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Araştırma Makalesi

# Farklı Kurutma Tekniklerinin Dört Farklı Trabzon Hurması Çeşidinin Kalite Parametreleri Üzerine Etkilerinin Karşılaştırılması

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## ÖZ

Bu çalışmada, dört farklı kurutma tekniğinin (fırında kurutma, akışkan yatakta kurutma, vakumla kurutma ve dondurarak kurutma) dört farklı hurma çeşidinin (Rojo Brilliante, Seedless, Hachiya, Türkay) kalite parametreleri üzerindeki etkileri araştırılmıştır. Bu amaçla antioksidan aktivite, toplam fenolik madde, renk değerleri ve rehidrasyon kapasitesi analizleri yapılmıştır. Tüm hurma çeşitleri farklı kurutma tekniklerinden benzer şekilde etkilenmiştir. Rojo Brillante çeşidi fizikokimyasal özellikler açısından üstün kurutulmuş ürünler vermiştir. Fırında kurutma hurmaların antioksidatif özelliklerini arttırmış (70,36±0,25), ancak bu yöntem rehidrasyon kapasitesinde (2,17±0,05) ve L* değerlerinde (38,06±0,90) azalmaya neden olmuştur. Dondurarak kurutma ile fizikokimyasal özellikler açısından üstün kurutulmuş ürünler elde edilmiştir. Ancak vakumla kurutulan ürünler ile dondurularak kurutulan ürünler benzer kalite özelliklerine sahip olmuştur. Dondurarak kurutmanın yüksek işletme maliyeti nedeniyle, yüksek kalite özelliklerine sahip kurutulmuş hurma elde etmek için vakumlu kurutma, dondurarak kurutma yerine kullanılabilir.

**Anahtar kelimeler:** Kurutma, Trabzon hurması, antioksidan aktivite

# Comparison of Effects of Different Drying Methods on Quality Parameters of Four Different Persimmon Cultivars

## ABSTRACT

In this study, influences of four different drying techniques (oven drying, fluidized bed drying, vacuum drying, and freeze drying) on quality parameters of four different persimmon cultivars (Rojo Brilliante, Seedless, Hachiya, Türkay) were investigated. For this aim, antioxidant activity, total phenolic content, color values, and rehydration capacity analyses were performed. All-persimmon cultivars were affected by different drying techniques similarly. Rojo Brillante cultivar gave superior dried products in terms of physicochemical properties. Oven drying increased antioxidative properties of persimmons (70.36±0.25), but this method caused a decrease in rehydration capacity (2.17±0.05) and L* values (38.06±0.90). Freeze drying gave superior dried products in terms of physicochemical properties. However, vacuum dried products and freeze-dried products had similar quality properties. Because of high operation cost of freeze drying, vacuum drying can be used to obtain dried persimmons with high quality properties.

**Key words:** Drying, persimmon, antioxidant activity

## INTRODUCTION

Persimmon (*Diospyros kaki* L.) originated in China is now being grown all over the world due to its adaptation capability to subtropical and temperate climates (Sampaio et al., 2017). There are two common types of persimmon cultivars, astringent which are only edible when already ripe for example 'Hachiya' cultivar, and non-astringent which are edible even in unripe conditions such as 'Fuyu' cultivar. Strong astringency of persimmon is caused by the high content of soluble tannin which is also responsible for the enzymatic browning of persimmons (Chung et al., 2017). Persimmon has a plenty of bioactive compounds such as carotenoids, condensed tannins, gallic acid, ascorbic acid, and other phenolic compounds that display valuable antioxidant, anti-inflammatory, antimicrobial, anti-hypertensive and anti-ageing characteristics (Zhao et al., 2021; Ge et al., 2017). On the other hand, persimmon is an easy-to-damaged fruit with low postharvest stability. While persimmons easily rot in a room temperature, they get chilling injury symptoms such as browning skin, softening, and discoloration under low temperatures most rapidly at 5–7 °C and slowest at 0 °C, (Besada et al., 2010; Saleem et al., 2020). Drying can increase the stability of fruits and vegetables by reducing the water activity which implies to microbial activity and physicochemical changes including mositure content, water activity, color and rehydration capacşty (Jia et al., 2019). Also, it is effective way for reducing astringency caused by soluble tannin contents (Zhao et al., 2021). During the drying process, the astringency decreases, and the sugars come out forming white spots on the surface (Hyun et al., 2019; Milczarek et al., 2020). Different techniques are suggested to dry persimmon fruit. In Japan, persimmon is usually prepared by drying the peeled whole shape indirectly to the sun. This dried persimmon is called Hoshigaki, a whole dried 'Hachiya' type of persimmon, which is dried until the water activity (aw) reaches around 0.77–0.83 and becomes an intermediate moisture product. Growing in the late fall to winter season makes it difficult to use sun drying. Vacuum drying hot-air drying, microwave drying, and freeze drying techniques were studied for drying persimmon (Jia et al., 2019; Senadeera et al., 2020; Zhao et al., 2021). Hot-air or oven drying is the most generally used method but gives a high browning effect and nutrition loss due to exposure to oxygen and high temperature. Freeze drying gives the best retaining nutritional values but very high in cost and time-consuming (Jia et al., 2019). Fluidized bed dryer has a good performance on heat and mass transfer that gives uniform drying results (Kaleta et al., 2013). Vacuum drying is performed under low pressure conditions. A vacuum oven is primarily used for gentle and rapid drying, and it is especially beneficial to fruits and vegetables (Reis et al., 2022). A number of studies were performed for drying persimmon (Bozkir et al., 2019; Bölek & Obuz, 2014; Cárcel et al., 2007). However, these studies were investigated the influences of different drying methods on properties of only one persimmon cultivar.

This present study not only focused on the influences of drying techniques on quality properties of only one persimmon cultivar but also compared the influences of different drying methods on four different cultivars (Rojo Brilliante, seedless, Hachiya, Türkay) of persimmons.

## MATERIAL ve METHODS

**Materials**

Rojo Brillante, Hachiya, Seedless and Türkay persimmon cultivars were obtained from Atatürk Horticultural Central Research Institute (Yalova, Turkey) in October 2022. Persimmon fruits with homogeneous characteristics (same color and size) were selected and damaged fruits were removed. Persimmons were stored at room temperature until further analysis.

**Drying Process**

Persimmon fruits were dried using hot air drying, fluidized bed drying, freeze drying, and vacuum drying methods. Before drying, the fruits were peeled, then sliced into equal rings of 5 mm thickness. Hot air drying was performed by a laboratory-scale convective dryer (Daihan Scientific ThermoStable, OF-50 South Korea, Wonju). Sliced persimmon samples were dried at 70°C at an air velocity of 1.0 m/s for 6 hours. The freeze-drying process was performed by a freeze-dryer (Buchi L-200 Flawil, Switzerland) for 72 hours under a condenser temperature of -58 °C and a vacuum of 0.1 mbar. Persimmons were dried for 10 hours at 40°C and 0.15 bar absolute pressure using a vacuum drying cabinet (Daihan Scientific ThermoStable, OV-30). Drying in the fluidized bed dryer was carried out using a laboratory type fluidized bed dryer (Retsch-TG 200, Germany) at 60 °C at an air speed of 1.5 m/s for 3 hours.

**pH measurement of persimmons**

Persimmons were held in distilled water (10%, w/v) for 24 h at +4 °C. Rehydrated fruits were homogenized and filtered through filter paper. The pH values of aliquots were measured by a pH meter (Mettler Toledo, Schwerzenbach, Switzerland). The measurements were repeated three times.

**Moisture content**

Moisture contents of persimmons were measured with a moisture analyzer (Daihan Biomedical, MA-10 South Korea, Wonju) in three replicates.

**Color analysis**

A colorimeter (Konica-Minolta CR-400, Japan, Tokyo) was used to measure the surface colors of the samples. A white tile (L* = 93.3, a* = 0.3162 and b* = 0.3321) was used as a reference for calibration. Analyzes were performed with three replications.

**Rehydration capacity**

Rehydration capacity was determined according to the method of Quintero et al. (1992). Distilled water was added to the dried samples at a fruit-water ratio of 1:30 (w/w). After waiting 24 hours at 4 °C, the samples were dried with a paper towel.. Rehydration capacity values were calculated according to the Eq 1.

RC (%) = (md/mr) x 100 (Eq. 1)

RC: Rehydration capacity (%)

md: dried persimmons weight

mr: rehydrated persimmons weight

**Total phenolic content (TPC)**

Total phenolic contents (TPC) of persimmon samples were meaasured by Folin Ciocalteu method (Singleton and Rossi, 1965). The absorbances were read at 720 nm using a spectrophotometer (Thermo Scientific, Multiskan-Sky, USA, Massachusetts). Total phenolic content was calculated as mg gallic acid equivalent (GAE) per 100 g dry matter (mg GAE/100 g DM). Analyzes were performed with three replicates

**Determination of antioxidant activity**

Antioxidant activity was measured according to the the method of Brand-Williams et al. (1995). Different concentrations of persimmon extracts were prepared. One milliliter of each diluted extract was mixed with 5 mL of freshly prepared 0.1 µM methanolic solution of DPPH. The content was incubated in the dark for 30 minutes. Absorbance was read at 517 nm by a spectrophotometer (Thermo Scientific, Multiskan-Sky, USA, Massachusetts). Percent inhibition values were calculated according to Eq. 2.

Inhibition (%) = [(Absblank-Abssample)/Absblank)] ×100 (Eq. 2)

Absblank: absorbance value of blank sample

Abssample: absorbance values of date samples

**Statistical analysis**

SPSS software (version 16.0) was used in the statistical analysis of the data obtained from the experiment. All data were presented as mean ± standard deviation. P value <0.05 was considered statistically significant. Differences were evaluated using analysis of variance (ANOVA) and mean values were compared using Duncan's multiple range test.

## RESULTS and DISCUSSION

**Drying Experiments**

At the end of the drying, the final moisture values of persimmons were about 9±0.5% (w.b.). The moisture value of the persimmons decreased until a constant value reached with the increasing drying time. All samples were shown similar drying properties.

**Color Properties of Persimmons**

Color values of persimmon samples are given in Table 1. L* refers to the lightness of the part ranging on a scale of 0 to 100. 0 is pure black (dark) and 100 is pure white (light). a* refers to the red-green range. A Negative a* value is green while a positive a* value is red. b* refers to blue-yellow range. A negative b* value is blue while positive b* value is yellow. The higher the b* the more yellow it is. L*, a* and b* values of Rojo Brillante, Hachiya, Seedless and Turkay cultivars were different from each other statistically significantly ($p<0.05$). Freeze drying and vacuum drying techniques decreased L* and b* values of persimmons but this decrease was not significant for all persimmon cultivars ($p>0.05$). Since the L* value is analogous to the color observation made by the operator, L* value is preferred for monitoring color development (Bolek & Ozdemir, 2017). Freeze drying and vacuum drying are considered as the reference process to obtain high-quality dried products in terms of color and nutritional properties. The color is preserved because of the absence of liquid water and the low temperatures required for these processes (Ratti, 2001). Similarly, Jia et al. (2019) found the highest L* values in freeze dried persimmon chips among the dried persimmon chips with different drying technologies. Fluidized bed drying and oven drying decreased L* and b* values of persimmons significantly for all persimmon cultivars ($p<0.05$). This result could be attributed to the non-enzymatic browning reactions and thermal degradation during drying (Cernîşev, 2010; Udomkun et al., 2015). The a* values of persimmon cultivars changed slightly during drying process.

Table 1. Color measurements of persimmons

| Dryer Type | Persimmon Type | L* | a* | b* |
|---|---|---|---|---|
| Oven Dried | Rojo Brillante | $38.06\pm0.90^{cd}$ | $14.28\pm1.43^{a}$ | $13.26\pm3.38^{f}$ |
| | Hachiya | $44.55\pm0.20^{c}$ | $13.88\pm0.78^{ab}$ | $19.67\pm1.92^{d}$ |
| | Seedless | $38.00\pm0.16^{cd}$ | $10.65\pm1.60^{c}$ | $16.75\pm5.67^{e}$ |
| | Turkay | $49.23\pm0.14^{b}$ | $15.53\pm1.60^{a}$ | $22.75\pm3.05^{bc}$ |
| Vacuum Dried | Rojo Brillante | $44.34\pm0.03^{c}$ | $12.22\pm0.12^{ab}$ | $17.59\pm0.70^{e}$ |
| | Hachiya | $50.49\pm0.13^{b}$ | $10.52\pm0.18^{c}$ | $23.89\pm3.79^{b}$ |
| | Seedless | $42.84\pm0.04^{c}$ | $7.60\pm0.07^{d}$ | $20.77\pm9.28^{c}$ |
| | Turkay | $54.18\pm0.09^{a}$ | $12.28\pm0.11^{ab}$ | $26.15\pm2.64^{a}$ |
| Fluidised Bed | Rojo Brillante | $41.34\pm0.10^{d}$ | $12.83\pm0.05^{ab}$ | $15.47\pm0.13^{e}$ |
| | Hachiya | $47.74\pm0.21^{c}$ | $10.90\pm0.07^{c}$ | $21.62\pm0.11^{c}$ |
| | Seedless | $40.32\pm0.19^{de}$ | $7.46\pm0.11^{d}$ | $18.77\pm0.08^{d}$ |
| | Turkay | $52.64\pm0.12^{b}$ | $12.68\pm0.16^{ab}$ | $24.04\pm0.19^{b}$ |
| Freeze Dried | Rojo Brillante | $44.70\pm0.05^{c}$ | $12.14\pm0.38^{ab}$ | $17.07\pm0.15^{d}$ |
| | Hachiya | $50.85\pm0.12^{b}$ | $10.44\pm0.22^{c}$ | $23.52\pm0.11^{b}$ |
| | Seedless | $43.36\pm0.24^{c}$ | $7.32\pm0.58^{d}$ | $20.79\pm0.09^{c}$ |
| | Turkay | $55.01\pm0.18^{a}$ | $12.25\pm0.01^{ab}$ | $26.06\pm0.14^{a}$ |
| Fresh Fruit | Rojo Brillante | $45.68\pm0.06^{c}$ | $11.60\pm0.15^{bc}$ | $18.57\pm12.05^{d}$ |
| | Hachiya | $52.88\pm0.13^{b}$ | $10.07\pm0.13^{c}$ | $24.26\pm11.85^{b}$ |
| | Seedless | $44.09\pm0.02^{c}$ | $6.99\pm0.14^{d}$ | $21.74\pm3.19^{c}$ |
| | Turkay | $56.25\pm0.08^{a}$ | $12.08\pm0.09^{ab}$ | $26.95\pm8.57^{a}$ |

Values are mean ± standard deviation of three separate determinations (n = 3) Values in the column with the same letter in superscript are not significant different from each other at $p<0.05$.

**pH and Rehydration Capacity of Persimmons**

The pH and rehydration capacity values of persimmons are given in Table 2. The initial pH values of persimmon cultivars were different from each other significantly ($p<0.05$). While Rojo Brillante cultivar has the highest pH value, Hachiya cultivar has the lowest pH value. Being directly affected the taste of fruits, pH is an important parameter needs to be taken into account during process. Drying processes affected the pH values of all persimmon cultivars significantly ($p<0.05$). The highest pH drop was found in oven dried persimmon cultivars. This result could be explained by proportional change in organic acid content as a result of moisture removal (Dal & Karacabey, 2021).

Rehydration capacity is an important quality characteristic for dried products. If dried fruit reabsorbs the containing water prior to drying, it is taken into consideration as a high quality dried product. Rehydration behavior is considered as a measure of the induced damage in the fruit during drying (Marques, Prado & Freire, 2009). As seen in Table 2, while freeze dried persimmon cultivars had the highest rehydration capacity, oven dried persimmons had the lowest rehydration capacity values. The freeze drying and vacuum drying techniques had the almost same effect on rehydration capacities of persimmon cultivars. Jiang et al. (2014) compared the rehydration capacities of microwave vacuum dried, freeze dried and microwave freeze dried banana cubes and they found the highest rehydration capacity in freeze dried samples. On the other hand, Rojo Brillante cultivars had the highest rehydration capacity, Turkay cultivars had the lowest rehydration capacity for all drying experiments.

**Antioxidant Activity and Total Phenolic Content of Persimmons**

Antioxidant activity and total phenolic contents of persimmon cultivars are given in Table 3. While Rojo Brillante cultivar had the highest antioxidant activity and total phenolic content values, Hachiya cultivar had the lowest antioxidant activity and total phenolic content. While freeze drying process did not change the antioxidant activity and total phenolic contents of persimmons significantly ($p>0.05$), oven drying, and fluidized bed drying processes increased these values statistically significantly ($p<0.05$). This may be due to formation of new phenolic compounds having antioxidant activity caused by non-enzymatic browning reactions occurring high temperatures (Soong & Barlow, 2004). Que at al. (2008) who compared hot air-drying and freeze-drying on antioxidant activities of pumpkin and Papoutsis et al. (2017) who investigated the effects of vacuum-drying, hot air-drying and freeze-drying on antioxidant properties of lemon pomace aqueous extracts were also found similar results.

Table 2. pH and moisture content of persimmons

| Dryer Type | Persimmon Type | pH | Rehydration capacity |
|---|---|---|---|
| Oven Dried | Rojo Brillante | 5.60±0.04$^{c}$ | 2.95±0.01$^{d}$ |
| | Hachiya | 5.26±0.02$^{e}$ | 2.65±0.09$^{de}$ |
| | Seedless | 5.54±0.01$^{c}$ | 2.24±0.07$^{e}$ |
| | Turkay | 5.32±0.03$^{de}$ | 2.17±0.05$^{e}$ |
| Vacuum Dried | Rojo Brillante | 5.78±0.02$^{ab}$ | 3.38±0.03$^{c}$ |
| | Hachiya | 5.42±0.01$^{d}$ | 3.80±0.09$^{bc}$ |
| | Seedless | 5.74±0.06$^{b}$ | 4.01±0.04$^{ab}$ |
| | Turkay | 5.46±0.05$^{cd}$ | 4.07±0.05$^{ab}$ |
| Fluidised Bed | Rojo Brillante | 5.70±0.05$^{b}$ | 3.12±0.02$^{cd}$ |
| | Hachiya | 5.35±0.07$^{e}$ | 3.34±0.07$^{c}$ |
| | Seedless | 5.68±0.02$^{b}$ | 2.96±0.03$^{d}$ |
| | Turkay | 5.39±0.01$^{d}$ | 2.95±0.09$^{d}$ |
| Freeze Dried | Rojo Brillante | 5.80±0.01$^{ab}$ | 3.65±0.05$^{bc}$ |
| | Hachiya | 5.45±0.03$^{cd}$ | 3.96±0.04$^{b}$ |
| | Seedless | 5.77±0.05$^{b}$ | 4.35±0.11$^{a}$ |
| | Turkay | 5.50±0.01$^{c}$ | 4.25±0.09$^{a}$ |
| Fresh Fruit | Rojo Brillante | 5.86±0.04$^{a}$ | |
| | Hachiya | 5.51±0.09$^{c}$ | |
| | Seedless | 5.84±0.03$^{a}$ | |
| | Turkay | 5.55±0.06$^{c}$ | |

Values are mean ± standard deviation of three separate determinations (n = 3) Values in the column with the same letter in superscript are not significant different from each other at $p<0.05$.

Table 3. Antioxidant activity and Total phenolic content of persimmons

| Dryer Type | Persimmon Type | Inhibition (%) | Total Phenolic Content (mg/kg GAE ) |
|---|---|---|---|
| Oven Dried | Rojo Brillante | 70.36±0.25$^{a}$ | 669.17±1.62$^{b}$ |
| | Hachiya | 68.73±0.85$^{a}$ | 318.61±2.99$^{g}$ |
| | Seedless | 63.82±1.52$^{ab}$ | 400.06±1.52$^{d}$ |
| | Turkay | 66.80±0.88$^{a}$ | 710.83±1.33$^{a}$ |
| Vacuum Dried | Rojo Brillante | 60.27±1.01$^{b}$ | 620.73±1.95$^{b}$ |
| | Hachiya | 59.74±1.33$^{b}$ | 265.39±2.50$^{i}$ |
| | Seedless | 53.19±1.02$^{c}$ | 352.89±1.19$^{f}$ |
| | Turkay | 60.02±0.54$^{b}$ | 640.33±1.82$^{b}$ |
| Fluidised Bed | Rojo Brillante | 64.88±0.70$^{ab}$ | 645.33±0.27$^{ab}$ |
| | Hachiya | 62.00±0.39$^{ab}$ | 290.33±0.30$^{h}$ |
| | Seedless | 55.35±0.22$^{bc}$ | 375.56±0.66$^{e}$ |
| | Turkay | 62.99±0.33$^{ab}$ | 678.90±0.92$^{ab}$ |
| Freeze Dried | Rojo Brillante | 58.12±0.91$^{b}$ | 635.28±0.96$^{c}$ |
| | Hachiya | 56.44±1.13$^{bc}$ | 252.30±0.93$^{j}$ |
| | Seedless | 51.22±0.89$^{d}$ | 345.90±1.13$^{f}$ |
| | Turkay | 57.42±0.95$^{b}$ | 625.88±0.64$^{c}$ |
| Fresh Fruit | Rojo Brillante | 56.94±1.15$^{bc}$ | 630.78±1.91$^{c}$ |
| | Hachiya | 55.25±0.97$^{bc}$ | 250.22±0.86$^{j}$ |
| | Seedless | 50.46±0.85$^{d}$ | 340.28±0.99$^{f}$ |
| | Turkay | 56.29±0.71$^{bc}$ | 623.33±1.49$^{c}$ |

Values are mean ± standard deviation of three separate determinations (n = 3) Values in the column with the same letter in superscript are not significant different from each other at $p<0.05$.

## CONCLUSION

Results revealed that although freeze-drying is superior to other drying methods in preserving the all-persimmon cultivars, vacuum dried and freeze-dried persimmons showed similar physicochemical properties. Oven drying increased antioxidative properties of persimmons, but this method caused a decrease in rehydration capacity and L* values, which are important quality parameters for dried products. Fluidized bed drying and oven drying used hot air, so they gave similar dried products. Because of high operation cost of freeze drying, vacuum drying can be applied to produce dried persimmons with high quality properties. All-persimmon cultivars were affected similarly different drying methods. Rojo Brillante cultivar gave superior dried products in terms of physicochemical properties. Additional precautions such as SO2 treatment and/or pH adjustment can ben given superior dried products.

**Çıkar Çatışması Beyanı:** Makale yazarları aralarında herhangi bir çıkar çatışması olmadığını beyan ederler.

**Araştırmacıların Katkı Oranı Beyan Özeti:** Yazarlar makaleye eşit oranda katkı sağlamış olduklarını beyan ederler.

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## KAYNAKLAR

Amanor-Atiemoh, R., Zhou, C., Abdullaleef Taiye, M., Sarpong, F., Wahia, H., Amoa-Owusu, A., ... & Chen, L. (2020). Effect of ultrasound-ethanol pretreatment on drying kinetics, quality parameters, functional group, and amino acid profile of apple slices using pulsed vacuum drying. Journal of Food Process Engineering, 43(2), e13347.

Besada, C., Jackman, R. C., Olsson, S., & Woolf, A. B. (2010). Response of 'Fuyu'persimmons to ethylene exposure before and during storage. Postharvest Biology and Technology, 57(2), 124-131.

Bolek, S., & Ozdemir, M. (2017). Optimization of roasting conditions of microwave roasted Pistacia terebinthus beans. LWT, 86, 327-336.

Bozkir, H., Ergün, A. R., Serdar, E., Metin, G., & Baysal, T. (2019). Influence of ultrasound and osmotic dehydration pretreatments on drying and quality properties of persimmon fruit. Ultrasonics sonochemistry, 54, 135-141.

Brand-Williams, W., Cuvelier, M. E., & Berset, C. L. W. T. (1995). Use of a free radical method to evaluate antioxidant activity. LWT-Food science and Technology, 28(1), 25-30.

Bölek, S., & Obuz, E. (2014). Quality characteristics of Trabzon persimmon dried at several temperatures and pretreated by different methods. Turkish Journal of Agriculture and Forestry, 38(2), 242-249.

Cárcel, J. A., García-Pérez, J. V., Riera, E., & Mulet, A. (2007). Influence of high-intensity ultrasound on drying kinetics of persimmon. Drying Technology, 25(1), 185-193.

Cernîşev, S. (2010). Effects of conventional and multistage drying processing on non-enzymatic browning in tomato. Journal of food engineering, 96(1), 114-118.

Chung, H.S., Kim, D.H., Kim, H.S., Lee, Y.G., Seong, J.H., Youn, K.S. and Moon, K.D., 2017. Quality comparison of dried slices processed from whole persimmons treated with different deastringency methods. Food science and biotechnology, 26(2), pp.401-407.

Dal, F. F., & Karacabey, E. (2021). Determination of The Physical, Physio-Chemical and Chemical Properties of Gilaburu Fruits (Viburnum opulus) Dried by Convectional Drying Technique. Turkish Journal of Agriculture-Food Science and Technology, 9, 2547-2551.

Ge, Z., Zhang, M., Deng, X., Zhu, W., Li, K. and Li, C., 2017. Persimmon tannin promoted macrophage reverse cholesterol transport through inhibiting ERK1/2 and activating PPARγ both in vitro and in vivo. Journal of functional foods, 38, pp.338-348.

Hyun, J.E., Kim, J.Y., Kim, E.M., Kim, J.C. and Lee, S.Y., 2019. Changes in microbiological and physicochemical quality of dried persimmons (Diospyros kaki Thunb.) stored at various temperatures. Journal of Food Quality, 2019.

Jia, Y., Khalifa, I., Hu, L., Zhu, W., Li, J., Li, K. and Li, C., 2019. Influence of three different drying techniques on persimmon chips' characteristics: A comparison study among hot-air, combined hot-air-microwave, and vacuum-freeze drying techniques. Food and Bioproducts Processing, 118, pp.67-76.

Jiang, H., Zhang, M., Mujumdar, A. S., & Lim, R. X. (2014). Comparison of drying characteristic and uniformity of banana cubes dried by pulse-spouted microwave vacuum drying, freeze drying and microwave freeze drying. Journal of the Science of Food and Agriculture, 94(9), 1827-1834.

Kaleta, A., Górnicki, K., Winiczenko, R. and Chojnacka, A., 2013. Evaluation of drying models of apple (var. Ligol) dried in a fluidized bed dryer. Energy Conversion and Management, 67, pp.179-185.

Marques, L. G., Prado, M. M., & Freire, J. T. (2009). Rehydration characteristics of freeze-dried tropical fruits. LWT-Food Science and Technology, 42(7), 1232-1237.

Milczarek, R.R., Vilches, A.M., Olsen, C.W., Breksa, A.P., Mackey, B.E. and Brandl, M.T., 2020. Physical, microbial, and chemical quality of hot-air-dried persimmon (Diospyros kaki) chips during storage. Journal of Food Quality, 2020.

Pérez-Munuera, I., Hernando, I., Larrea, V., Besada, C., Arnal, L. and Salvador, A., 2009. Microstructural study of chilling injury alleviation by 1-methylcyclopropene in persimmon. HortScience, 44(3), pp.742-745.

Papoutsis, K., Pristijono, P., Golding, J. B., Stathopoulos, C. E., Bowyer, M. C., Scarlett, C. J., & Vuong, Q. V. (2017). Effect of vacuum-drying, hot air-drying and freeze-drying on polyphenols and antioxidant capacity of lemon (Citrus limon) pomace aqueous extracts. International Journal of Food Science & Technology, 52(4), 880-887.

Que, F., Mao, L., Fang, X., & Wu, T. (2008). Comparison of hot air-drying and freeze-drying on the physicochemical properties and antioxidant activities of pumpkin (Cucurbita moschata Duch.) flours. International journal of food science & technology, 43(7), 1195-1201.

Ratti, C. (2001). Hot air and freeze-drying of high-value foods: a review. Journal of food engineering, 49(4), 311-319.

Reis, F. R., Marques, C., de Moraes, A. C. S., & Masson, M. L. (2022). Trends in quality assessment and drying methods used for fruits and vegetables. Food Control, 109254.

Quintero-Ramos, A., Bourne, M. C., & Anzaldua-Morales, A. (1992). Texture and rehydration of dehydrated carrots as affected by low temperature blanching. Journal of Food Science, 57(5), 1127-1139.

Saleem, M. S., Ejaz, S., Anjum, M. A., Nawaz, A., Naz, S., Hussain, S., ... & Canan, İ. (2020). Postharvest application of gum arabic edible coating delays ripening and maintains quality of persimmon fruits during storage. Journal of Food Processing and Preservation, 44(8), e14583.

Sampaio, R.M., Neto, J.P.M., Perez, V.H., Marcos, S.K., Boizan, M.A. and Da Silva, L.R., 2017. Mathematical modeling of drying kinetics of persimmon fruits (Diospyros kaki cv. Fuyu). Journal of Food Processing and Preservation, 41(1), p.e12789.

Senadeera, W., Adiletta, G., Önal, B., Di Matteo, M. and Russo, P., 2020. Influence of different hot air-drying temperatures on drying kinetics, shrinkage, and colour of persimmon slices. Foods, 9(1), p.101.

Singleton, V. L., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. American journal of Enology and Viticulture, 16(3), 144-158.

Soong, Y. Y., & Barlow, P. J. (2004). Antioxidant activity and phenolic content of selected fruit seeds. Food chemistry, 88(3), 411-417.

Udomkun, P., Nagle, M., Mahayothee, B., Nohr, D., Koza, A., & Müller, J. (2015). Influence of air drying properties on non-enzymatic browning, major bio-active compounds and antioxidant capacity of osmotically pretreated papaya. LWT-Food Science and Technology, 60(2), 914-922.

Zhao, C.C., Ameer, K. and Eun, J.B., 2021. Effects of various drying conditions and methods on drying kinetics and retention of bioactive compounds in sliced persimmon. LWT, 143, p.111149.