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Compositional Changes of the Jujube Fruit During Solar and Tray Drying

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ABSTRACT
This study aims to determine the changes in some components of jujube fruit after drying in the solar and tray dryer, and to choose the appropriate drying method in terms of component loss. In this study, jujube fruit *(Zizyphus jujuba Mill.)* was used as material and were obtained from producers in the Çivril-Denizli regions of Turkey. Firstly, we analysed the total soluble solids, dry matter, titratable acidity, pH, total phenolic content, organic acids (malic, citric, succinic and tartaric acid), sugars (glucose, fructose and sucrose) and water-soluble vitamins (ascorbic acid, riboflavin, niacin, pyridoxine and thiamine) in fresh jujube fruit. Secondly, the fresh jujube fruits were dried in the solar and tray dryer (50, 60 and 70 °C). Following the drying processes, changes of the above-mentioned parameters were evaluated. The total phenolic content was determined using the spectrophotometric method. Sugars, organic acids and water-soluble vitamins content were determined using a high-performance liquid chromatography (HPLC) instrument. The solar drying of the jujube fruit resulted in glucose and sucrose content decrement and in fructose content increment, while tray drying resulted in decrement in glucose, fructose and sucrose content. A high decrement in organic acids and water-soluble vitamins content of the jujube fruit both in the solar and tray drying process was determined. In addition, solar drying resulted in more vitamin content decrement compared to the tray drying.

Keywords**:** HPLC, *Zizyphus jujuba Mill.*, Organic acids, Sugars, Water-soluble vitamin

1. Introduction

Jujube (*Zizyphus jujuba Mill.*), a Chinese-origin plant with about 400 different culture varieties, is known to have been grown in China for around 4000 years. Jujube also grows in Russia, India, North Africa, Southern Europe, the Middle East, and Anatolia, which is a natural spreading area. Although it is not native to Turkey, it can be grown in the Marmara, and West and South Anatolia regions (Genç 2005; Yücel 2005). Jujube is known in different cultures with various names such as jujube, hong zao, chinese date, tara, liane crocs chien, nan tsao, azufaifo, pomme malcadi, petite pomme, ta tsao, annap, ünnap (Hernandez et al. 2016).

Jujube is a fruit with high nutritional value for the fruit is important in many places for human nutrition because of its rich source of ascorbic acid, total phenolic compounds, antioxidant capacity, carotenoids, and minerals. Jujube fruits contain essential trace elements such as magnesium, zinc, copper, iron, phosphorus, and substances such as niacin and riboflavin necessary for the body's enzyme and hormone system. In addition, they contain mucilage and pectin (Promyou et al. 2012; Gao et al. 2013).

Jujube fruits, which are rich in water-soluble vitamins, minerals, and many more organic and inorganic substances, can be used in the treatment of many diseases such as liver and heart, vascular disorders, and cholesterol disorders in the blood. It is used among people as a breast softener, sputum and diuretic, constipating, aphrodisiac, and a good toxin suppressant cough (Omid 1997).

Jujube is used as an additive in the production of many medicinal drugs and has an anti-inflammatory, pain-relieving effect (Abd-Alrahman et al. 2013). Several studies report that the fruit can be effective in the treatment of diseases such as diabetes (Miri 2018; Shahrajabian et al. 2019; Proestos 2020), jaundice (Rahman et al. 2018) diarrhea, wounds, and ulcers (Kaur et al. 2019; Soni & Malik 2021).

Drying is the oldest preservation method and has been used since ancient times. Through the drying process, the shelf life extends, water activity reduces, microbiological safety increases and transportation costs are reduced. The choice of drying method is crucial for the preservation of quality parameters. Solar drying and hot air drying are traditional drying methods (Elmas et al. 2019). Drying with hot air provides some advantages compared to solar drying, such as being free from climatic effects and hygienic conditions. However, hot air drying also brings disadvantages such a longer drying time, loss of nutritional and bioactive value, and changes in sensory properties (Wang et al. 2016).

Although fresh jujube fruit contains a high amount of vitamin C, this fruit is typically consumed as nuts. Therefore, it is important to know the changes that occur in its composition during the drying process. To the best of our knowledge, there is no published research study about the water-soluble vitamin determination of jujube fruits during solar and tray drying. The objectives of this study are (a) to determine some physical and chemical properties of jujube fruits during solar and tray drying, and (b) to determine the changes of organic acids, sugars, and water-soluble vitamins during solar and tray (50, 60, and 70 °C) drying.

2. Material and Methods

2.1. Material

Approximately 200 kg of Jujube fruit was obtained from jujube producers in the Çivril district of Denizli and shipped to the laboratory in crates. The samples were harvested in 2013. Jujube fruits collected under controlled conditions from the garden in the Çivril region were used for solar and tray drying. Mature stage jujube fruits were collected from 10 different predetermined trees. The collection process was carried out homogeneously from all sides of the tree (north, south, east, and west). Then, the jujube fruits were used in both the initial analysis and drying process following the selection, sorting, and washing processes.

2.2. Drying procedure

Two different methods, namely solar and tray drying, were used to dry the fruits. In the solar drying process, the fruits were laid on wooden exhibitions and dried in the shade. The drying time of jujube fruit for solar and tray drying is 7-11 days and 60-72 hours, respectively.

The working temperature range, relative humidity range, and air-speed range of the oven used for the drying were 40 °C - 120 °C, 20-95%, and 0-2 m/s, respectively. The drying conditions were carried out according to the method suggested by Fang (2009). Tray drying experiments were carried out in a hot air dryer (Yücebaş Makine Ltd. İzmir, Turkey) at temperatures of 50, 60, and 70 °C. The hot air dryer consists of a centrifugal fan, electric heater, and electronic proportional controller to ensure airflow. A constant airflow of 0.2 m/s and a constant 20% relative humidity were used during the drying process. The weight of the jujube fruits were regularly recorded during hot air drying. The drying process was applied until the sample weight reached a moisture content of 15 g/100 g. Three replicates for each of the experiments were performed.

Care was taken to ensure that the jujube fruits, which will be dried, had the same degree of maturity. The fruits were stored in a refrigerator at 4 °C until they were to be dried in the solar and tray dryer. In the hot air-drying processes, approximately 4500 grams of jujube samples were used for each temperature and 4000 grams in the solar drying processes. Samples were dried to an approximately 20% moisture content. The moisture content of the final product was determined by the rapid moisture determination method in order not to be affected by ambient humidity.

2.3. Extraction for organic acids and sugars

Organic acid and sugar analyses were carried out according to the method suggested by Soyer et al. (2003) and Sturm et al. (2003). Fresh and dried jujube fruits were weighed 20 g and ultrapure water was added at a ratio of 1/1 (w/w). Then, it was homogenized with a blender (Waring-USA). After 10 g of the obtained mixture was taken, 50 mL of ultrapure water was added and centrifuged at 13440 G-force for 15 minutes (core NF800R-Turkey). Following the centrifugation, 5mL of the supernatant was filtered in amber vials through a 0.45µm PTFE (Sartorius, SM16555Q, Germany) syringe-type filter. The obtained extracts were stored at -20 °C until analysis. The extracts were carried out in triplicate.

2.4. Determination of organic acids

In order to determine the organic acid content of the jujube fruit, calibration solutions were prepared at five different concentrations with tartaric, malic, citric, and succinic acid standards. The prepared solutions were injected into the HPLC device, a linear regression analysis was applied to the obtained data and the equation definition curve was created. The reliability of the method was confirmed by the recovery tests. The recoveries for malic, citric, succinic, and tartaric acid were determined as 99.5%, 98.32%, 98.96%, and 98.18%, respectively. The detection limits for each organic acid, based on a signal-to-noise ratio (S/N) of 3, were 0.035 g/L for malic acid, 0.040 g/L for citric acid, 0.040 g/L for succinic acid, and 0.050 g/L for tartaric acid. The HPLC conditions of organic acid analyses are given in Table 1. The linearity of the standard curve, limit of detection, recovery, coefficient of variation, and relative error in the determination of organic acids are given in Table 2.

Table 1- HPLC conditions for the analysis of sugars, organic acids, and water-soluble vitamins

Apparatus/Condition and Pump	*Sugar*	*Organic acid*	*Water-Soluble vitamin*
Liquid Chromatography	Shimadzu, LC20AD/Japan	Shimadzu, LC20AD /Japan	Shimadzu, LC20AD /Japan
Column	Bio Rad Aminex HPX-87 ion exclusion column (300x7.8 mm)	Bio Rad Aminex HPX-87 ion exclusion column (300x7.8 mm)	Nucleosil, C-18 (250 x 4.6 mm, ID) Macherey-Nagel
Degasser	Shimadzu, DGU-20A3	Shimadzu, DGU-20A3	Shimadzu, DGU-20A3
System controller	Shimadzu, CBM, 20Alite	Shimadzu, CBM, 20Alite	Shimadzu, CBM, 20Alite
Detector	Shimadzu, RID-10A Detector	Shimadzu, Photo Diode Array (PDA) Detector, SPD-M20A, 214 nm	Shimadzu, Photo Diode Array (PDA) Detector, SPD-M20A, 214 nm
Column oven-temperature	Shimadzu, CTO-20A, 85 °C	Shimadzu, CTO-20A, 25 °C	Shimadzu, CTO-20A, 25°C
Flow rate	1 mL/min	1 mL/min	0.6 mL/min
Mobile Phase	Isocratic, Acetonitrile: Ultra pure water (80:20 v/v)	Isocratic, 0.01 N H_2SO_4	Isocratic: KH_2PO_4-Asetonitril (99:1, v/v)
Injection volume	20 µL	20 µL	20 µL
Signal to Noise Ratio	3	3	3

2.5. Determination of sugars

The external standard method was used to determine the sugar concentration in the jujube fruits. To draw the standard calibration curves, solutions of 5 different concentrations were prepared from glucose, fructose, and sucrose standards. The prepared standard solutions were injected into the HPLC device and the equation defining curve was calculated by applying linear regression analysis. Recovery experiments have used the confirmation the reliability of the method. Recoveries for glucose, fructose, and sucrose were determined as 98.48%, 99.96%, and 98.18%, respectively. The detection limits for each sugar based on a signal-to-noise ratio (S/N) of 3, were 0.2 g/L for glucose, 0.3 g/L fructose, and 0.15 g/L sucrose. The HPLC conditions of the sugar analysis are given in Table 1. The linearity of the standard curve, the limit of detection, the recovery, the coefficient of variation, and the relative error in determining the sugars are given in Table 2.

Table 2- Linearity of the standard curve, detection limit, recovery, coefficient of variation, and relative error of determination of organic acid, sugars, and water-soluble vitamin in jujube fruits

Parameter	*Linear range^{xy}*	*R*	*r^2*	*Detection limit ^{xy}*	*Recovery (%) Mean SD^b*	*Relative error (%)*	*CV (%)*
Malic acid	0.0-100.0	0.9993	99.40	0.035	99.5±1.88	0.50	1.89
Citric acid	0.0-100.0	0.9935	99.54	0.040	98.32±1.68	1.68	1.71
Succinic acid	0.0-50.0	0.9987	99.80	0.040	98.96±0.11	0.11	0.11
Tartaric acid	0.0-100.0	0.9987	99.86	0.050	98.18±1.80	1.80	1.83
Ascorbic acid	0.0-200.0	0.9992	99.90	0.1	96.68±1.61	3.32	1.67
Riboflavin	0.0-40.0	0.9998	99.94	0.2	96.36±0.91	5.60	0.94
Niacin	0.0-200.0	0.9996	99.93	0.1	96.24±1.93	3.79	2.00
Pyridoxine	0.0-30.0	0.9990	99.82	0.2	95.94±0.67	3.96	1.04
Thiamine	0.0-50.0	0.9985	99.69	0.5	97.44±1.19	2.40	1.22
Glucose	0.0-250.0	0.9982	99.69	0.2	98.48±3.04	0.11	3.09
Fructose	0.0-250.0	0.9992	99.67	0.3	99.96±3.22	0.40	3.22
Sucrose	0.0-25.0	0.9989	99.83	0.15	98.18±1.87	1.80	1.90

^{x}: Malic, citric, succinic, tartaric, glucose, fructose, and sucrose concentration (g L^{-1}); ^{y}: Ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine concentration (mg L^{-1}); ^{b}: Mean ± standard deviation; ^{CV}: Coefficient of variation

2.6. Extraction of water-soluble vitamins

Seven different concentrations of ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine standards, were obtained from Sigma-Aldrich Chemie GmbH (Deisenhafen, Germany) and prepared in pure water. A water-soluble vitamin analysis was performed according to the method of Kadakal et al. (2004). Ultra-pure water was added to fresh, solar, and tray-dried jujube fruits in a ratio of 1:9 and homogenized by shredding with a laboratory blender (Waring-USA) for 4 min. Following filtering through the coarse filter, the filtrate was centrifuged (core NF800R- Turkey) for 15 min at 13440 G-force. A 5 mL of supernatant was passed through a 0.45 µm PTFE (FP 30/45 CA-S, Schleicher & Schuell, Darmstadt, Germany) syringe-type filter and transferred to 5 mL vials. The extracts were stored at -20 °C until analysis. The extracts were carried out in triplicate and the HPLC conditions of the water-soluble vitamins analysis are given in Table 1. The linearity of the standard curve, the limit of detection, the recovery, the coefficient of variation, and the relative error in determining the water-soluble vitamins are given in Table 2.

2.7. Recovery of organic acids, sugars, and water-soluble vitamins

The standard addition model was used to determine the recovery rates of organic acid, sugar, and vitamin analyzes. For this purpose, standard solutions were added to the jujube samples in which the organic acid, sugar, and vitamin content were known. Then, the prepared solutions were injected into the HPLC device under the same conditions. Linear regression analysis was applied to the obtained data and the equation definition curve was created. The reliability of the method was confirmed by the recovery tests.

2.8. Total phenolic substance analysis

The Folin-Ciocalteu spectrophotometric method was used to determine the total amount of phenolic substances (Singleton & Rossi 1965). 5 g of dried jujube samples were weighed and a 1:9 (w/v) methanol solution was added. After disintegration in the homogenizer, it was centrifuged at 10 °C at 9000 rpm. Following centrifugation, the samples were filtered through coarse filter paper. 300 µL of the samples prepared by methanol extraction was taken and 1500 µL of Folin-Ciocalteu solution (1:10, Folin-Ciocalteu reagent: ultrapure water) was added and waited for 5 minutes. Then, 1200 µL of 7.5% sodium bicarbonate solution was added and incubated for 2 hours in the dark at room temperature. After incubation, the absorbance values of the samples were determined in a spectrophotometer device (PG Instruments T80 UV/VIS, UK) at a wavelength of 760 nm. In order to calculate the results, the gallic acid standard obtained from the Sigma-Aldrich company was used. Solutions of different concentrations were obtained from the gallic acid standard and the gallic acid standard calibration curve was drawn.

2.8. Physicochemical analysis

The analysis of water-soluble solid (°Bx), total solid (%), pH, and titratable acidity (dry tartaric acid) were realized according to the method of the Association of Official Analytical Chemists (1990).

2.9. Statistical analysis

The experiments were carried out in triplicate and repeated twice. The obtained data were analyzed with variance for the comparison of all data. Following the revealed significant effect ($P<0.05$) of variance, the least significant difference test was used (Statistical Analysis Software 1985).

3. Results and Discussion

The water-soluble dry matter and total dry matter values increased both in solar and tray drying. Similarly, an increase in pH values of jujube fruit dried in solar and tray dryer was observed. In contrast, there was a decrease in titratable acidity of jujube fruits by solar and tray drying process. However, the pH increase in tray drying at lower temperatures was higher than those drying at high temperatures. The increase in pH and decrease in titratable acidity are parallel in the tray drying and the solar drying processes depending on the drying temperatures. Changes in dry matter, °Bx, pH, titratable acidity, and total phenolic content of the jujube fruit through solar and tray drying are given in Table 3. A high amount of total phenolic substance (1968.5 mg GAE / 100 g) was detected in fresh jujube fruit. However, as seen in Table 3, there is a considerable loss of total phenolic substance both in the tray drying at 50, 60, and 70 °C and in the solar drying process. The loss in the solar drying process is far higher than the tray drying. This may be due to the fact that the drying time of jujube fruits dried in the sun is longer. There is no similar study in the literature showing the change in pH, titratable acidity, °Bx, and total phenolic substance depending on drying, but Guclu et al. (2021) studied the phenolic characteristics of fresh and powdered sweet red peppers. In their study, organic and conventional peppers were dried by hot air, intermittent microwave and infrared drying methods. While phenolic compounds were not found in red peppers dried by intermittent microwave method, they were detected in samples dried with hot air and infrared. Their study revealed that the drying method was effective on phenolic compounds. Studies are generally concerned with the content of fresh ripe fruit or its change due to ripening. The pH, titratable acidity, and °Bx value of fresh ripe jujube fruit were given as 6.4, 1.7 (citric acid L^{-1}), and 18.2, respectively (Hernandez et al. 2015). The total phenolic content of fresh jujube fruit was reported as 600.5 GAE/100 g (Gao et al. 2011).

Table 3- Changes in dry matter, °Bx, pH, titratable acidity, and total phenolic content of jujube fruit with solar and tray drying

Drying Method		*Dry matter (%)*	*°Bx*	*pH*	*Titratable acidity (%)*	*Total phenolic (mg GAE/100g)*
Control		19.4 ± 0.2c[y]	9.1 ± 0.1c	2.50 ± 0.06b	3.16 ± 0.07a	1968.5 ± 12.4a
Solar drying		76.4 ± 0.1b	65.1 ± 0.1b	2.92 ± 0.05ab	1.63 ± 0.04b	718.2 ± 8.7d
Tray drying (°C)	50	79.8 ± 0.3a	69.8 ± 0.2a	3.07 ± 0.08a	1.12 ± 0.05c	1482.6 ± 18.5b
	60	80.2 ± 0.2a	70.0 ± 0.2a	2.94 ± 0.06ab	1.26 ± 0.09c	1410.1 ± 25.1b
	70	80.6 ± 0.2a	70.2 ± 0.3a	2.88 ± 0.08ab	1.54 ± 0.06b	1233.7 ± 14.8c

*: Results are given on dry basis; y: Different letters on the same column are statistically different ($P<0.05$)

Changes in sugar values of jujube fruit with solar and tray drying are given in Table 4. A decrease in glucose and sucrose content and an increase in fructose content in dried jujube fruits were determined. The glucose, fructose, and sucrose content of the jujube fruit dried in the tray dryer at 50, 60, and 70 °C were decreased in all three temperatures. The decrease in glucose and fructose content drying at 50 °C is higher than drying at 70 °C. The loss of glucose, fructose, and sucrose decreases as the drying temperature increases. Results are given on g/100 mg DW. However, the sucrose content of jujube fruit, which has an initial sucrose content of 29.8 mg/100 g, decreased to 3.2 mg/100 g with drying at 50 °C in the tray dryer. The sucrose content of jujube fruits dried at 60 and 70 °C was found below the detectable limit. In particular, the decrease in sucrose content can be explained by the inversion of sucrose with the effect of temperature. Non-reducing carbohydrates such as sucrose are broken down into glucose and fructose under the influence of temperature, pH, and water in the environment. For this reason, a large decrease in sucrose content is observed (Artık et al. 2011). Gao et al. (2012) found that the glucose amount of jujube fruit dried with different drying techniques decreased from 274.5 mg/100 g dry weight (DW) to 229.5 mg/100 g DW. Elmas et al. (2019) reported that the amount of fructose and sucrose in jujube fruit dried at 60, 70 and 80 °C decreased due to increasing drying temperature and air velocity. Tepe & Ekinci (2021) similarly found that there was a decrease in the content of sucrose, fructose, and glucose with the hot air drying of jujube fruit. They reported that the highest loss of glucose and fructose was determined at 50 °C, and the highest loss of sucrose was detected in samples dried at 70 °C.

Table 4- Changes in sugar, organic acid, and water-soluble vitamin values of jujube fruit with solar and tray drying

Parameters		*Control*	*Solar drying*	*Tray drying (°C)*		
				50	*60*	*70*
Sugars (mg/100 g)	Glucose	1426.7±3.4a[y]	1370.6±6.0b	1211.4±2.8d	1271.8±4.0cd	1304.8±4.3bc
	Fructose	242.6±4.3ab	256.9±4.0a	201.8±4.9c	209.3±5.2bc	222.9±4.3b
	Sucrose	29.8±1.4a	Nd	3.2±0.3b	Nd	Nd
Organic acids (mg/100g)	Malic acid	186.5±2.4a	118.3±3.9c	171.3±2.8b	169.1±3.5b	164.4±3.0b
	Citric acid	178.7±4.6a	121.3±2.6c	170.5±4.1ab	163.8±5.0b	160.2±3.8b
	Succinic acid	17.5±0.5a	10.7±0.3c	15.0±0.5ab	14.2±0.3b	13.8±0.4b
	Tartaric acid	40.8±0.5a	34.2±0.6b	40.6±0.7a	39.5±0.9a	39.0±0.5a
Water-soluble vitamins (mg/100g)	Ascorbic acid	71.2±0.5a	9.6±0.1d	28.7±0.5b	19.3±0.4c	12.1±0.2d
	Riboflavin	0.036±0.002a	0.025±0.01b	0.024±0.001b	0.024±0.001b	0.022±0.001b
	Niacin	0.82±0.04a	0.33±0.02d	0.70±0.04b	0.59±0.05bc	0.52±0.02c
	Pyridoxine	0.076±0.002a	Nd	Nd	Nd	Nd
	Thiamin	0.018±0.002a	0.013±0.001c	0.018±0.002a	0.018±0.001a	0.015±0.001b

[y]: Different letters on the same line are statistically different ($P<0.05$); *: Results are given on dry basis; Nd: Not detectable limit

Changes in the organic acid content of jujube fruit with solar and tray drying are given in Table 4. There was a decrease in the amount of tartaric, malic, citric, and succinic acid in jujube fruits that were dried both in the solar and tray drying. The decreases in malic, citric, succinic, and tartaric acid content at 70 °C, which is the highest drying temperature, are more than 50 °C. That is to say that, as the drying temperature increases, the loss of malic, citric, succinic, and tartaric acid is increased. The reason for the decrease in organic acids can be explained by temperature and oxidation reactions (Levent 2017).

Changes in the water-soluble vitamin content of jujube fruit with solar and tray drying are given in Table 4. Solar drying caused a decrease in the ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine content of jujube fruits. Solar drying caused a decrease in all analyzed vitamins. Moreover, solar drying caused a 100% decrease in pyridoxine content. As a result of drying jujube fruits at 50, 60, and 70 °C in the tray drying, there was a decrease in ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine content in all three temperatures. The decreases in ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine content at 70 °C, which is the highest drying temperature, are more than 50 °C. That is to say that, loss of ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine are related to the increase in drying temperature. It was reported that the loss of vitamin C in jujube fruit dried with different drying techniques increased (Fang et al. 2009; Wojdylo et al. 2016). However, the least loss was reported in jujube fruits dried at 70 °C (Fang et al. 2009). Ascorbic acid is accepted as one of the main indicators in determining quality loss due to its thermal sensitivity. In general, the fact that the loss of ascorbic acid is low after the applied process shows that the loss of other nutritional elements is also low. Tepe & Ekinci (2021) reported that drying temperature has a great effect on B complex vitamins (especially on pyridoxine) and they found that the highest losses were observed in thiamine, riboflavin, and niacin contents at 70 °C, while the lowest loss at 50 °C.

4. Conclusions

Solar drying of jujube fruit caused a decrease in glucose and sucrose content of fruits and an increase in fructose content while drying on a tray caused a decrease in glucose, fructose, and sucrose content. Solar drying caused significant losses in tartaric, malic, citric, and succinic acids compared to tray drying (50, 60, and 70 °C). A high decrement in ascorbic acid, riboflavin, niacin, pyridoxine, and thiamine content of jujube fruit both in the solar and tray drying process was determined. With this in mind, solar drying of jujube fruit can be considered an alternative method in terms of efficient use of energy and energy saving. However, it is recommended to dry the jujube fruit in a tray dryer in terms of nutrient content, product quality, and component loss. In the literature, there are a limited number of studies on the drying of jujube fruit. We believe that our article may be useful to close the gap in the literature. Apart from this, it is industrially important to determine the best drying method in terms of nutritional value and product quality as a result of drying the jujube fruit, which is mostly consumed dry, in the solar and on a tray. In future studies, it is recommended to determine the physical and chemical properties of jujube fruits grown in different regions and to dry them using innovative drying methods.

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