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Drying of *Vitis vinifera* L. cv "Sultanina" in tunnel solar drier

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Abstract. Raisin production and export is an important business in Turkey. In this research *V. vinifera* L. cv. "Sultanina" was dried in polythene tunnel type rack systems solar drier and in direct sunlight (traditional drying method). The inside temperature of the tunnel has been increased by adding solar panels to the drying tunnel. The cluster of grapes was dipped in four different alkali solution (dipping solution); such as 1%, 2%, 3%, and 5% of sodium hydroxide + 1% olive oil. Each application was two replicates and at each repetition to be 2 kg/m^2 grapes. After dipping grapes were placed on the rack. Drying process were continued until 14% humidity. In the study drying period of the grapes, drying ratio, % moisture, % total soluble solids content, 100 berry weight, berry surface color (CIE, L, a, b), alcohol-soluble color values were measured.

Drying period of grapes in the solar drying tunnel is faster than direct sunlight. Solar tunnel drying was found to be satisfactory and competitive to traditional drying method. The color of grapes dried in the sun drying tunnel not seen a negative change.

Provision of solar dryers in drying, air distribution and heat conservation is to make a positive impact on the drying process and capacity. The most important advantage of the dried product in the tunnel type solar drier is protected raisins from external environment.

The main factor in the drying process is to obtain minimum energy consumption of the product with the desired quality and reach a maximum speed of drying. The results obtained from this research are used in practice compliance.

1. Introduction

Anatolia has a very rich grapevine varieties and about 6000 years viticulture culture. Using the cultivation of grapes is based on a very old age in Turkey [1].

By the year 2011, Turkey produced 4 296 351 tonnes of grape, they are considered as 52.8% of (2 268 967 tonnes) table grapes, 36.4% of (1 562 064 tonnes) raisin and 10.8% of (465 320 tonnes) wine. Aegean Region in Turkey has 33% of the vineyards in Turkey's agricultural region and that region is 44% of grape production.

Vineyards of Aegean Region starts İzmir and Çandarlı golf and they are spread over 150–200 km long coastal area. Manisa province also Alaşehir, Salihli, Turgutlu, Sarıgöl, Saruhanlı, Ahmetli are an important wine growing district center. This area is carried out 75% of Turkey seedless grape production. The second important wine growing region is Çivril plain in which starts Büyük Menderes valley has Çal, Çivril, Buldan, Tavas district. 9% of grape production in Turkey is produced here. Kemalpaşa, Menemen and Menderes district in Aegean Region is the third most important grape production areas is produced 15% of grape production in Turkey. Manisa and Aydın province are 99% of seedlees grapes production. *V. vinifera* L. cv. "Sultanina" is extensively grown in Aegean Region as table grape and raisin [2].

V. vinifera L. cv. "Sultanina" has 38 different types. Anatolian is homeland of *V. vinifera* L. cv. "Sultanina" variety and is taken to other parts of the world by different ways at over time. *V. vinifera* L. cv. "Sultanina" is known as "Thompson Seedless" in USA, "Sultanina" or "Sultanieh" in Near East, "Oval Kişmiş" in Centrial Asia, "Sultana" or "Sultanina" in Australia, "Akkişmiş" in Russian [3,4].

V. vinifera L. cv. "Sultanina" is often considered to be raisin. Raisin is a major profit making business in different regions where grapes are grown in Turkey. Exports of raisin in Turkey is an important commercial activity since the early years of The Republic of Turkey. Turkey is the second market for raisin in the world after USA and holds 28% of the world market. Iran, Chile, Afghanistan and S. Africa is followed by Turkey, respectively [5].

Drying is the process of removing excess moisture from crop produce through evaporation. Generally, three drying methods are employed to produce raisins; sun drying, shade drying and mechanical drying. Sun drying is used for centuries and it is oldest and the most economic methods than others. Hygienic conditions can't be fully achieved and this method effects climatic events, but despite all the negativity drying is still continuing [6].

Raisins are dried into dipping solution in Turkey, Australia and Greece. In the USA, raisin without using any dipping solution (Natural) is performed. For this method seedless grapes dried under sun after harvest. Drying time is 15–20 days, depending on weather conditions. Raisins are dried by Natural have gray-black, gray-browns skin colours and hard. Taste is oxide characteristic and skin surface is more resistant to processing.

After harvest "Sultanina" are dipped in an alkaline oil emulsion and then open sun drying in the Aegean Region of Turkey. Grape drying using solar energy is an age old traditional method. The drying time in this method required for grapes is 5–7 days. Raisins that they are dried

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by this method have both thin and light skinned colour. Raisins are very sweet and the skins are mostly fat. The good weather conditions may improve the situations further. The unexpected weather conditions at some drying period further worsen the situation. It is important that farmer must use new method like solar energy because this system has controlled environment and drying time is faster than old traditional method. For this purpose, at the farmer must use solar energy for clean raisin and also they can use local facilities like greenhouse.

In this study, tunnel solar drier was used for *V. vinifera* L. cv. "Sultanina". The main objective of this study is obtain minimum energy consumption of raisin and protected from external weather conditions by using solar energy. "Sultanina" after different pretreatments (1%, 2%, 3%, and 5% of sodium hydroxide + 1% olive oil) were dried in tunnel solar drier with heated air under forced convective conditions. The effect of different alkali solution (dipping solution) on the drying time, the detailed organoleptic qualities of the raisins produced has been investigated in this paper.

2. Materials and methods

Plant material. *V. vinifera* L. cv. "Sultanina" was used. Grapes used for drying experiment were same production area, whereas The Total Soluble Solids (TSS) 21 were harvested.

Drying media. Drying experiments were performed in tunnel solar drier. In addition to used open sun drying as control at same time.

Tunnel solar drier. Drying module was designed by TARTES (`www.tartes.com.tr`) is used for drying process. Size of tunnel is 8 × 6 × 2.86 m, and has a solar collectors in size 6 × 6 m on the north side. Hot weather is absorbed at the bottom of the tunnel solar drier. Size of a fan (Alfan trademark) is 0.98 × 0.95 m, at 0.3675 kW, has 8500 m^3/h maximum air flow and located on the opposite of the collector. Grapes are dried on racks (size of rack is 2.5 × 1 m) in the tunnel solar drier.

Water content. Each application was two replicates and at each repetition to be a certain amount of sample in an oven (Metter) at 65°C until fixed weight was determined dried weight.

Alcohol-soluble color. For the alcohol soluble color of raisin, each application was two replicates and at each repetition to be 15 g raisin after crushed into conical container (250 ml) and add 200 ml (50%) ethanol. The top of the conical container was covered by parafilm and then over heated for 23 hours at room temperature. After the resulting solutions were filtered by filter paper, were measured by spectrometer (VARIAN, CARY 100 Bio) at 440 nm. Absorbance values were converted to dry matter of 100 g values. The dry substance of 100 g was read at 440 nm value in spectrometer [7].

Raisin color. The external raisin color was measured at the equatorial area of each side of 30 berries using a colorimeter (CR-300, Minolta Co, Osaka, Japan), Average scores were recorded in terms of CIE-L* a* b* values. The colorimeter had an 8 mm diameter viewing area and was calibrated with a white tile (L* = 97.26, a* = +0.13, b* = +1.71).

100 berry weight. 100 berry weight for raisin was measured by laboratory scales (XR 405A-FR, Swiss).

The total soluble solids (TSS). The total soluble solids (TSS) content in the juice was determined with a digital refractometer (PR-1, Atago, Tokyo, Japan) and expressed as percentage.

Statistical analysis. The cluster of grapes was dipped in four different alkali solution (dipping solution), such as 1%, 2%, 3%, and 5% of sodium hydroxide + 1% olive oil. Each application was to be 2 kg/m^2 grapes. The study was designed as 4 replications based on the Coincidence Plots Experiment Design and each plastic case was accepted as a replication. The performance of each variety was evaluated during storage separately. The data were subjected to analysis of variance by IBM® SPSS® Statistics 19 statistical software (IBM, NY, USA) and differences between means at each sampling date were determined by Duncan's multiple range test ($p \le 0.05$).

3. Result and discussion

Drying time of grapes shows that the cluster of grapes was dipped in four different alkali solution (dipping solution); such as 1%, 2%, 3%, and 5% of sodium hydroxide + 1% olive oil reduces the drying time of grapes significantly and is most efficient and more effective. The results shows that dipping solution is of shorter drying period than naturel drying methods. As seen in Fig. 1, drying period of the grape found in natural (open sun drying) was 14 days, natural (tunnel solar drier) was 13 days, followed by all different alkali solution were 7 days.

As seen in Fig. 2, significant differences were found in drying ratio in grape from cluster of grapes was dipped in different alkali solution (dipping solution); such as 1%, 2%, 3%, and 5% of sodium hydroxide + 1% olive oil in tunnel solar drier, dried natural (open sun drying) and natural (tunnel solar drier). The results shows that drying ratio of naturel (open sun drying) treatment was lowest than naturel tunnel solar drying. On the other hand, 5% of sodium hydroxide + 1% olive oil "Control" (open sun drying) drying ratio had same ratio like naturel tunnel solar drying (Fig. 2).

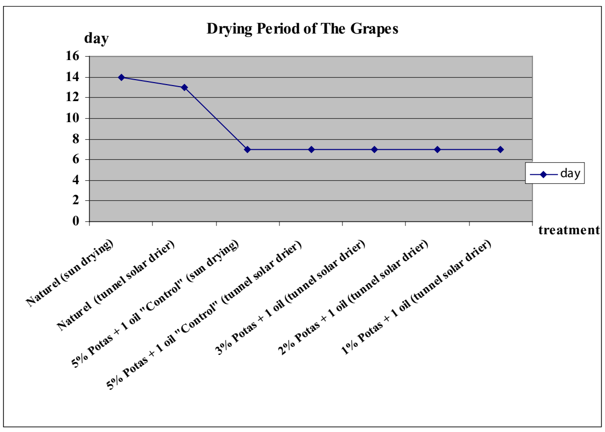

Figure 1. Drying time of grapes at different alkali solution (dipping solution).

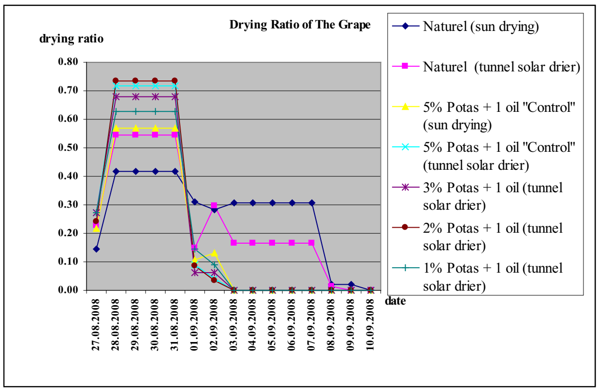

Figure 2. Drying ratio of grapes at different alkali solution (dipping solution).

Table 1 shows results for general composition of grapes, and % moisture, % total soluble solids content, 100 berry weight, alcohol-soluble color values, berry surface color (L, a, b) obtained from the cluster of grapes was dipped in different alkali solution from tunnel solar drier and open sun drying.

As seen in Table 1, significant differences were found in % moisture. Increases in % moisture were significantly ($P \leq 0.05$) all different treatments. % moisture found in Naturel (open sun drying) was 16.27, followed by 5% Potas + 1 oil "Control" (open sun drying) (13.74), 3% Potas + 1 oil (tunnel solar drier) (11.66), 1% Potas + 1 oil (tunnel solar drier) (11.05), 5% Potas + 1 oil "Control" (tunnel solar drier) (10.45), Naturel (tunnel solar drier) (9.89) and 2% Potas + 1 oil (tunnel solar drier) (9.70) (Table 1).

Effect of tunnel solar drying and open sun drying on L* color volue of raisin was found insignificant for all treatments whereas the different alkali solution were statistically significant ($P \leq 0.05$) on surface color (a) and surface color (b). Berry surface color (a) found in the 5% Potas + 1 oil "Control" (open sun drying) was 3.34, 5% Potas + 1 oil "Control" (tunnel solar drier) had the highest (6.88), followed 1% Potas + 1 oil (tunnel solar drier) (6.15), 3% Potas + 1 oil (tunnel solar drier) (5.60), Naturel (tunnel solar drier) (5.29), 2% Potas + 1 oil (tunnel solar drier) (4.96), Naturel (open sun drying) (4.86) (Table 1).

Table 1 shows results of berry surface color (b) of different alkali solution dipped in grape for tunnel solar drier and both open sun drying were found significantly differences. In all treatments, berry surface color (b) value increased on 5% Potas + 1 oil "Control" (tunnel solar drier) and the changes in the other treatments were found to be significant. In 1% Potas + 1 oil (tunnel solar drier) and 2% Potas + 1 oil (tunnel solar drier) had a positive effect on berry surface color (b).

Various chemical pre-treatments (hot and cold) have been used to increase berry surface color of grapes [8].

In this research was found 5% Potas + 1 oil "Control" (tunnel solar drier) have worse color in tunnel solar drier. In this research, 3% Potas + 1 oil (tunnel solar drier) and 1% Potas + 1 oil (tunnel solar drier) are essential that grape to be dried at least loss of quality and quantity in a clean environment and good investment.

4. Conclusion

Mass losses and low quality are the most serious disadvantages of traditional grape drying methods. For the production of high quality raisins an increase in the drying rate is

Table 1. General properties of grapes was dipped in different alkali solution from tunnel solar drier and open sun drying.

General properties of grapes	Treatment						
	Naturel (open sun drying)	Naturel (tunnel solar drier)	5% Potas + 1 oil "Control" (open sun drying)	5% Potas + 1 oil "Control" (tunnel solar drier)	3% Potas + 1 oil (tunnel solar drier)	2% Potas + 1 oil (tunnel solar drier)	1% Potas + 1 oil (tunnel solar drier)
% moisture	16.27 ± 2.927	9.89 ± 2.927	13.74 ± 2.927	10.45 ± 2.927	11.66 ± 2.927	9.70 ± 2.927	11.05 ± 2.927
% total soluble solids content	74.44 ± 1.293	78.67 ± 1.293	73.55 ± 1.293	78.00 ± 1.293	76.22 ± 1.293	68.89 ± 1.293	74.22 ± 1.293
100 berry weight	36.89 ± 1.447	36.25 ± 1.447	38.32 ± 1.447	39.56 ± 1.447	40.05 ± 1.447	36.04 ± 1.447	34.38 ± 1.447
Alcohol-soluble color values	0.48 ± 0.885	0.22 ± 0.885	0.17 ± 0.885	0.16 ± 0.885	0.17 ± 0.885	0.17 ± 0.885	0.17 ± 0.885
berry surface color (L)	17.50 ± 1.387	20.64 ± 1.387	17.41 ± 1.387	19.36 ± 1.387	18.60 ± 1.387	17.27 ± 1.387	16.57 ± 1.387
berry surface color (a)	4.86 ± 3.893	5.29 ± 3.893	3.34 ± 3.893	6.88 ± 3.893	5.60 ± 3.893	4.96 ± 3.893	6.15 ± 3.893
berry surface color (b)	6.28 ± 8.661	5.97 ± 8.661	9.90 ± 8.661	11.82 ± 8.661	10.03 ± 8.661	8.71 ± 8.661	7.48 ± 8.661

required and the grapes should be protected from rain, dust and insects during drying [9].

All different treatments in high tunnel solar drier dried close time. However, the most important advantage of the high tunnel dryer, product is dried without any contamination in clean environment. Soil-born pests and diseases are transmitted by wind and dust on outdoors products while drying period. This situation is not desirable for quality. Today due to increasing competition not only with the price of the final products, but also superiority in the food safety and quality are important factors. Compared to traditional sun drying methods solar drying reduces significantly drying time and mass losses [10,11]. During drying the crop is completely protected from rain, dust, animals and insects come into contact with foreign materials [12].

Test with tunnel solar drier has shown that it is possible to reduce the drying time and improve the quality significantly compared to the traditional drying methods [13,14]. In this research, 3% Potas + 1 oil (tunnel solar drier) and 1% Potas + 1 oil (tunnel solar drier) are essential that grape to be dried at least loss of quality and quantity in a clean environment and good investment.

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