

Determination of The Characteristics of Candidate Varieties Suitable for Drying

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Abstract

Raisins are food with high nutritional benefits including mineral substances, vitamins, phenolic compounds it contains, and are increasingly in demand across the world. Sultana is preferably the most dried grape variety around the world, but there is a need for candidates with different characteristics that can be grown in different conditions where the Sultana is not grown. In our study, the drying kinetics and quality properties of 5 different types of candidates that can be evaluated as raisins, obtained through breeding studies in Tekirdag Viticulture Research Institute, were examined. Among these candidate varieties, the 43*B-103 variety candidate, which is the second in sensory evaluation score and has the least drying time stands out. The bioactive component properties of two of the candidate varieties (40*D-17 and 40*D-160) were found better than Sultana, too. At the same time, these two grapes were dried in a shorter time than Sultana.

Introduction

Grape is one of the most common cultivated plants in the world due to reasons such as not being very selective in terms of climate and soil requirements, easy propagation methods and being consumed in a wide variety of ways. Turkey is the fifth in the world in terms of vineyard area, ranks sixth in terms of production quantity. According to 2019's data, Turkey's grape production is considered to be 50% table grape, 39% drying and 11% wine-must. It is great importance for our country to evaluate grape as dried fruit. While we are in the first place in the production of raisins in the world, our country is in same level with the USA in the production of seedless raisins. Turkey is the world leader in the production of raisins with seeds. Most of the raisins produced in Turkey are exported. Turkey, in return for 520 million dollars in 2019, has made about 243 thousand tons of dried grape exports (TSI, 2019).

250-300 thousand tons of seedless raisins,

Sultanas, are produced in Turkey yearly. The main seeded of raisins from Turkey, unique to a total of 100-150 thousand tons produced are varieties such as Dimişki, Sergi Karası, Karadimrit, Besni, Ekşikara and Rumi (Çelik, 2013).

Preservation of fruits and vegetables by drying is an old preservation method used since ancient times, and sun drying has been used mostly in open areas (Bennion, 1990; Doymaz, 2003). The term drying means the removal of moisture from the foodstuff (Ratti, 2001). Thus, the moisture level of the food is lowered to a level that prevents the growth of microorganisms (Cemeroğlu, 2004). With these features, drying is the easiest and most common food preservation method for a wide variety of products.

Raisins are highly bio-useful food, which are a source of protein and carbohydrates and increasingly in demand in the world due to their iron, phosphate, calcium and other mineral substances and vitamins A, B1, B2, B6, C (Özden, 2008). Carughi (2008) stated that it is necessary

to investigate raisins with their natural qualities due to their unique phytochemical composition and mineral resource, and they stated that raisins, like other fruits, lack fat, saturated fat and cholesterol, and they have high health protection due to their phenolic content.

Although the studies on raisins have increased in recent years due to its health benefits, it is still not at a sufficient level and number. Especially, studies on raisin varieties other than the Sultana grape variety are very few. In this study, drying and quality characteristics of some grape varieties obtained as a result of hybridization improvement studies carried out in Tekirdağ Viticulture Research Institute and Sultana seedless grape were determined.

Material and Methods

Material

In this study, 5 different varieties of grapes and Sultanas grapes were used from the new candidate varieties to be registered as a result of the breeding studies in the Tekirdağ Viticulture Research Institute trial vineyards at latitude 40.969184° - 40.973562° N and longitude coordinates 27.461911° - 27.477504° E in 2019. Pictures of all the candidate grapes are shown in Figure 1. Only one of the grape varieties (43*B-103) studied was black, the others all were white.

Sultana: Sultana is a variety which ripens in midseason. It grows strong with conical clusters, wings, normal density, small oval shaped berries and average berry skin thickness. Although it is a variety for drying, Sultana Seedless variety is also processed as table grapes through a series of culture practice (Ateş et al., 2016).

43*B-103: It was obtained by crossing Hönüsü and Perlette cultivars. It's berries are seedless, dark-red violet and in the form of obtuse ovoid. It's berries are very small and average 2 g. It forms dense bunches. It's yield per vine is 11.2 kilograms (Ergönül et al., 2020).

7*D-258: It was obtained by crossing Italia and Barış cultivars. It's berries are seedless, green-yellow color and globose shaped. Average berry weight is 4.8 grams. It forms medium dense bunches. It's yield per vine is about 10 kilograms (Ergönül et al., 2020).

43*B-42: It was obtained by crossing Hönüsü and Perlette cultivars. It's berries are seedless, green-yellow and globose shaped. It's berries are about 2-3 grams. It forms medium dense bunches. It's yield per vine is 8-9 kilograms (Ergönül et al., 2020).

40*D-17: It was obtained by crossing İrikara and Barış cultivars. It's berries are seedless, green-yellow color and broad ellipsoid shaped. Average berry weight is about 5-6 grams. It forms medium dense bunches. It's yield per vine is about 8-10 kilograms (Ergönül et al., 2020).

40*D-160: It was obtained by crossing İrikara and Barış cultivars in Tekirdağ Viticulture Research Institute. It's berries are seedless, green-yellow and broad ellipsoid shaped. Average berry weight is about 5 g. Its bunches are medium density. The yield per vine is over 10 kilograms (Ergönül et al., 2020).

Method

Grape harvest

Disease-free, normal-looking grapes were collected when the grapes reached the harvest maturity depend on the variety (brix degree 22-23%). Fresh grape samples to be analyzed by extraction were brought to the laboratory. It was placed in polyethylene bags and kept in the freezer at -20 °C until analysis was performed. Other measurements on fresh grapes were carried out on the same day without waiting in the laboratory.

Raisin production

Fruit samples were dipped into the potasa solution containing 5% K₂CO₃ and 0.5% high acid olive oil. Then it was left to dry in a solar collector drying system. Figure 1 shows that the photos of grape varieties both after harvesting and drying. A solar collector drying system has been used instead of open sun drying, which is the traditional method for drying grapes. The main reason for this is that the climatic conditions in Tekirdağ province are not suitable for drying when the grapes are grown. Especially in September-October, drying is getting more difficult due to the high humidity values at night and the high number of rainy days.



Figure 1. Photos of harvested and dried grape varieties.



Figure 2. Solar collector drying system used in drying.

When the grape varieties reached maturity, they were dried in the solar collector drying system shown in Figure 2. The drying chamber of this solar collector consists of two compartments.

The inside size of each room is 88x98x194 cm. There are 6 trays of 59x80 cm in the drying room. The total capacity of wet products that can be put in the drying rooms is 2x120 kg. Humidity and temperature indicators are available for each compartment. There is a control panel outside the dryer. There are 4 radial fans with a flow rate of 1700 m³ h⁻¹. The internal temperature of the drying chamber was recorded continuously throughout drying.

The samples were put on the drying trays for the drying followings of the grapes.

Weight losses were measured manually in 3 replications every 3 hours.

Analysis and measurements on fresh and raisin samples

Water soluble dry matter determination

The water-soluble dry matter (brix) in the samples was determined with the help of a refractometer (Anonymous, 1983).

Titration acidity determination

A certain amount of sample was taken, a few drops of phenolphthalein (1% in ethanol) will be dropped and titrated with 0.1 N NaOH solution. Results were calculated in terms of "tartaric acid" (Anonymous, 1983).

Maturity index

It was calculated by dividing the water-soluble dry matter (%W.S.D.M) value determined in the samples by the titration acidity (%).

pH value

The pH value of the samples was measured with a digital pH meter (Mettler Toledo FE20, Leicester, UK).

Drying time and dry matter analysis

In the drying system, the time elapsed from the beginning of drying until it reaches raisin was measured. The amount of dry matter in dry products was calculated with the help of Equation 1 by taking it out of the dryer at regular intervals and measured by their weights (Perry, 1973).

Equation 1

$$DM1 = \frac{\text{Starting weight} \times DM0}{\text{Final weight}}$$

DM1: Dry matter content after drying (%)

DM0: Dry matter content of fresh fruit (%)

Moisture content analysis

Raisins were broken into a mixer before dry matter analysis. Before the drying process, mass of samples was measured and dried at 70 °C in a laboratory type vacuum oven (Nuve EV 018, Turkey) until it reaches constant mass. Then samples were placed in the desiccators for cooling to room temperature, then mass of samples were measured again. The MC of the samples was specified by dividing the difference between the initial and final measurement into the initial measurement.

Water activity (a_w)

Water activity is a very important factor which is regarded as a microbiological stability indicator in foodstuffs and a_w can be determined by the use of the water activity device (AquaLab 4 TE Series Decagon Device, Pullman WA, USA).

Color analysis

Color analysis was performed on whole fruit in samples. Color analysis L^* , a^* , b^* , chroma and hue values were determined with Koniko-Minolta CM-5 device. By using the obtained values, browning indices and total color change values of raisins were calculated according to the method of Maskan (2001). Browning Index has been shown as "BI" and calculated using the formula in Equation 2. The 'x' value in the formula was calculated according to Equation 3 by using the L^* , a^* , b^* values obtained in color measurements.

Equation 2

$$BI = \frac{100(x - 0.31)}{0.17}$$

Equation 3

$$x = \frac{a + 1.75L}{5.645L + a - 3.012b}$$

Extraction of phenolic compounds

Raisin samples were grounded in a blender and then samples were placed in a eppendorf tube, were weighed, then were added an extraction solvent (80% aqueous methanol

acidified with 0.1% HCl). With using a rotary shaker, the mixture was shaken (Rotator, Dragon Laboratory Instruments) at 50 rpm and room temperature for 2 h. Then, the extracts were centrifuged for 10 min at 4500 rpm and to remove suspended materials. All extractions were performed as triple.

Determination of total phenolic content (TPC)

The TPC was specified by use of the Folin–Ciocalteu method with micro scale protocol (Waterhouse, 2002). Briefly, 40 μ l of raisin extract or gallic acid standards (50–500 mg l⁻¹), 200 μ l of Folin–Ciocalteu reagent and 3.16 ml of water were pipetted into a 4 ml spectrophotometer cuvette. After 3–4 min, 600 μ l solution of Na₂CO₃ (20%) were added. The content was held at room temperature for 2 h, with using a spectrophotometer, at 765nm against a blank, the absorbance of the sample was determined (Shimadzu UV–Vis Mini 1240, Tokyo, Japan). TPC was specified as mg gallic acid equivalent per gram of dried sample (mg GAE g⁻¹ dw).

DPPH free radical scavenging activity

For the determination of the total free radical capture capacity DPPH (2,2-diphenyl-1-picrylhydrazyl), Brand-Williams et al. (1995)'s method was used and the results were given in micromoles trolox equivalent per gram of raisin (μ mol TE g⁻¹ dw). A 1.95 ml of 0.1mM DPPH extract solution was mixed with different volume of raisin extracts (25–50–75 μ l), the reaction mixture was left in the dark at room temperature for 30 min, and then the absorbance was measured at 517 nm against a blank at spectrophotometer.

The blank was methanol. The percentage scavenging effect was calculated as Scavenging rate= $(A_0 - A_1/A_0) \times 100$, where A_0 was the absorbance of the control (without extract) and A_1 was the absorbance in the presence of the extract. The concentrations of Trolox for the calibration curve were ranged by 20–1000 μ M.

Sensory analysis

Sensory evaluation was carried out with 6 panelists in raisin samples with the Quantitative

Identification Analysis (QDA) of the International Standards Organization (ISO) ISO 4121: 2003 standard. Panelists made markings on a 100 mm long linear scale for 7 sensory parameters (color, appearance, odor, taste, hardness, chewability and total sensory effect) determined for each sample.

Statistical analysis

Experiments were conducted with three replications and results were evaluated statistically. Statistical analyses were performed by the JMP7 package program. LSD (least significant difference) test with $P < 0.05$ as a limit of significance was applied to data.

Results and Discussion

Dry matter amounts of the harvested grapes varied between 13.2% and 33.7%. Water activity values were determined as 0.96 in all fresh grapes. The physical properties of the grape varieties at harvest time and after drying were shown at Table 1 and Table 2.

The most ripened grape was Sultana. Its water-soluble dry matter value is not very high, but since its acidity is low compared to other grapes, the ripening index is high. Since the harvest dates of the grapes were the same, their maturation was different.

43*B-42 and 40 * D-160 grapes were not dried sufficiently. During drying of these two grapes, due to the climatic effects, sufficient temperature could not be provided in the solar collector, so drying was completed before

enough drying properties got. Therefore the water activities and moisture values of these raisins are higher than they should be. The amount of water that a food has and can be used by microorganisms is called as the water activity (a_w) of that food. Microbiological stability of foods can be measured by water activity value (Demirci, 2010). Any microbiological activity is not possible in foods where the water activity value is below 0.60. Only osmophilic yeasts can function between 0.65 and 0.60 (Mossel, 1974). In order for dry products not to spoil, water activity values should be 0.65 or less.

Drying kinetics

In order to correctly evaluate the drying kinetics of all grape varieties, we have taken into account the drying times from the same initial moisture content (75%) to the same dry product final moisture content (20%).

Changes of moisture content of grape samples with 75% initial moisture in collector drying until it is reduced to 20% moisture level are given in Figure 3.

The experiments were carried out between 17-24 September and the average solar radiation intensity was measured as 440 W m^{-2} in the weather mostly cloudy and sunny period (Figure 4). During the trials, the drying room temperature changed mostly between 30-40 °C, but increased to 52 °C maximum (Figure 5).

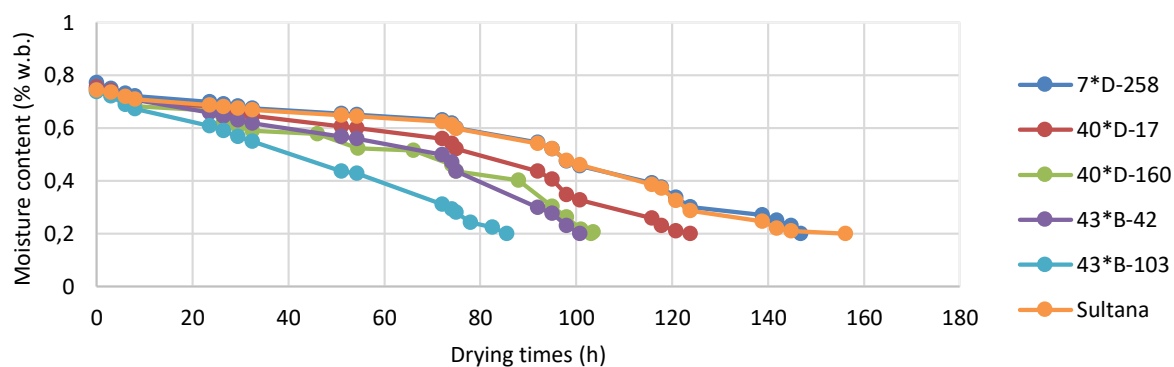
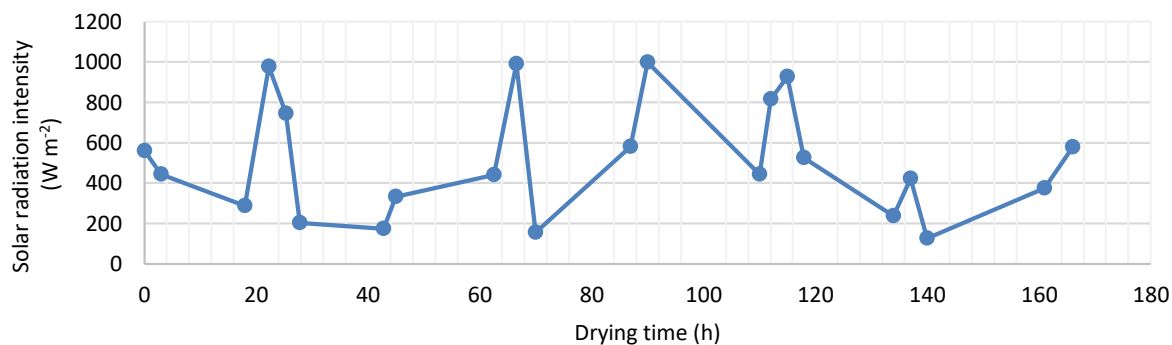
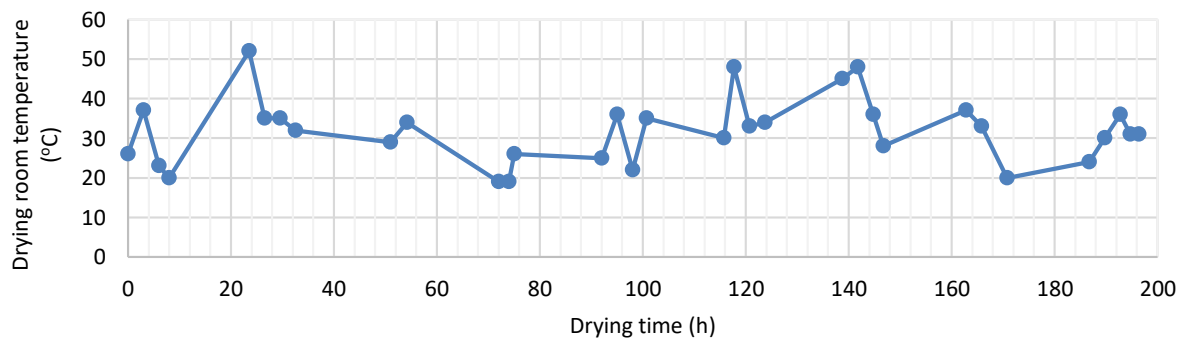
When a statistical evaluation was made with the JMP7 package program in terms of drying times between the varieties, it was observed that there were differences between all

Table 1. Properties of harvested grape samples

Grape variety	Water Soluble Dry Matter (%)	Titration Acidity Determination (g 100g ⁻¹ tartaric acid)	Maturity Index	pH
Sultana	22.40	0.55	40.72	4.12
43*B-103	21.80	0.62	35.16	3.78
7*D-258	22.40	0.78	28.72	3.56
43*B-42	21.00	0.84	25.00	3.41
40*D-17	20.80	0.69	30.15	3.57
40*D-160	18.00	0.75	24.00	3.48

Table 2. Dry matter, water activity and moisture content of fresh grape and raisin samples

Grape variety	Fresh grape's dry matter (%)	a_w of fresh grape	Raisin's dry matter (%)	Raisin's moisture content (%)	a_w of raisin
Sultana	33.65	0.96	80.42	19.58	0.64
43*B-103	25.23	0.96	88.00	12.00	0.62
7*D-258	26.24	0.96	85.79	14.21	0.65
43*B-42	26.60	0.96	78.58	21.42	0.68
40*D-17	21.97	0.96	88.93	11.07	0.61
40*D-160	13.18	0.96	73.92	26.08	0.72

**Figure 3.** Change of moisture content in all varieties.**Figure 4.** Changing of solar radiation intensity during drying process.**Figure 5.** Change of drying room temperature during drying process.

varieties at the level of 0.05 importance, the lowest drying time occurred as 87.28 hours in the variety candidate with the code of 43*B-103 and the highest drying time occurred as 156.13 hours in Sultana seedless variety which is treated as control (Table 3). These results show that all

kinds of candidates performed higher in terms of drying time than Sultana variety.

Color analysis

Color analysis of all harvested and dried

Table 3. Changing of drying time according to varieties

Grape Variety	Drying time (h)
	Mean
Sultana	156.13 ^a
43*B-103	87.28 ^b
7*D-258	146.21 ^a
43*B-42	101.75 ^b
40*D-17	123.58 ^{ab}
40*D-160	103.15 ^b
LSD _{P<0,05}	40.61

The values with different letters in a column are significantly different ($P < 0.05$) according to paired comparison through with t-test of the data.

Table 4. CIE L *, a *, b * values, Browning Index and total color changes of grape varieties

Grape Variety		L*	a*	b*	Browning Index (BI)	Total color change (ΔE)
Sultana	Fresh grape	43.425	-1.117	5.996	-	-
	Raisin	30.829 ^{ab}	2.223 ^d	3.987 ^b	1.85 ^{cd}	13.19 ^a
43*B-103	Fresh grape	35.513	3.719	2.557	-	-
	Raisin	29.140 ^c	2.567 ^{cd}	3.007 ^c	17.08 ^d	6.50 ^c
7*D-258	Fresh grape	40.169	-0.697	5.806	-	-
	Raisin	29.795 ^{bc}	2.474 ^{cd}	4.404 ^b	21.81 ^c	10.96 ^b
43*B-42	Fresh grape	41.495	-0.929	6.219	-	-
	Raisin	31.276 ^a	3.066 ^{bc}	5.547 ^a	26.36 ^b	11.00 ^b
40*D-17	Fresh grape	40.503	-0.365	5.086	-	-
	Raisin	30.549 ^{ab}	4.503 ^a	5.789 ^a	31.36 ^a	11.14 ^b
40*D-160	Fresh grape	40.724	-0.646	4.614	-	-
	Raisin	31.624 ^a	3.504 ^b	5.566 ^a	27.09 ^b	10.07 ^b
LSD _(P<0,05)		1.34	0.59	0.77	3.26	1.10

The values with different letters in a column are significantly different ($P < 0.05$) according to paired comparison through with t-test of the data.

Table 5. Bio-active property results of raisins

Grape Variety	Total Fenolic Content mg GAE Kg ⁻¹	TEAC DPPH $\mu\text{mol TE g}^{-1}$
Sultana	1150 ^{bc}	1.58 ^b
43*B-103	847 ^{cd}	1.77 ^{ab}
7*D-258	613 ^d	1.11 ^c
43*B-42	539 ^d	1.10 ^c
40*D-17	1823 ^a	1.89 ^{ab}
40*D-160	1448 ^{ab}	2.05 ^a
LSD _(P<0,05)	383.54	0.44

The values with different letters in a column are significantly different ($P < 0.05$) according to paired comparison through with t-test of the data.

Table 6. The total sensory evaluation scores of the raisins

Grape Variety	Color	Appearance	Smell	Taste	Hardness	Chewiness	Total sensory impact	Total
Sultana	7.60	7.75	4.58	6.55	6.58	7.08	7.10	47.25
43*B-103	6.42	5.80	5.82	5.98	6.02	6.60	6.33	42.97
7*D-258	4.23	4.12	5.30	6.28	6.40	5.95	6.02	38.30
43*B-42	5.00	5.17	4.95	5.78	6.13	5.80	5.72	38.55
40*D-17	5.05	5.25	5.13	4.37	5.97	5.92	5.35	37.03
40*D-160	4.72	4.32	4.77	4.12	6.00	5.32	4.83	34.07

grape samples were made and CIE L*, a*, b* value obtained for each grape variety were given in Table 4. Using these color values, browning indices were determined and total color changes were examined. While the most color change was in the Sultana variety, the most browned variety was 40*D-17. Browning in raisins is not highly desirable, with the least browning and also the least discoloration in the 43*B-103 variety. Since the color of the 43*B-103 grape variety is black in fresh grapes, so the color change is minimal and at the same time the L* value is lower. Since there was browning in colors during drying, at L* value's there was no difference from the others as raisin.

Bio-active properties of raisins

The total amounts of phenolic matter in the candidate varieties ranged from 539 to 1823 mg GAE kg⁻¹, showing significant differences between varieties (Table 5). The highest value belongs to the 40*D-17 variety. The phenolic content of the 40*D-17 and 40*D-160 varieties is higher than the Sultana variety. At the same time, antioxidant activity values of these varieties were determined to be higher. Fabani et al. (2017), in their study on 4 different grapes in Argentina, determined the total amount of phenolic substances between 1540-2010 mg GAE kg⁻¹ DW. Breksa et al. (2009) found the total amount of phenolic matter they made in 16 different raisins between 3163 and 11413 mg gallic acid kg⁻¹ DW. Differences between varieties may arise from the characteristics of the variety, the climatic characteristics of the region where they

grow, the soil characteristics, and the differences in cultural processes.

Sensory analysis

When the sensory analysis results were examined, Sultana and 43*B-103 grape varieties were selected as the most admired varieties (Table 6). The least admired variety was 40*D-160. 43*B-103 variety surpassed Sultana in the sensory analysis scores in the smell section, but received a lower score in appearance. It was generally accepted by the panelists for this kind of candidate, whose sensory score is closest to Sultana.

Conclusion

Sultana is the most dried grape variety all over the world. In regions where Sultana can not be grown, there is a need for different grape varieties with different characteristics, can be used for drying. Generally, the bioactive component properties of Sultana grapes are low, where two of the candidate varieties (40*D-17 and 40*D-160) are better. At the same time, these two grapes dry in a shorter time than Sultana. The 43*B-103 variety candidate, which is the second in sensory evaluation score and has the least drying time, stands out with the least color change and the lowest browning index. It is very important to evaluate drying kinetics and food quality parameters together for determination of suitable candidate varieties for drying. In this study, these specifications were examined altogether and three candidate varieties showed hopeful drying characteristics.

Also, this research was carried out in a period in which ambient temperature and solar radiation values were not high. This result reveals that these hopeful candidate varieties have also advantages in terms of drying kinetics and possible lower energy consumption result of shorter drying time.

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