Influence of Air Temperature and Pretreatment Solutions on Drying Time, Energy Consumption and Organoleptic Properties of Sour Cherry

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Summary

The effects of pretreatment solution (no treatment, boiling water, salty boiling water, ethil oleat) on drying time of sour cherry were studied experimentally. The thin layer drying of sour cherries was carried out at three air temperatures of 50, 60, 70°C and with constant airflow velocity of 1 m/s. Drying kinetic, energy consumption and organoleptic properties as taste, visual color and texture were evaluated in dried fruits. Results of experiments showed that pretreatment solutions and air temperatures had significant effect on drying time and organoleptic properties of dried sour cherry. Using of pretreatment solution is necessary before drying process. It reduced drying time up to 80% and energy saving was approximately 83% in comparison with no treatment samples.

Results of this research indicated that using of salty boiling water as pretreatment and temperature of 50°C in sour cherry drying process cause the best result in drying time and organoleptic evaluation such as taste quality, visual color and texture suitability of dried fruit. In addition, energy consumption for drying reduced noticeably when sour cherry was pretreated with salty boiling water.

Key words

sour cherry, drying, energy, organoleptic properties

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Introduction

Sour cherries (*Prunus cerasus* L.) belongs to the *Cerasus* subgenus within genus *Prunus*, being fairly distinct from plums, apricots, peaches, and almonds. They are members of the *Rosaceae* family, and subfamily *Prunoideae*. Sour cherries are relatively diverse and broadly distributed around the world, being found in Asia, Europe, and North America (Doymaz, 2007). Russian, Poland, Turkey, United States of America, Serbia, and Montenegro are the leading sour cherry production countries in the world. Iran is one of the ten prior countries in sour cherry production in the world (FAO, 2010). In Iran, about half of the total quantity is consumed as fresh fruit. The other half is used for processing purposes such as juice, jam and confectionery. The fruits of sour cherries can also be frozen and dried. By using drying method weight and volume of sour cherry fruits is reduced and can be stored for long period (Do et al., 1975; Doymaz, 2004). Fresh cherries such as sweet and sour cherry are very sensitive to microbial spoilage, even at refrigerated conditions; thus, they must be preserved in some form. Drying, which is the oldest food preservation technique practiced by humankind, is the most important process to preserve sour cherry since it has a great effect on the quality. The objective in drying sour cherry is to reduce the moisture content to a level that allows safe storage over an extended period (Abdelhaq & Labuza, 1987; Vagenas & Marinos-Kouris, 1991). Sun drying has been the most widely used method of food drying in the world for thousands of years. In many Middle East countries such as Iran, Pakistan, Iraq, and Turkey, the most common drying method for horticultural fruits is open-air sun drying. Sun drying permits one to produce a product with a dark or semi dark color, unclear appearance, and desirable gummy texture. Sun drying may be good for some fruits as apricot but it is not recommended for some sensitive fruits to sun light. However, long drying time is undesirable for economic reasons and because of the danger of contamination and spoilage of the product exposed to the open environment (Vagenas & Marinos-Kouris, 1991; Kostaropoulos & Saravacos, 1995).

In order to reduce time and improve the quality of fruits, solar and industrial dryers should replace traditional drying methods. The main disadvantages of solar dryers are the limited time of solar radiation and the short season of ripening of many agricultural products. Industrial dryers, which are far more rapid, providing uniformity and hygiene, are inevitable for industrial food drying processes (Karathanos & Belessiotis, 1997; Sarsilmaz et al., 2000; Doymaz & Pala, 2002a). Hot-air dryers, which are far more rapid, providing uniformity and hygiene are inevitable for industrial food drying processes (Demir et al., 2004; Karathanos & Belessiotis, 1997). Literature review showed that using of pre treatment solutions greatly reduces drying time and improves water permeability of grape, apricot, mulberry, and plum. Dipping waxy fruits for several seconds in solutions of ethyl oleate or other suitable compounds (usually fatty acid derivatives are used as wetting agents and emulsifiers) greatly reduces drying time (Ponting & McBean, 1970; Bolin et al., 1975; Saravacos et al., 1988; Dincer, 1996; Doymaz & Pala, 2002b; Doymaz & Pala, 2003;). The effect of ethyl oleate solution on drying time of sour cherry was studied on sour cherry drying. Drying time of pretreated samples was about 26–30% shorter than that of untreated samples (Doymaz, 2007). Although using of alkali ethyl oleate solution was investigated in sour cherry drying (Doymaz, 2007), but no study was found in the literature that compares the effect of different pretreatment solutions such as ethyl oleate, boiling water, boiling salty water in comparison with untreated sample as control on sour cherry drying.

The objective of this study was to investigate the effect of dipping sour cherry in ethyl oleate, boiling water, boiling salty water as pretreatment solutions in comparison with untreated sample (control treatment) at 50-70°C on the drying rates and energy consumption of sour cherry. Beside quality parameters, taste, color, and texture were compared between treatments after drying process.

Materials and Methods

Sample preparation

Ripe sour cherries (*Prunus cerasus* L.) of proper maturity, uniform size, red color, and firm texture from a local garden of Karaj-Iran were prepared. The over-ripe and bruised fruits were separated manually. After washing in cold water to remove all foreign material such as dust, dirt, and leaves, the fruits were kept in refrigerator at 4°C before pretreatment and drying. Generally, samples of uniform size were selected. The average diameter of samples was 13.40 ± 0.20 cm. Initial moisture content of the fresh sour cherries was approximately 75.0 ± 2.0% on wet basis (w.b.), and was determined by drying in an air convection oven at 105°C for 7-10 h, performed in five replications (Doymaz, 2007; Ghaderi et al., 2010). Chemical materials used for dipping sample were of laboratory grade.

Using three units lab scale precision dryer (Figure 1) effect of drying temperature at three temperatures: 50, 60 and 70°Con drying time of sour cherry was investigated for following treatments:

1 – Fresh sour cherry without pre treatment (Control)

2 – Dipping fresh sour cherry in 2% ethyl oleate for 1 minute

3 – Dipping fresh sour cherry in boiling water for 1 minute

4 – Dipping fresh sour cherry in boiling 20% salty water (sodium chloride) for 1 minute

Drying procedure

In order to study pretreatment effect on drying time and sensory parameters, Completely Randomized Design (CRD) was used with three replications. All data were statistically analyzed using Statistica software version 6.0 and the differences between the treatment means were compared by Duncan's multiple range test at 5% level of significance. In each experiment, about 1500 g of fresh sour cherry were used. All treatments were dried to 17.0 ± 3.0% (w.b.). The product was cooled and packed in low-density polyethylene (LDPE) bags that were heat-sealed. The runs were performed in triplicate (Doymaz, 2007; Tarhan et al., 2006).

The temperature and air velocity were measured by a digital thermometer (Atbin, AT400K) with 1°C accuracy and Hot-wire anemometer (Testo 425) with 0.1 m/s accuracy, respectively. Air velocity was measured and adjusted approximately 1 m/s in outlet air gate.

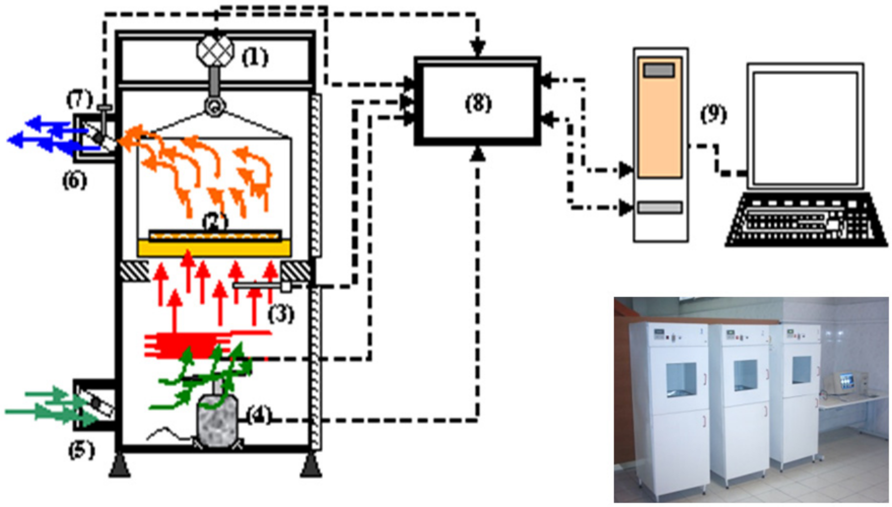

Figure 1. Schematic diagram of Lab dryer. Where: (1) load cell, (2) tray sample holder, (3) warm air sensor, (4) DC motor, (5) inlet air gate, (6) outlet air gate, (7) exit air sensor, (8) data accusation and controller, (9) computer

Sample weights were determined automatically every 15 minutes using an electronic weighting system (0.1 g precision) connected to the computer. Temperature and Relative humidity of laboratory was 24±2°C and 39±8%, respectively.

Drying kinetic of treatments was monitored using the moisture ratio MR of sour cherries during the drying experiments. It was expressed by the following equation:

$$MR = \frac{M_t - M_e}{M_o - M_e} \quad (1)$$

Where M_t is the moisture content at any time (kg water/kg dry basis), M_o is the initial moisture content (kg water/kg dry basis), and M_e is equilibrium moisture content of sample (kg water/kg dry basis).

The values of M_e are relatively small compared to M_t or M_o, hence the error involved in the simplification is negligible (Doymaz, 2004; Akpinar et al., 2003; Diamante & Munro, 1993).

Organoleptic properties for dried sour cherry

Some organoleptic properties such as taste, visual color and texture were compared between dried sour cherry of experimental treatments using product-oriented testing method and ten untrained judges; researchers of the Department of Post Harvest Technology and Food Science of the Agricultural Engineering Research Institute of Agricultural Ministry of Iran (Esti et al., 2002; Martinez- Romero et al., 2006). The panelists were also asked to give their opinion about the overall quality of the product, taking into account the judgment assigned to each above-mentioned attribute. A scale ranging from 1 to 5 (1=extremely unacceptable and 5=extremely acceptable) was used, according to the procedure reported by Gazor and Minaee (2005). The analyses were performed in isolated booths in a standard taste panel kitchen by presenting samples with 12 digit codes. The panelists drunk water between the samples. During the test sessions, the sample presentation order was randomized.

Energy requirement

In order to calculate specific energy consumption for drying of one kilogram of sour cherry, total electrical consumption (heater + fan) in dryer was calculated for each treatment using equation 2. Electric Current was measured by digital clamp ampere meter (Lutorn CM 9930). Considering active time for devices, it was 9 and 2 Am for heater and fan respectively. Technical specification of fan was cosφ = 0.95.

Specific energy requirement for drying of wet sour cherry was calculated as kilowatt-hour per kilogram-wet sour cherry (Sharma and Prasad, 2006; Koyucu et al., 2007; Jindarat et al., 2011).

$$W = P_1 \times h_1 + P_2 \times h_2 = (V \times I) \times h_1 + ((V \times I) cos\varphi) \times h_2 \quad (2)$$

where: W is the total electrical consumption (KWh), P_1 electrical power consumption of heater, P_2 electrical power consumption of fan, V is AC voltage (220 V), I is the electric current (Am), h_1 is the active time of heater (h), h_2 is the active time of fan

Results and discussion

Drying characteristics of sour cherries

Results and statistical analysis of the data show that air temperature and pretreatment have very significant effects at 1% level on drying time of sour cherry (Table 1). In addition, interaction effect between temperature and pretreatment was very significant at 1% level.

Comparison of the means for drying times of the differently treated sour cherry is given in Table 2.

Table 1. ANOVA table for drying time of sour cherry

S.O.V	d.f	M.S
Temperature	2	4389.40**
Pretreatment	3	4561.82**
Temperature x Pretreatment	6	1559.54**
Error	24	0.74
Total	35	
C.V		0.82

** = significant at 1% level

Table 2. Comparison of the means for sour cherry drying time in experimental treatments

Temperature (°C)	Pre treatment solution	Drying time (h)
50	No treatment (Control)	119.7i
	Ethyl oleate	24.2 f
	Boiling water	26.7 g
	Salty boiling water	20.2 e
60	No treatment (Control)	42.7 h
	Ethyl oleate	13.2 c
	Boiling water	13.7 c
	Salty boiling water	10.5 b
70	No treatment (Control)	17.3 d
	Ethyl oleate	9.0 ab
	Boiling water	9.8 b
	Salty boiling water	7.7 a

* Means with the same letter have no significant difference (α= 5%)

Table 3. Drying time reduction of sour cherry (%)

Temperature (°C)	Dipping in salty boiling water in comparison with control	Dipping in salty boiling water in comparison with ethyl oleate	Dipping in salty boiling water in comparison with boiling water
50	83.1	16.5	24.3
60	75.4	20.5	23.4
70	55.5	14.4	21.4
Average	71.3	17.1	23.0

Generally, drying times for sour cherry samples that were dipped in pretreatment solutions were shorter than control samples, at experimental temperatures (Table 2). According to the results, sour cherry dipped in salty boiling water solution prior to drying, were found to have a shorter drying time when compared to the samples dipped in ethyl oleate, boiling water and control treatments.

In previous research results, effect of ethyl oleate has been found good in drying of grapes (Saravacos et al., 1988; Dincer, 1996; Doymaz & Pala, 2002b), apricots (Pala et al., 1996), red pepper (Doymaz & Pala, 2002a) and mulberry fruit (Doymaz & Pala, 2003) but in this research using of salty boiling water as pretreatment was better than other solutions for sour cherry preparation before drying process. Results of experiments demonstrated that salty boiling water has bigger influence on decreasing drying times sour cherry than other solutions at three temperatures (Table 3). Using of salty boiling water as pretreatment caused reduction of drying time for 71.3% (average) in comparison with control treatment. This effect was greater at 50°C than at 60 and 70°C.

Curves of moisture ratio versus drying time for pre/untreated sour cherry are shown in Figures 2, 3 and 4. It is apparent that at all drying temperatures, moisture ratio decreases continuously with drying time.

These curves show that there was no constant-rate period but it was falling-rate period. This shows that diffusion is the dominant physical mechanism governing moisture movement in the

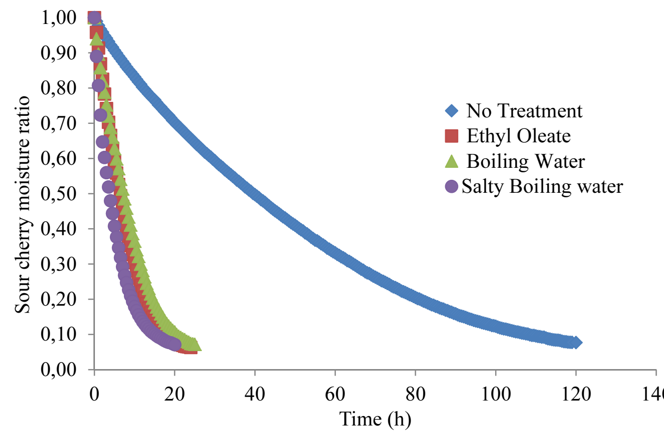

Figure 2. Effect of different dipping pre-treatments on sour cherry drying at temperature of 50°C

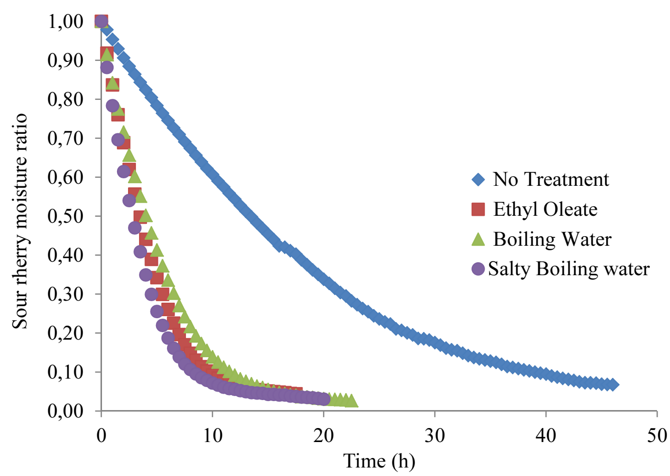

Figure 3. Effect of different dipping pre-treatments on sour cherry drying at temperature of 60°C

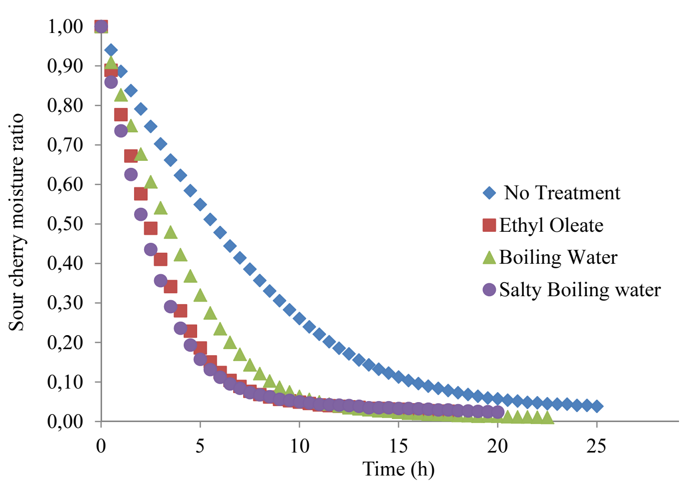

Figure 4. Effect of different dipping pre-treatments on sour cherry drying at temperature of 70°C

Table 4. ANOVA table for sensory parameters of dried sour cherry

Source of variance	d.f	M.S Taste	Visual color	Texture
Temp.	2	1404.34 **	1324.14**	3542.35**
Pretreatment	3	1923.41**	1513.47**	4493.71**
Temp. x Pretreatment	6	252.24n.s	1936.20**	642.32**
Error	24	196.56	456.15	79.28
Total	35			
C.V		12.8	13.3	11.5

** Significant at 1% level; n.s Not significant at 5% level.

Table 5. Comparison of the means of sensory parameters in dried sour cherry

Pretreatment	Temp. (°C)	Comparison of means* Taste acceptance (%)	Visual color acceptance (%)	Texture acceptance (%)
No treatment	50	86.8^{a}	67.0^{cd}	85.7^{a}
	60	78.9b^{c}	70.6^{c}	83.4^{a}
	70	76.4^{c}	72.1^{c}	66.9^{cd}
Boiling water	50	75.8^{c}	87.9^{a}	84.3^{a}
	60	73.9^{cd}	74.6^{b}	69.4^{c}
	70	70.1^{d}	73.8^{b}	62.8^{d}
Salty boiling water	50	81.8^{ab}	86.9^{a}	80.1^{ab}
	60	78.8^{bc}	78.3^{b}	57.9^{e}
	70	76.3^{c}	76.1^{b}	56.1^{e}
Ethil oleat	50	65.3^{e}	68.3^{cd}	78.4^{b}
	60	64.1^{ef}	64.9^{d}	70.7^{c}
	70	61.8^{f}	67.9^{cd}	69.3^{c}

*Means with the same letter have no significant difference (α = 5%).

Table 6. Energy consumption for sour cherry drying at different treatments

Pretreatments	Temp. (°C)	Total energy consumption (kWh)	Specific energy for drying 1 kilogram wet sour cherry (kWh/kg)
No treatment	50	120.74	62.88
	60	43.09	27.07
	70	29.67	22.91
Ethil oleat	50	24.15	10.61
	60	13.03	6.84
	70	15.71	8.06
Boiling water	50	27.17	24.00
	60	14.03	6.44
	70	17.45	8.03
Salty boiling water	50	20.12	13.09
	60	11.02	7.04
	70	13.96	9.21

samples. Similar results were obtained by different authors on drying of various fruits such as grapes, apricots, and mulberries (Raouzeos & Saravacos, 1986; Vagenas & Marinos-Kouris, 1991; Doymaz & Pala, 2003).

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No treatment	50	120.74	62.88
	60	43.09	27.07
	70	29.67	22.91
Ethil oleat	50	24.15	10.61
	60	13.03	6.84
	70	15.71	8.06
Boiling water	50	27.17	24.00
	60	14.03	6.44
	70	17.45	8.03
Salty boiling water	50	20.12	13.09
	60	11.02	7.04
	70	13.96	9.21

Sensory parameters for dried sour cherry

Result of experimental analysis indicated that temperature changes and use of pretreated solution had significant effects at 1% level on dried sour cherry quality parameters such as taste, visual color, and texture (Table 4).

Using of pretreatment solutions had different effects on sensory quality of dried sour cherry. Salty boiling water pretreatment had the best influence on taste, visual color, and texture of dried fruit in comparison with other pretreatment solutions. Mostly, using of pretreatment solutions has good effect on color of dried fruits in comparison with control treatment (no treatment). Salty boiling water was the best pretreatment solution, especially when the fruit was dried at 50°C. Using of ethil oleat as pretreatment had minimum acceptance level for drying of sour cherry. Results of research confirmed that salty flavor is more acceptable among dried sour cherry consumers, but it is not suitable for people that have blood pressure problem. It is suggested to use boiling water as pretreatment before drying process of sour cherry.

Energy Consumption

Result of experiments indicated that using of pre treatment solutions reduced energy consumption for sour cherry drying process. It is more efficient at 50°C than at other temperatures (Table 6). Sour cherry pretreated with salty boiling water had the least of total energy consumption among other pretreated sour cherries. In comparison with untreated sour cherry, specific energy consumption for drying of 1-kilogram wet sour cherry was reduced 83.12, 74.73 and 64.81% at 50, 60 and 70°C respectively, when sour cherry was pretreated with ethil oleat. Pretreatment of sour cherry with salty boiling water reduced specific energy consumption 79.18, 73.99 and 59.89% at 50, 60 and 70°C respectively.

Conclusion

The results of this research showed that the use of pretreated solution is necessary for sour cherry drying process. It is reduces drying time up to 80%, and saves energy approximately 83% in comparison with no treatment samples. Results of this research indicated that use of salty boiling water as pretreatment at the temperature of 50°C in sour cherry drying process causes the best result in drying time, and sensory evaluation such as quality taste, visual color and suitable texture of dried fruit. In addition, energy consumption for drying was reduced noticeably when sour cherry was pretreated with salty boiling water. Use of ethil oleat had the lowest acceptance level among test panel members.

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