

## Assessment of Physicochemical and Bioactive Properties of Fresh and Dried Sweet Cherry Fruit

Duygu ALTIOK<sup>1</sup>, Mustafa Remzi OTAĞ<sup>1\*</sup>

<sup>1</sup> Department of Food Engineering, Faculty of Engineering, Giresun University, 28200 Gure, Giresun, Turkey

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\*Corresponding Author: mustafa.otag@giresun.edu.tr

### Abstract

In this study, the changes in the pH, water soluble dry matter (TSSM), color, total phenolic substance and antioxidant activity of cherry (*Prunus avium*) grown in Giresun by drying in laboratory type oven at three different temperatures (40, 50, 60 °C) were investigated. The total phenolic content was determined by Folin-Ciocalteu spectrophotometric method and the results were expressed as Gallic Acid Equivalent (GAE). The antioxidant activity was determined by ABTS + radical scavenging activity and the results were expressed as Trolox Equivalent Antioxidant Capacity (TEAC). It was determined that the total drying time decreased as the drying temperature increased, and the cherry flesh samples dried in a shorter time than the whole cherry samples. It was found that the pH of the whole cherry and cherry flesh samples dried at different drying temperatures varied in the range of 4.08-4.45. When the color changes of the cherry samples during drying were examined, it was determined that L \* values were not significantly affected by the increase of drying temperature but a \* value increased and b \* values decreased. After drying, the total phenolic substances in the extracts of flesh and whole cherry were found to be 362.58-347.26 mg GAE / 100g and 372.49-355.17 mg GAE / 100g, respectively. Antioxidant activity values were determined as 14.70-20.59 µM trolox/g dry sample and 15.51-27.46 µM trolox/g dry sample respectively in flesh and whole cherry extracts. Because of the exposure of the cherry samples to the high temperature and oxygen during drying, the total phenolic content and consequently the antioxidant activity of the cherry samples decreased in both whole cherry and cherry flesh samples.

**Keywords:** Cherry (*Prunus avium*), drying, total phenolic content, antioxidant activity.

## Taze ve Kurutulmuş Kiraz Meyvesinin Fizikokimyasal ve Biyoaktif Özelliklerinin Değerlendirilmesi

### Öz

Bu çalışmada Giresun'da yetişen kirazın (*Prunus avium*) laboratuvar tipi etüvde, üç farklı ortam sıcaklığında (40, 50, 60 °C) kurutulması sonucunda pH, suda çözünür kuru madde (SÇKM), renk, toplam fenolik madde ve antioksidan aktivite özelliklerinde meydana gelen değişimler araştırılmıştır. Toplam fenolik madde içeriği Folin-Ciocalteu spektrofotometrik yöntemle belirlenmiş ve sonuçlar Gallik Asit Eşdeğeri (GAE) olarak ifade edilmiştir. Antioksidan aktivite ise ABTS+ radikal süpürücü aktivite ile belirlenmiş ve sonuçlar Trolox Eşdeğer Antioksidan Kapasite (TEAC) olarak ifade edilmiştir. Kurutma sıcaklığı arttıkça toplam kurutma süresinin azaldığı, ayrıca kurutmada yarım kiraz örneklerinin tam kiraz örneklerine göre daha kısa sürede kuruduğu tespit edilmiştir. Farklı kurutma sıcaklıklarında kurutulan yarım ve tam kiraz örneklerinin pH değerinin 4.08-4.45 aralığında değiştiği belirlenmiştir. Kurutma süresince kiraz örneklerinin renk değişimleri incelendiğinde kurutma sıcaklığının artmasıyla renkte L\* değerlerinin önemli ölçüde etkilenmediği fakat a\* değerinin arttığı ve b\* değerlerinin azaldığı tespit edilmiştir. Kurutma sonrası yarım kiraz ve tam kiraz ekstraktlarında toplam fenolik madde miktarları sırasıyla 362.58-347.26 mg GAE/100g ve 372.49-355.17 mg GAE/100g aralığında bulunmuştur. Antioksidan aktivitesi değerleri ise yarım ve tam kiraz ekstraktlarında sırasıyla 14.70-20.59 µM trolox/mg kuru örnek ve 15.51-27.46 µM trolox/mg kuru örnek olarak belirlenmiştir. Kiraz örneklerinin kurutulması sırasında yüksek sıcaklık ve oksijene maruz kalmasından dolayı tam ve yarım olarak kurutulmuş kiraz örneklerinde fenolik madde içeriği ve buna bağlı olarak daha antioksidan aktivitesinde azalma tespit edilmiştir.

**Anahtar Kelimeler:** Kiraz (*Prunus avium*), Kurutma, Toplam Fenolik Madde, Antioksidan Aktivite.

## 1. Introduction

The sweet cherry (*Prunus avium L.*) is the fruit from the genus *Prunus* of the *Rosaceae* family of roses (Rosales) (Önen, 2008). It is a hard-core fruit species and is considered one of the most important fruits of temperate climates (Göksel and Aksoy, 2014). Cherry is one of the most consumed fruits in the world which has its own taste, aroma, flavor and appearance (Tosun ve Koyuncu, 2007). Turkey ranks first in the world with 480.748 tons of cherry production. There are many wild cherry trees in the North Anatolian mountains, Taurus and Eastern Taurus in Turkey. Aegean region and the Black Sea region are important cherry producing areas in Turkey (İkinci and Bolat, 2015).

Cherry contains 83% water, 13% carbohydrate, 1% protein, 1.7% fiber and various vitamins and minerals (URL-1). Glucose and fructose constitute more than 80% of the total amount of sugar. The cherry fruit contains vitamins A, C and B and minerals such as potassium, magnesium, sodium, zinc and iron. It contains approximately 1500 mg/kg total phenolic substance. Hydrosinamic acids, anthocyanins, flavan-3-ol (catechins) and flavonols account for 60-74% of phenols. Although phenolic compounds are non-nutritive compounds, they have various specific effects on biological systems, especially antioxidant activity. It is known that phenolic substances found in cherries have a high correlation with antioxidant activity depending on cultivar (Göksel and Aksoy, 2014; Usenik et. al., 2008). Usenik et. al. (2008) showed that total phenols and total antioxidant activity significantly increased during ripening.

Cherry is mostly consumed fresh. In the industry, fruit juice, wine, canned, brine, dried or frozen cherries and products are produced (Başkaya, 2011). Cherry color, hardness and size are the main criteria that directly affect the consumer. The parameters used for cherry quality evaluation are color of fruits, sugar content, acid content, dry matter content and hardness (Göksel and Aksoy, 2014). Color is one of the most important quality and maturity indicators in fresh, processed and stored cherries. The color of cherries is mainly affected by the distribution and concentration of different anthocyanins in the shell. In addition, pH, the amount and types of colorless phenolic compounds in the fruit, light, temperature, oxygen, metal ions and enzymes are other factors that affect color. There are some studies about the sensory, nutritional, physicochemical and functional properties of different cherry cultivars showing the effect of harvest time and ripening on these properties (Diaz-Mula et.al., 2009; Serradilla et. al., 2011).

Drying of fruits and vegetables is an old preservation method that has been used since the early ages. Reducing the moisture content of the food by drying provides an environment that will prevent the operation of enzymes and microorganisms. A number of drying methods are commercially used to remove moisture from fruit and vegetables. Sun drying is the most universal method that is used to preserve agricultural products. Natural drying is done under the sun and artificial drying is done in

industrial plants. Dried foods, unlike those processed and stored by other methods, are concentrated in terms of nutrients. The drying process in food industry is applied to reduce the volume and weight of the substances making the transportation, storage and handling processes easier and more economical; to ensure that fruits and vegetables are transformed into long-lasting and more easily transported products; to sterilize or maintain the products by adjusting the moisture content of the products and thus to prevent mold, decay and spoilage caused by moisture. During the drying of fruits and vegetables, some irreversible physical and chemical changes occur. Regional dry matter deposition, crust binding, changes in bulk density, rehydration ability of dried product are examples of physical changes. Chemical changes have an effect on the color, flavor, texture, viscosity, nutritional value and storage stability of the dried or rehydrated product. The intensity of the heat applied in the drying process is the most important factor affecting the level of these changes. Mostly non-enzymatic browning occurs in the dried products. There are some losses in the nutritional value of dried products. Vitamins C and A are the most susceptible substances to degrade in both drying and storage (Polatoğlu and Beşe, 2017).

The objective of present study is to determine the effect of drying temperatures (40, 50 and 60°C) on physicochemical and bioactive properties and drying rate of the sweet cherry fruit collected from Giresun province in Turkey.

## **2. Materials and Methods**

### **2.1. Materials**

The cherry fruits used in the study were collected from three different trees from an orchard in Kargı Village in Piraziz district of Giresun province in the third week of June of 2017-2018 harvest year. The collected cherries were frozen and stored at -40 ° C until the experiments and analyses to be performed as suggested in literature (Woodward et al., 2009; Talens et al., 2003)

### **2.2. Methods**

#### **2.2.1. Drying Experiments**

The sweet cherry samples were chosen to have a similar size and weight as much as possible. The fresh cherries were cut into two halves (cherry flesh) and the stones were removed. Drying experiments were carried out using a laboratory scale hot-air dryer. About 40 g of whole and flesh cherry samples were placed on a flat tray and dried in a pilot-scale dryer (Nuve FN300, Turkey) at

40, 50 and 60 °C drying temperatures until the final moisture content of 10 % to be reached. The sample weight was recorded at every hour during first 12 h and then at 2h intervals for remaining drying period.

### **2.2.2. Physicochemical Analyses**

The equilibrium moisture content was determined by means of AOAC method No. 934.06. All methodologies followed the recommendations of the Association of Official Analytical Chemists (AOAC, 1990). The pH was measured using a pH meter (Ohaus Starter3000, Germany). Total soluble solids were measured using a refractometer (Abbe Refractometer ABBE-REF 1, United Kingdom) which measures refraction indices of both solid and liquid samples in a fast and accurate way and its scale ranges from 0.0 to 95° Brix. All measurements were done in triplicate.

### **2.2.3. Color Measurement**

The color of whole cherry skin and the cherry fleshs was determined by Hunter Lab Colorimeter (Hunterlab MiniScan EZ 4000L, USA) based on the CIELab color space, after calibration with the white and black glass standards. Three equidistant spots were examined on the major axis of each cherry sample. The color values were expressed using CIELab\* coordinates where L\* represents the luminosity (0 = black; 100 = white), a\* the redness ( $a^* > 0$ ) or greenness ( $a^* < 0$ ) and b\* the blueness ( $b^* > 0$ ) or yellowness ( $b^* < 0$ ).

### **2.2.4. Determination of Total Phenolic Content**

The total phenolic content (TPC) was determined according to the adapted Folin–Ciocalteu colorimetric method (Waterhouse, 2002). 0.5 mL of cherry fruit extract obtained at 70% ethanol was mixed with 2.5 mL of Folin–Ciocalteu reagent (10% (v/v)) and 2 mL of sodium carbonate solution (7.5% (w/v)). The mixture was stirred and kept at room temperature for 1h in the dark place. The absorbance of sample against blank was determined at 725 nm using UV-Visible Spectrophotometer (Hach DR6000, Lange GmbH, 189 Germany). The TPC of the samples was expressed as mg of gallic acid equivalents (GAE) per gram of dry weight (dw) by using Gallic acid calibration curve obtained for the concentrations of 40–400 mg/L.

### 2.2.5. Determination of Antioxidant Activity

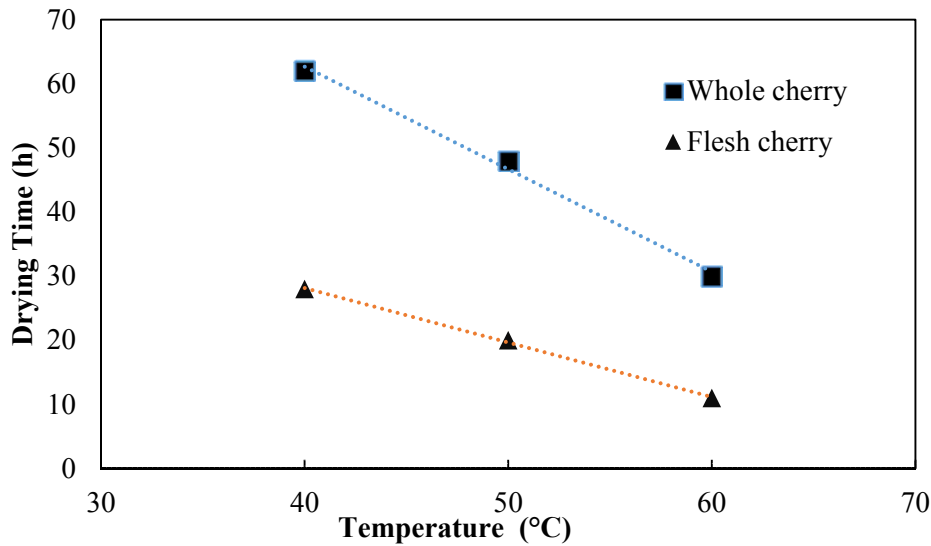
The antioxidant activity was determined by ABTS method of Re et al. (1999) with slight modifications. The ABTS radical cation (ABTS<sup>\*+</sup>) was generated by the reaction of 5 mL of aqueous ABTS solution (7 mM) with 88 $\mu$ L of potassium persulfate (2.45 mM). The mixture was kept in the dark for 16 h before use that results blue–green ABTS+ radical solution. After adjusting the initial absorbance of ABTS+ radical solution to  $0.700 \pm 0.05$  at 734 nm by diluting with ethanol, the fruit extracts or a reference substance (Trolox) was added in different concentrations to 2 mL of ABTS+ radical solution. The decrease of absorbance at 734 nm was measured every minute during 6 minutes using UV-Visible Spectrophotometer (Hach DR6000, Lange GmbH, 189 Germany). The results were expressed as Trolox equivalent antioxidant capacity (TEAC) ( $\mu$ M trolox/g dry weight of sample) by using Trolox calibration curve.

### 2.2.6. Statistical analysis

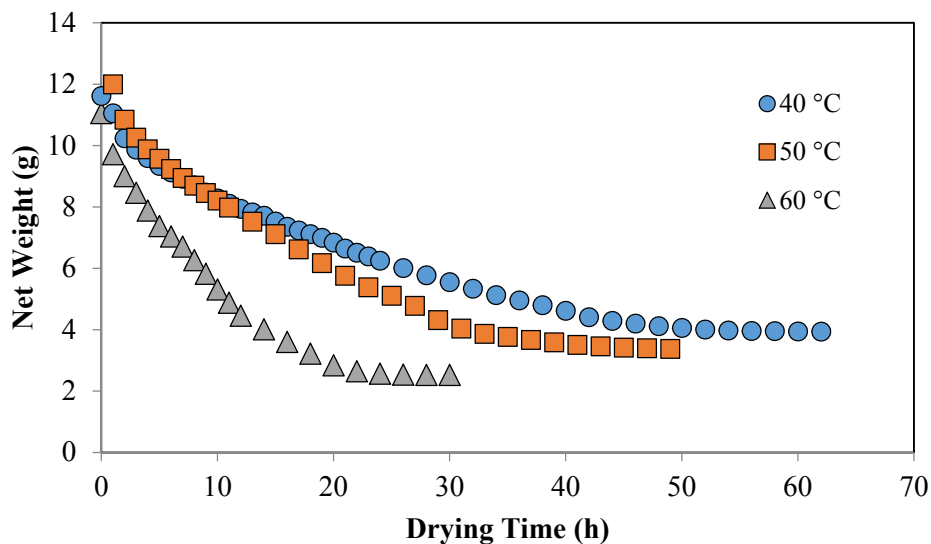
Experimental data were analyzed by analysis of variance (ANOVA) using a statistical program SPSS (Version 16). Duncan's multiple range tests was employed to establish the multiple comparison of mean values. Mean values were considered significantly different when  $p < 0.05$ . Each experiment was performed in triplicate.

## 3. Results and Discussion

Cherry samples were dried using hot air at 40, 50 and 60 °C until the moisture content was reduced to 10%. The drying time of whole and flesh cherry samples at three different temperatures are given in Figure 1. It was found that the time elapsed during the drying of the whole cherry samples was higher than the flesh cherry samples at the same drying temperatures. It was observed that the drying time was 62, 48 and 30 h at 40, 50 and 60 °C for the whole cherry samples, respectively, while it was 28, 20 and 11h at the same temperatures for the flesh cherry samples, respectively. The reason for longer drying time of whole cherry than the cherry flesh is that the skin of whole cherry has a barrier property with low permeability in moisture evaporation. In the case of cherry flesh, due to the high evaporation surface area and the absence of the skin barrier, both the heat transfer and the evaporation rate were high, resulting in rapid drying.

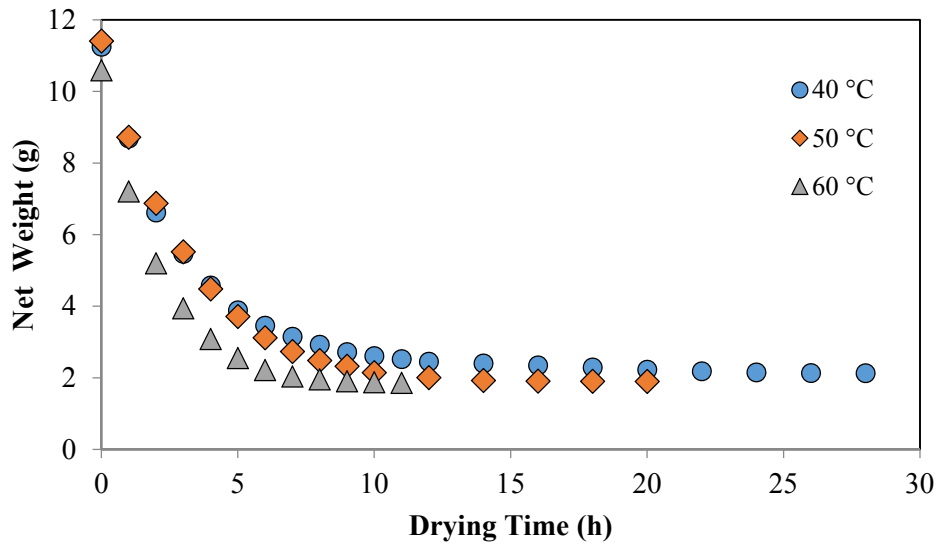


**Figure 1.** Drying time as a function of temperatures and fruit sample



**Figure 2.** Drying curves of hot air dried whole cherry samples at different drying temperatures

As evident from drying curves (Figure 2 and Figure 3), the drying time was reduced with an increase in temperature, in whole and cherry flesh samples used. It could be due to increase in vapor pressure inside samples, thereby pressure gradient between surface and inside of the cherry samples which in turn leads to higher heat transfer rate at higher temperature (Mitra et al. 2011). As shown in Figure 2 and Figure 3 the drying curves depict drying of cherry samples in fall ingrate period. These results were in accordance with the previous studies on drying of cherry samples by Doymaz and İsmail (2011) and Horecki et al. (2017)



**Figure 3.** Drying curves of hot air dried cherry flesh samples at different drying temperatures

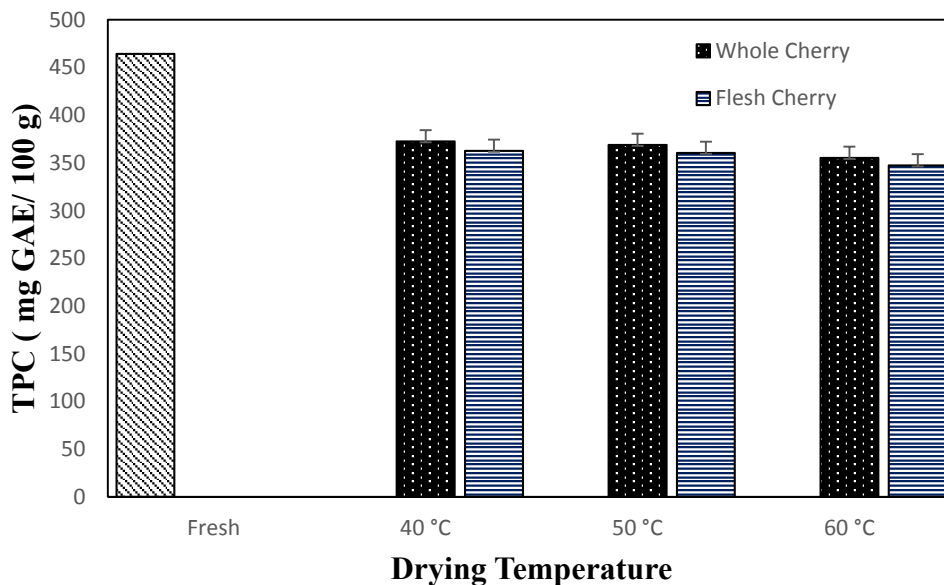
Dried products contain various nutritional and non-nutritional elements intensively. Because the water was removed by drying and a dense dry substance remained. The results for total soluble solids (TSS) and pH are presented in Table 1. There were some significant differences in TSS between the fresh and dried whole and flesh cherry. Brix values increased from 13.30 of fresh cherry to 61.92-69.94 for dried samples. This is resulted from the removal of water with drying which causes a dense dry substance remained and dried products with various nutritional and non-nutritional elements intensively. Drying process didn't affect pH of cherry samples significantly. pH of fresh and dried cherry samples was in the range of 4.08-4.45.

**Table 1.** Soluble solids, pH and color values of fresh and dried cherry samples

	Drying Temperature	TSS (°Bx)	pH	L*	a*	b*
<b>Fresh</b>	-	13,30±0,06 <sup>a</sup>	4,08±0,03 <sup>a</sup>	26,89±0,36 <sup>a</sup>	11,39±0,27 <sup>a</sup>	15,97±0,04 <sup>a</sup>
<b>Dried</b>	40 °C	61,92±0,03 <sup>b</sup>	4,33±0,02 <sup>b</sup>	56,74±0,34 <sup>b</sup>	4,73±0,11 <sup>b</sup>	- 1,07±0,25 <sup>b</sup>
<b>Whole</b>	50 °C	63,17±0,07 <sup>c</sup>	4,37±0,05 <sup>c</sup>	59,86±0,42 <sup>c</sup>	5,27±0,16 <sup>c</sup>	- 1,74±0,38 <sup>c</sup>
<b>Cherry</b>	60 °C	64,25±0,05 <sup>c</sup>	4,45±0,02 <sup>d</sup>	66,32±0,54 <sup>d</sup>	5,54±0,12 <sup>d</sup>	- 7,00±0,57 <sup>d</sup>
<b>Dried</b>	40 °C	68,87±0,03 <sup>d</sup>	4,28±0,07 <sup>e</sup>	53,92±0,70 <sup>e</sup>	5,84±0,21 <sup>e</sup>	8,54±0,43 <sup>e</sup>
<b>Cherry</b>	50 °C	69,21±0,09 <sup>d</sup>	4,35±0,04 <sup>f</sup>	55,56±0,48 <sup>b</sup>	5,83±0,32 <sup>e</sup>	3,83±0,28 <sup>f</sup>
<b>Flesh</b>	60 °C	69,94±0,05 <sup>d</sup>	4,38±0,03 <sup>c</sup>	63,30±0,24 <sup>f</sup>	4,66±0,25 <sup>f</sup>	3,11±0,31 <sup>g</sup>

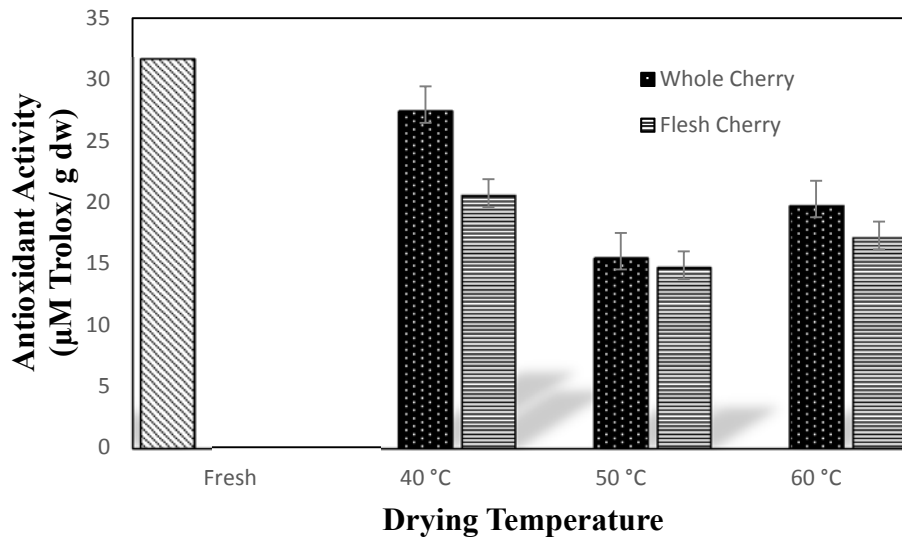
Values are represented as mean ± SD. Different superscript letters within the same column indicates that the values are significantly different ( $p < 0.05$ )

$L^*$ ,  $a^*$  and  $b^*$  values of fresh and dried cherry samples are provided in Table 1.  $L^*$  values increased with after drying in all treatments showing that the dried samples are brighter than fresh fruit.  $a^*$  values of fresh and dried samples were approximately 11.4 and 5.5, respectively which indicates the dried samples are greener than the fresh sample but among different drying temperatures, there was no significant difference. In the case of  $b^*$  coordinate, the values of dried whole cherry samples became negative which means color became more yellowish as compared to fresh where drying at 60 °C had the greatest effect.  $b^*$  value of dried flesh cherry samples decreased to the range of 3.83-3.11 by drying at 50 °C and 60 °C, respectively. These positive values indicate the decrease in the blueness of the samples. It has been stated in many studies that the fruits are affected by heat treatments at high temperatures and the quality loss increases in proportional to the temperature. Mostly the pigments that give the characteristic color of the food have been affected by heat treatments and lost at significant levels. In this study, in accordance with the literature, when the color parameters of fresh and dried cherry samples were compared, it was observed that the color parameters of the dried cherries decreased and the color darkened due to concentration of pigments during drying. However, the color attributes are still acceptable for consumers since there is no significant browning observed in the samples. The color parameters differ according to the type of fruit, the climate, soil and harvest time. Therefore, there is no any reference for *Prunus avium* cherry grown in Giresun region



**Figure 4.** Total Phenolic Contents of fresh and dried cherry (whole and flesh) samples at different drying temperatures





**Figure 5.** Antioxidant capacity of fresh and dried cherry (whole and flesh) samples at different drying temperatures

The total phenolic content and antioxidant activity of whole cherry and cherry flesh are presented in Figure 4 and Figure 5. Total phenol content (TPC) in fresh cherry was 464.15 mg GAE/100 g, which is similar to the findings of Samec & Piljac-Zegarac, (2011) as 437.45 mg GAE/100 FW. At 60 °C drying temperature, the highest decrease in TPC of whole cherry and cherry flesh samples was observed. It decreased to 355.17 mg GAE/100 g and 347.26 mg GAE/100 g in whole cherry and cherry flesh samples, respectively, while that of 464.15 mg GAE/100 g in fresh cherry. TPC of dried cherry flesh samples is also significantly lower ( $p < 0.05$ ) compared to dried whole cherry samples after the same drying applications. TPC decreased as drying temperature increased in all dried products (Figure 4). According to Martín-Cabrejas et al. (2009) and Qu et al. (2010), a decrease in phenolic contents during drying can also be attributed to the binding of polyphenols with other compounds (proteins) or to alterations in the chemical structure of polyphenols which cannot be extracted or determined by available methods.

ABTS assay was used for quick screening of antioxidant activities of fresh and dried cherry samples. The Trolox equivalent antioxidant capacity of fresh cherry was found as 31.64 µM trolox /g of dw, while it was determined as 27.47 and 14.70 µM trolox /g dw for dried whole cherry and cherry flesh, respectively. The antioxidant activity of cherry flesh decreased significantly by drying at 50 °C. It remained almost unchanged for whole cherry by drying at 40 °C. It is noted that drying temperature has an obvious influence on the antioxidant capacity of cherry. The reduction of antioxidant activity is partially related to drying time and temperature. Both long time and high temperature stimulate the oxidation and degradation of phenolic components which are responsible for antioxidant activity. Similar trends have been reported by Michalska et al. (2008) that higher drying temperature shortened drying time and decrease in antioxidant capacity of plum powders. The

other factor resulting in the reduction of antioxidant capacity of cherry flesh could be the increased surface area without cherry skin barrier during dehydration which results in the high exposure to high drying temperature and oxygen causing oxidation and degradation of phenolic compounds. However, drying at 60 °C with a shorter drying time resulted in higher antioxidant activity than at 50 °C with longer drying time. Prolong exposure to hot air during dehydration of cherries could be responsible for the greater degradation of phenolic compounds having antioxidant potential. Zielinska and Markowski (2016) have reported the similar trends about the effect of drying temperature on the antioxidant capacity of blueberry.

#### 4. Conclusion

The drying experiments were carried out at different drying temperatures. The effect of drying temperature on some biological and chemical properties of dried cherry samples. The increase in drying temperature decreased the drying time. Cherry fleshs have shorter drying time than whole samples at all drying temperatures. Both the total phenolic content and antioxidant activity of dried samples slightly decreased. The reduction in the bioactivity of cherry samples was minimum at 40 °C drying temperature when compared with 50 and 60 °C. Since high temperature and presence of oxygen during drying affect negatively antioxidant activity of the products during drying processes, it can be suggested to apply different drying methods and to optimize the parameters in future studies in order to preserve antioxidative compounds such as phenols and flavonoids.

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