ab}	7.45^{ab}	67.68^{a}	27.78^{a}	27.86^{a}
	F2	30.05^{c}	2.40^{b}	4.53^{b}	5.23^{b}	65.59^{a}	25.43^{a}	22.06^{a}
	F3	26.08^{d}	3.14^{ab}	4.48^{b}	5.63^{b}	29.99^{b}	21.77^{b}	27.32^{a}
Open dryer	—	32.21^{bc}	3.51^{ab}	4.98^{b}	6.18^{ab}	58.52^{ab}	26.68^{a}	24.60^{a}

P: passive drying, F1: one fan active drying, F2: two fans active drying, F3: three fans active drying and Open: drying by laying out in the sun.

statistically significant difference ($p < 0.05$) was found in the dried samples. It was found that the overall color characteristics of the samples dried with the open drying method were closer to those of fresh sweet cherries. This is due to lack of temperature control in solar driers. The sudden increase or decrease of temperature causes the damage of pigments, thus the color changes of the dried samples. However, the F1 method can be used as an alternative to sun drying to reduce the drying time of the product.

4 Conclusion

It was observed that it affected the drying kinetics, energy parameters, effective diffusion values, thermophysical properties and color values of sweet cherry.

- It was determined that active drying methods (F1, F2 and F3) had higher energy consumption values compared to passive (P) and open drying methods.
- The highest SMER value was determined in the F2 method, while the highest SEC value was determined in the F3 method.
- The highest average specific heat, thermal conductivity, thermal diffusivity and specific mass of the dried samples were obtained in the indirect dryer and at the F1 fan speed.
- After analyzing all color data, it was determined that the open-air drying method is the closest to freshness. For sweet cherries, the F1 drying method is recommended as the second most effective method in terms of color.
- When all the findings obtained within the scope of the study are examined, it is recommended to dry sweet cherries in a solar dryer at 1 fan speed, namely the F1 method.

The limitations of this study and its future implications are as follows: The study was conducted with a prototype dryer. It may differ with larger-scale systems. Due to insufficient financial resources, electrical energy was supplied from the grid. Photovoltaic systems may be used in future studies. For sweet cherries, it is recommended that future studies be conducted using different pretreatments to preserve drying kinetics, quality properties, energy analyses and bioactive properties. Such studies will enable consumers to consume dried fruit out of season, preventing product losses and protecting farmers' labor in terms of sustainable production. The novelty of this research lies in promoting the consumption of dried cherries, which are usually consumed fresh, by comparing energy and color parameters in the drying process using solar-type dryers and open-air drying.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MM: Data curation, Validation, Methodology, Investigation, Writing – review & editing, Conceptualization, Writing – original draft.

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Conflict of interest

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Glossary

a* - Redness (+)/greenness (−)

b* - Yellowness (+)/blueness (−)

BI - Browning index

C - Chroma

C_p - Specific heat (J kg^{-1} K^{-1})

D_{eff} - Effective moisture diffusion value (m^2 s^{-1})

DR - Drying rate (g water g^{-1} dry matter min^{-1})

E_t - Total energy consumed (kWh)

h° - Hue angle (°)

k - Thermal conductivity (W m^{-1} K^{-1})

L - Thickness of value (m)

L* - Lightness color

M - Instantaneous moisture content (g water g^{-1} dry matter)

M_e - Equilibrium moisture content (g water g^{-1} dry matter)

M_i - Initial weight of the sample (g)

M_l - Last weight of the sample (g)

M_o - Initial moisture content (g water g^{-1} dry matter)

MR - Moisture ratio

m_w - Amount of moisture removed (kg)

p - Specific gravity (kg m^{-3})

SEC - Specific energy consumption (kWh kg^{-1} water)

SMER - Specific moisture extraction rate (kg kWh^{-1})

t - Drying time (min)

ΔE - Total color difference