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Original article

Bioactive Compounds, Antioxidant Potential and Color Properties of Dried Red Pepper (*Capsicum annuum* L.)

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Abstract

This experiment was carried out to study the effects of drying on physical quality, color development, bioactive compounds and antioxidant potential of red peppers (Capsicum annuum L.). Dry matter, surface color values (L*, a*, b*, h*, ΔE*, C*), extractable color (ASTA), non-enzymatic browning, total-carotenoids, total phenolic content (TPC), total flavonoid content (TFC) and antioxidant potentials were measured for fresh and dried samples. Besides, the rehydration rate was determined for dried samples. The L*, a*, b* values were used to calculate hue angle (h), chroma (C*) and color differences (ΔE*).

Total phenolic content (TPC), total flavonoid content (TFC) and antioxidant potentials were extracted by different solvents that were water, methanol and ethanol. TPC had differences for each solvent ($P < 0.05$) and water extracts had the highest value (178.1 mg GAE/ 100g dw), followed by ethanol and methanol. Otherwise, TFC and antioxidant potentials had no significant differences according to solvents ($P > 0.05$). Antioxidant potentials were evaluated with DPPH free radical scavenging assay and ferric reducing power assay. DPPH free radical scavenging activity showed significant moderately strong negative correlations with TPC (r=-0.958) and TFC (r=-0.821). A decrease in color values is an expected value for dried samples and the results showed a loss for all color measurements. L*, a* and b* values decreased because red pepper color became darker may be related to the carotenoids and the formation of browning compounds. As ASTA values decreased, hue angles increased, indicating color change slightly from red to orange hues. Physical examination of the rehydrated pepper samples resulted in displaying improved rehydration rate (5.95).

Keywords: Antioxidant, Capsicum annuum L., color, phenolics, red pepper, rehydration.

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INTRODUCTION

Red pepper (*Capsicum annuum L.*) is a fruit that has been preferred for its color, aroma and nutrition value (Wang et al., 2018). It is an excellent source of carotenoids, ascorbic acid and polyphenols which are known to have the high antioxidant capacity (Wang et al., 2018; Srinivasan, 2016). Peppers have also functional, nutritional, and physiological importance (Hwang et al., 2017; Cao et al., 2016). Red peppers are consumed as fresh, dried, powdered, paste or canned. However, fresh pepper has a short shelf life, and it is commonly preserved by drying (Hwang et al., 2017; Tunde-Akintunde, 2011). Also, peppers are often used to give color and aroma to sauces, soups, pickles and pizzas and a significant number of red peppers is consumed as powders (Guclu et al., 2021). Therefore, the drying process is also important.

Sun drying is a traditional method, and it has some disadvantages, such as contaminations, soil, dust and insects (Doymaz and Pala, 2002). Dehydrated red pepper has been generally produced by hot air drying, which is faster, supplies uniformity and hygiene, which are important for industrial food drying processes (Doymaz and Pala, 2002; Vega-Galvez et al., 2008). However, conventional drying had serious quality losses for pepper like degradation of nutritional value and loss of color and texture of dried product (Kim et al., 2006; Vega-Galvez et al., 2008). They are the main attribute for dried red pepper, especially color is an important quality criterion for consumer preference and marketing quality (Carbonel et al., 1986; Hirayama et al., 1994; Chen et al., 1999). Red pepper takes its red color from some carotenoids, like carotene, cryptoxanthin, capsorubine, lutein (Erdoğrul, 2000). So, loss of surface color is an indicator for the deterioration of carotenoid pigments (Mínguez-Mosquera and Gálvez, 1998).

Apart from the processing type of foods, their color attributes are the main indicator affecting consumer acceptance and their purchase preference remarkably (Guclu et al., 2021). Undesirable changes in the color may lead to a decrease in its quality and marketing value, therefore, the surface color of the pepper is an important criterion. Loss of red color is caused by autoxidation of carotenoids. The stability of the main carotenoids of the red bell pepper during storage has been shown to depend on the drying conditions, with the rate of deterioration increasing as the drying temperature increases (Vega-Ga´lvez et al., 2008). Another important compound group in vegetables is phenolics. These have a great importance for color, taste, aroma and their positive effects on human health (Jeong et al., 2011). The amounts of phenolic compounds and color properties of fruits depend on the drying process. For this reason, the present study was aimed to determine the effect of drying on the amounts and compositions of TPC, TFC, antioxidant potential, color properties and rehydration capacity.

MATERIALS and METHODS

Red Pepper Sample Preparation and Drying Process

Fresh red peppers were purchased from a local market in Çine, Aydin. The peppers were carefully selected with the same size and uniform color. Samples were stored at + 4˚C before the experiments in order not to undergo physiological and chemical changes and they were removed from the cold conditions before drying. Cups, seeds and stems were removed from peppers, after samples were cut into pieces about 1x1 cm. The initial moisture content of samples was 86.64±0.68 % wet basis (Wang, Fang et al., 2017).

The drying process was carried out by using pilot scaled tray dryer at 65 ºC with air velocity of 1 m/s (Renewalde Energy Research and Implementations Center in Suleyman Demirel University, Isparta). The drying period was continued for 9 h when samples reached to the 13.89±0.23 % moisture is constant value. Approximately 667.4 g fresh red pepper samples were dried in tray drier had 22x22 cm dimensions having holes and only one tray. The air flow was given as horizontal and cross over the samples. Each experiment was carried out in triplicate.

Moisture Analysis

The moisture content of fresh and dried samples were determined by drying weighed samples to constant weight at 105 ºC according to the Association of Office Analytical Chemists (AOAC, 2000).

Determination of ASTA Color Values

The extractable color of the red pepper sample was measured following Method 20.1 of the American Spice Trade Association (ASTA 1985). Dried red pepper powder (0.08 g) was added to 100 ml acetone, and then the mixture was stored in the dark at room temperature (19 ºC-24 ºC) for 24 h. The absorbance of the extract was measured using a spectrophotometer (UV-Visible-Shimadzu, Japan) at 460 nm and calibrated with an acetone blank. ASTA color value was calculated using the formula given below (Osuna-Garcia and Wall, 1997) and results were expressed in ASTA units.

$$\text{ASTA Color Value} = (A \times 16.4 \times I_f)/\text{Sample Weight (g)} \qquad \text{(Eq.1)}$$

I_f = Instrument correction factor,

A= Absorbance of the acetone extract.

Surface Color Properties

The surface color was measured as L^* (Whiteness), a^* (greenness or redness), b^* (blueness or yellowness) color values of fresh and dried red pepper samples with Conica Minolta CR 400 Colorimeter. Chroma differences (ΔC^*), color differences (ΔE^*) and hue angle (h^*) were also calculated

for fresh and dried peppers for storage time using formulas following as (Osuna-Garcia et al., 1997; Osuna-Garcia and Wall, 1997).

$$\Delta C^* = [(a^* - a^*_{taze})^2 + (b^* - a^*_{taze})^2]^{1/2} \quad \text{(Eq. 2)}$$

$$\Delta E^* = [(L^* - L^*_{taze})^2 + (a^* - a^*_{taze})^2 + (b^* - b^*_{taze})^2]^{1/2} \quad \text{(Eq. 3)}$$

$$h^* = \tan^{-1}(b/a) \quad \text{(Eq. 4)}$$

Non-Enzymatic Browning (NEB)

Determinatiın of non-enzymatic browning compounds dissolved in the rehydration water was performed according to Vega-Ga´lvez et al. (2008). Firstly, the rehydration water was clarified by centrifugation at 3200xg for 10 minutes. The supernatant was diluted with ethanol at 95% (v/v; ethanol/water) and centrifuged again at the same conditions. The extracts were used to determine the browning index, and the absorbances of the extracts were measured at 420 nm in quartz buckets using a spectrophotometer (Shimadzu UV/Vis Spectrophotometer).

Determination of Total Carotenoid Content (TCC)

Fresh and dried red pepper samples (5 g) were grounded and extracted with a mixture of acetone and petroleum ether (1:1, v/v) repeatedly using a mortar and pestle until the residue was colorless. The supernatant was collected and washed several times with water and combined with the crude extracts. The volume of the extract was made up with petroleum ether. The absorbance at 450 nm with a spectrophotometer was measured to determine total carotenoids. The content of carotenoids was expressed in mg equivalent β-carotene per 100 g dry weight (Tripathi and Mishra, 2009).

Extraction of Sample

The fresh and dried samples (1 g) were extracted with three different solvents, absolute methanol, absolute ethanol and aqueous (10 mL). The mixtures were vortexed for 5 min, followed by sonicated for 30 min at 45 ºC in a sonicator (Bandelin, 35 kHz; 580W). After this procedure, the mixtures were centrifuged at 1000 x g for 5 min, and the supernatant was concentrated with a vacuum rotary evaporator. The extraction was repeated three times. The extracts were kept at +4 °C until analyzes were performed.

Determination of Total Polyphenol Content (TPC)

Total polyphenol contents were measured using the Folin-Ciocalteu method described previously (Mouratoglou et al. 2016). An aliquot of 780 µL of distilled water, 20 µL of sample and 50 µL of Folin-Ciocalteu reagent were mixed, and then incubated at room temperature for 1 min. Following the addition of 150 µL of sodium carbonate (20 % w/v), the samples were allowed to incubation in dark for 60 min. The absorbance of the resulting blue color was measured at 750 nm. Gallic acid was the preferred as a

standard for comparison and the results were expressed in milligrams of gallic acid equivalent (GAE) per 100 g of dry weight (mg GAE/100g dw). All determinations were performed in triplicate (n =3).

Determination of Total Flavonoid Content (TFC)

A previously published methodology was employed (Mouratoglou et al. 2016). An aliquot of 250 µL sample was mixed with 750 µL $AlCl_3$ (0.16 %, w/v, $AlCl_3$ and 5 %, v/v, acetic acid in methanol), and left at room temperature for 30 min. The absorbance was obtained at 415 nm and the total flavonoid concentration was calculated from a calibration curve of quercetin. Total flavonoid content was expressed as mg quercetin equivalents (QE) per 100g of dry weight (dw) (mg QE/ 100g dw).

Determination of Antioxidant Activity

For the measurement of the antioxidant activity of the pepper extracts, two methods were used. The first one evaluates the reduction of DPPH$^{\bullet}$ in presence of antioxidants, which is detected as a change of color (from purple to yellow) in the solution. Determination of free radical scavenging capacity (DPPH$^{\bullet}$) of the extract was performed based on the method of Sanchez-Moreno et al. (2003). The extract dissolved in methanol was prepared in various concentrations (50–400 µg/mL). 500 µL of the extract solutions was mixed with 3 mL of DPPH$^{\bullet}$ solution (6×10^{-5} M) dissolved in methanol. After incubation at room temperature for 30 min, the absorbance of samples at 517 nm was read against a methanol blank. All of the experiments were conducted in triplicate. The percentage of DPPH radical remaining against extract concentration was then plotted to obtain the amount necessary to decrease the initial DPPH radical concentration by 50 % (IC_{50}). IC_{50} value was defined as the extract concentration providing 50% inhibition of µg dry plant sample per mL (µg/mL).

The second method was ferric reducing power (FRAP) assay described by Oyaizu (1986). The different concentrations of sample alcoholic and aqueous extracts were mixed with 1 ml of sodium phosphate buffer (pH 6.6) and 1 ml of 1% potassium ferricyanide. The mixture was incubated at 50 ºC for 20 min. After that, 1 ml of 10% trichloroacetic acid (w/v) was added and the mixture was centrifuged at 3000 rpm for 10 min. The upper layer (1.5 ml) was mixed with 1.5 ml deionized water and 0.1 ml of 0.1% of ferric chloride, kept for 10 min and the absorbance was measured at 700 nm. An increase in absorbance of the reaction mixture indicates increased reducing power. The antioxidant capacity of extracts was expressed as EC_{50}. The EC_{50} value (the effective concentration at which the absorbance was 0.5) was calculated from the graph of absorbance at 700 nm against extract concentration (µg/mL; µg dry plant sample per mL).

Rehydration Properties (RR)

The dried red peppers were rehydrated. For this, approximately 4.20-4.35 g of dried red peppers were added to 200 mL of water, mixed thoroughly, and allowed to rehydrate for various lengths of time. Water was drained from the surface by a paper towel and weighed. After rehydration, the moisture

content of rehydrated slices was determined. All the measurements were carried out in triplicate and the averages were calculated (Singh et al., 2006). The rehydration ratio (RR) was calculated according to Eq. (5) and expressed as grams of water absorbed per gram dry matter.

$$RR= (W_{reh.}X_{reh}.- W_{dried}. X_{dried}) / (W_{dried}.(1- X_{dried}) \quad \text{(Eq. 5)}$$

where W_{reh} is the weight of the sample after the rehydration process, X_{reh} is the corresponding moisture content on a wet matter, W_{dried} is the weight of the sample after the drying process, Xdried is the corresponding moisture content on a wet matter.

Statistical Analysis

Analyses of variance of data for each attribute were worked out using SPSS 17.0 (SPSS Chicago, Illinois, USA). All the experiments were carried out in triplicates. The results of the replicates were expressed as mean ± standard deviation (SD). Significant differences ($P < 0.05$) among means were determined by Duncan's multiple range test. A probability value of $P < 0.05$ was considered to denote a statistically significant difference between the mean values.

RESULTS and DISCUSSION

Color Changes

Color measurements are important for the red pepper industry to set standards for color when pepper powder is used as a spice or as a coating on foods (Vega-Ga´lvez et al., 2008). The Figure 1 shows the average values of the surface color properties and calculated values of chroma differences (ΔC*) and color differences (ΔE*) for fresh and dried red peppers. After drying, the samples showed a decrease of 38.52% in L* (Lightness) value. The decrease in L* could be due to a decrease of moisture content after drying and could be attributed to brown pigment formation during drying. Some authors reported that brown pigment in dried red peppers was due to their high levels of reducing sugars and amino acids in red pepper (Demiray and Tülek, 2020; El-Hamzy and Ashour, 2016; Vega-Ga´lvez et al., 2008). Modifications in coordinate a* (redness) for dried samples were also presented in Figure 1 where there was a decrease of this coordinate (33.53%) concerning to fresh samples. The drying time and temperatures involved in oven drying might lead to reductions in the redness of the samples. During the drying process, a* value is related to carotenoid content decreasing with heat degradation of carotenoids; the decrease in L* value is a function of the logarithm of a percent increase in browning compounds (El-Hazhy and Ashor, 2016; Addala et al., 2015). Coordinate b* (yellowness) value, which is not a desirable variable for high-quality dried red pepper, showed a slight decrease in its values of 17.78 and 25.37% for the fresh and dried samples. The decrease in b* value could be caused by the degradation of the carotenoids and also related to non-enzymatic reactions (Addala et al., 2015; Adam et al., 2000). Some estimated values being chroma differences (ΔC*) and color differences (ΔE*) of the dried samples retained as 15.8% and 23.71%, respectively, the hue angle showed an increase from 28.84 to 32.93 in

the samples, indicating discoloration of the color of the red peppers. Several authors have reported similar results for surface color properties (Anoraga et al., 2018; Addala et al., 2015; Simal et al., 2005; Osuna-Garcia et al., 1997).

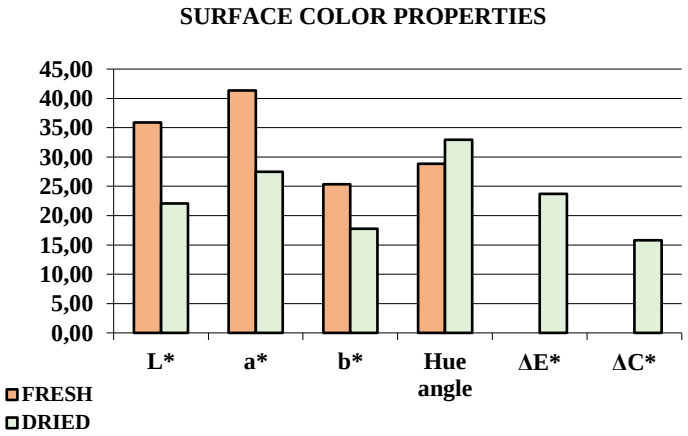

Figure 1. Surface color properties of fresh and dried red pepper samples.

Briefly, non-enzymatic browning and carotenoid loss occurring during drying are major reasons for the color degradation in the red pepper. The fewer color alterations for dried peppers have relation to providing less carotenoids decomposition and less formation of undesirable pigments. It is suggested that less color degradation was conducted to investigate the effect of main factors, i.e., drying method, storage period, and their interactions (El-Hamzy and Ashour, 2016). However, surface color does not necessarily depend on the total amounts of pigments in red peppers, color was additionally expressed in ASTA units, which are related to the total coloring capacity (Zaki et al., 2013).

The color of dried red pepper can be estimated either as extractable color or surface color. Extractable color is the official method used by the American Spice Trade Association (ASTA ,1985). Surface color characteristics can give some measurements about the perception of color with eye (Osuna-Garcia et al., 1997).

Table 1. Some physical properties of fresh and dried red peppers.

Sample	ASTA	COLOR LOSS (%)	NEB (ABS/g initial d.m.)	TCC (mg/100gDW)	RR	DM (%)
Fresh	182			111.75		13.35
Dried	154	15.34	0.0653±0.007	106.85	5.96±0.25	86.11

The fresh and dried red pepper samples showed a high ASTA value 154 units and 182 units/g d.m., respectively (Table 1). Similar results were obtained by Zaki et al. (2013), and some other literatures reported higher ASTA values for dried pepper such as El-Hamzy and Ashour (2016), Koç et al. (2004), Osuna-Garcia et al. (1997). The extractable color value is typically specified as ASTA color

value. In our results, extractable color and hue angle had a high negative correlation. With the drying of fresh red peppers, the hue angle increased by 14%, while the ASTA value decreased by 15%.

The NEB is another parameter attributed to evaluate the quality of the dried red pepper. Red pepper has a high content of reducing sugars and amino acids, and these are main actors of Maillard Reactions during processing and storage of products. It can be noticed that an increase in the drying time caused an important formation of brown products. It has been known that the water activity and temperature had significant impacts on the NEB rate of dried red peppers during their storage (Vega-Ga´lvez et al., 2008). In addition, it was observed that the NEB value of dried samples was 0.0653 ± 0.007 Abs/g initial d.m in current study (Table 1).

Carotenes are also largely responsible for the color of the red peppers. According to the cultivars, maturity and processing conditions, red pepper is a rich source of carotenoids (Sayın and Arslan, 2015). It is known that carotenoids are very sensitive to oxidation and degradation in response to environmental stress. They are highly unstable and high relative humidity leads to enzymatic hydrolysis of the structure and in turn makes it susceptible to oxidation and loss (Tripathi and Mishra, 2009). In the fresh and dried red pepper samples, total carotenoid content was determined, and the calculated values ranged from 111.75 mg/100g DW to 106.85 mg/100g DW. It was found that there was a 4.38% loss (Table 1).

Rehydration Rate

In Table 1, RR constant was 5.96 ± 0.25 kg absorbed water/kg DM for dried red pepper. According to the literatures, lower RR values were calculated for oven-dried peppers (El-Hamzy and Ashour, 2016). By Kaymak-Ertekin (2002), the lower RR values were explained with cellular structure damage resulting in modifications of osmotic properties of the cell as well as lower diffusion of water through the surface during rehydration. Moreover, pretreatments before drying with solutions, blanching etc. retained greater RR value (El-Hamzy and Ashour, 2016; Lewicki, 2006; Papageorge et al., 2003).

Total Polyphenol Content (TPC), Total Flavonoid (TFC) and Antioxidant Activity

Red pepper (*Capsicum annuum* L.) is a good source of phenolic compounds, and flavonoids which are antioxidant components, as well as has vitamins A and C contents. Antioxidants naturally present in vegetables and fruits are powerful substances and can play an important role in neutralizing and absorbing free radicals which cause damage the body cells (Raybaudi-Massilia et al., 2017; Borra *et al*., 2013). Phenolic compounds in plant sources are extracted by different solvents. The polarity of solvents has an important role in increasing the solubility of phenolic compounds (Haminiuk et al., 2014). Water, methanol and ethanol are some of the most commonly preferred solvents for the extraction of bioactive compounds (Shelembe et al., 2012; Gomes and Torres, 2016).

Table 2. TPC, TFC, DPPH Radical Scavenging Activity (IC_{50}), and Ferric Reducing Power Values of Extracts from Red Pepper (*Capsicum annuum* L.).

Extracts	**TPC mg GAE/ g 100dw**	**TFC mg QE/ g 100dw**	**DPPH IC_{50} µg /mL**	**Reducing power EC_{50} µg /mL**
Water extract	178.1±0.05[a]	78.2±0.01 [a]	215.3±0.07[b]	170.5±0.11[a]
Methanol extract	118.3±0.01[c]	67.2±0.05 [a]	295.6±0.08[a]	190.3±0.7 [a]
Ethanol extract	171.2±0.03[b]	82.3±0.02 [a]	205.4±0.01[b]	180.5±0.9 [a]

*IC_{50} and EC_{50} expressed as the weight in µg of dw that gave 50% inhibition. Values are mean ±SD (n=3). Different letter within the same column show differences of means among the extracts obtained with different solvents ($P < 0.05$).

In this study, to investigate the effect of solvent type on the extraction of the phenolic compounds, 3 solvents (ethanol, methanol, water) were selected. Table 2 shows the TPC, TFC, and antioxidant activities of the extracts obtained with these solvents. All extracts were found to have significant total phenolic contents and there were significant differences TPC in extracts obtained with different solvents ($P < 0.05$). The water extract exhibited the highest TPC (178.1 mg GAE/ 100g dw). It was followed by ethanol and methanol in decreasing order. Zaki et al. (2013) reported that TPC values in methanol (80%) extracts ranged from 675 and 1360 mg GAE/100g dw according to the period of production of paprika (*Capsicum annuum* L.). The variability in the phenolic contents noted may also be due to the method of extraction or the solvent used.

In the study, the highest TFC was achieved with ethanol (82.1 mg QE/100g dw). Corresponding values for water and methanol were 78.2 and 67.2 mg QE/100g dw, respectively. Previous study reported that the TFC values of extract from *Capsicum annuum* L. averaged from 121 to 130 mg QE/100 dw (Zaki et al., 2013). Interestingly, the study found that ethanol was better than other studied ones as a solvent for extraction of flavonoids. Similar results were reported in other studies (Lou et al., 2014; Sopee et. al., 2019). It is known ethanol has lower polarity than water. Some flavonoids, such as O-methylated flavonoids in plants, are considered less polar compounds than non-methylated flavonoids (Sopee et. al., 2019). However, the flavonoid concentrations of the three extracts were close, although the TFC in the ethanol extract was higher ($P > 0.05$). The results may be explained that red pepper contains a different group of flavonoids soluble in different polarities.

Antioxidant activity is an important parameter to establish the antioxidant capacity of fruits and vegetable and it has been tested using different methods (Zaki et al., 2013). In this study, the antioxidant capacity of all tested extracts was evaluated with reducing power and DPPH assays. The antiradical activity of flavonoids and phenolic compounds is mainly based on the redox properties of their hydroxy groups and the structural relationships (Raybaudi-Massilia et al., 2017). In the present study, all extracts were able to reduce the free radical DPPH. DPPH radical scavenging activities of water and ethanol extracts (205.4 and 215.3 µg/mL, respectively) were found to be significantly better than methanol extract (295.6 µg/mL) ($P < 0.05$) (Table 1). In another study, the DPPH IC_{50} of extract from Moroccan

paprika, ranged from 260 to 425 µg/mL (Zaki et al., 2013). Also, Kim et al. (2011) and Tundis et al. (2012) reported 150.40 µg/mL and 85.3 µg/mL of DPPH IC_{50} values of extracts from *Capsicum annuum* L. var. special and *Capsicum annuum* var. acuminatum, respectively. The findings obtained in our study are consistent with these results and confirmed to have good antioxidant capacity of red pepper.

A correlation analysis was carried out on TPC and TFC in extracts. The correlation between TPC and TFC was found to be 0.713 which was highly significant at the 0.05 level. The result shows that flavonoids are the dominating phenolic group in extracts of sweet pepper (*Capsicum annuum* L.). Similar results were reported by several studies (Alothman et al., 2009; Do et al., 2014).

The correlation between phenolic compounds and antioxidant activity was supported by many studies (Zaki et al., 2013; Fidrianny et al., 2015; Krishnappa et al., 2017). In this study, Pearson's correlation coefficient indicated that TPC correlated to DPPH radical scavenging activity and reducing power capacity (r =-0.958 and -0.676, respectively) (Table 3).

Table 3. Correlation between total phenolics and antioxidant capacities of extracts from sweet pepper.

	TPC	TFC	DPPH	Reducing power
TPC	1	0.713*	-0.958**	-0.676*
TFC	0.713*	1	-0.821**	-0.292
DPPH	-0.958**	-0.821**	1	0.536
Reducing power	-0.676*	-0.292	0.536	1

*Correlation was significant at P < 0.05

**Correlation was significant at P < 0.01

Total flavonoid contents in extracts have a good correlation with DPPH radical scavenging activity (r=-0.821), but there is not any correlation with reducing power (r=-0.292). Belhadj et al. (2016) found that there is no correlation between reducing power and polyphenols contents for peach extracts. They suggested that the antioxidant activity of extracts is not dependent only on phenolic compounds content and the reducing power of extracts may be related to content of vitamin C in the extract.

Conclusion

In conclusion, physico-chemical properties, rehydration ability, color parameters, carotenoid content, total phenolic content, total flavonoid content and antioxidant activity affect the final quality of dried red pepper. Chromatic parameters (L*, a*, b*, ΔE*, ΔC* and hue angle), extractable color (ASTA) and Non-Enzymatic Browning index (NEB) contributed to figure out the extent of the discoloring of the original red pepper color during the drying process. In addition, these values provided information about both the dried product quality and the browning level.

Considering the phenolic contents and antioxidant activities of red pepper extracts, water extract had the highest TPC, while water and ethanol extracts showed the best DPPH radical scavenging activity. However, there was no significant differences between TFC values and the reducing power activities of extracts. The results imply that extractions of antioxidant compounds are not dependent only on the polarity of solvents and it may be related with other seconder metabolites such as vitamin C in extracts. The study confirms that red pepper is a good source of a mixture of phenolic compounds, has antioxidant activity and it has potential health benefit.

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REFERENCES

Addala, R., Vasavada, M., Dong, J., Subramanian, S. (2015). Effect of Storage Conditions on Rate of Color Degradation of Paprika based Products. J Food Process Technol, 6 (3), 2-6.

Alothman, M., Bhat, R., Karim, A. A. (2009). Antioxidant capacity and phenolic content of selected tropical fruits from Malaysia, extracted with different solvents. Food Chemistry, 115(3), 785-788.

Anoraga, S. B., Sabarisman, I., Ainuri, M. (2018). Effect of different pretreatments on dried chilli (*Capsicum annum L.)* quality. International Conference on Green Agro-industry and Bioeconomy Conf. Series: Earth and Environmental Science, doi:10.1088/1755-1315/131/1/012014.

ASTA. (1985). Official Analytical Methods of the American Spice Trade As- sociation, 68 p. Englewood Cliffs, NJ.

AOAC (2000). Association of Official Analytical Chemists Official Methods of Analysis. Washington, DC, USA.

Belhadj, F., Somrani, I., Aissaoui, N., Messaoud, C., Boussaid, M., & Marzouki, M. N. (2016). Bioactive compounds contents, antioxidant and antimicrobial activities during ripening of Prunus persica L. varieties from the North West of Tunisia. Food chemistry, 204, 29-36.

Borra, S. K., Gurumurthy, P., Mahendra, J. (2013). Antioxidant and free radical scavenging activity of curcumin determined by using different in vitro and ex vivo models. J. Med. Plants Res., 7(36), 2680-2690.

Cao, Z., Zhou, L., Bi, J., Yi, J., Chen, Q., Wu, X., Zheng, J., Li, S. (2016). Effect of different drying technologieson drying characteristics and quality of red pepper (*Capsicum frutescens L.*): a comparative study. Journal of the Science of Food and Agriculture, 96, 3596-3603.

Carbonell, J. V., Pinaga, F., Yusa, V., and Pen˜ a, J. L. (1986). The dehydration of paprika with ambient and heated air and the kinetics of colour degra- dation during storage. J. Food Eng. 5, 179–193.

Chen, Q., Koh, H. K., Park, J. B. (1999). Color evaluation of Red Pepper Powder. Transactions of the ASAE, 42(3), 749-752 .

Demiray, E., Tulek, Y. (2020). Color and Ascorbic Acid Degradation Kinetics of Red Pepper (*Capsicum annuum L.*) Slices during Vacuum Drying. Akademik Gıda, 18(1), 19-26. DOI: 10.24323/akademik-gida.730013

Do, Q. D., Angkawijaya, A. E., Tran-Nguyen, P. L., Huynh, L. H., Soetaredjo, F. E., Ismadji, S., & Ju, Y. H. (2014). Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica. Journal of food and drug analysis, 22(3), 296-302.

Doymaz, I., Pala, M. (2002). Hot-air drying characteristics of red pepper. J. Food Eng, 55(4), 331- 335.

El-Hamzy, M. A., Ashour, M. S. (2016). Effect of Different Drying Methods and Storage on Physico-chemical Properties, Capsaicinoid Content, Rehydration Ability, Color Parameters and Bioactive Compounds of Dried Red Jalapeno Pepper (*Capsicum annuum*) Slices. Middle East Journal of Applied Sciences, 6, 4, 1012-1037.

Erdoğrul, Ö. T. (2000). Kahramanmaraş'ta Satılan Acı Kırmızı Pul Biberin Bazı Mikrobiyolojik Özellikleri. Fen ve Mühendislik Dergisi, 3, 2, 108-113.

Fidrianny, .I, Natalia, S., Insanu, M. (2015). Antioxidant capacities of various fruit extracts from three varieties of tomato and correlation with total phenolic, flavonoid, carotenoid content. International Journal of Pharmaceutical and Clinical Research, 7(4), 283-289.

Gomes, S., Torres, A. G. (2016). Optimized extraction of polyphenolic antioxidant compounds from Brazil nut (*Bertholletia excelsa*) cake and evaluation of the polyphenol profile by HPLC. Journal of the Science of Food and Agriculture, 96(8), 2805-2814.

Guclu, G., Keser, D., Kelebek, H., Keskin, M., Sekerli, Y.E., Soysal, Y., Selli, S. (2021). Impact of production and drying methods on the volatile and phenolic characteristics of fresh and powdered sweet red peppers. Food Chemistry, 338, 15, 128-129.

Haminiuk, C. W. I., Plata-Oviedo, M. S. V., Guedes, A. R., Stafussa, A. P., Bona, E.,Carpes, S. T. (2011). Chemical, antioxidant and antibacterial study ofBrazilian fruits. Int J Food Sci Technol, 46, 1529–1537.

Hirayama, O., Nakamura, K., Hamada, S., Kobayasi, Y. (1994). Singlet oxygen quenching ability of naturally occurring carotenoids. Lipids , 29, 149–150.

Hwang, I. M., Choi, J. Y., Nho, E. Y., Lee, G. H., Jamila, N., Khan, N., Jo, C. H., Kim, K. S., (2017). Characterization of Red Peppers (*Capsicum annuum*) by High-performance Liquid Chromatography and Near-infrared Spectroscopy. Analytical Letters, 50, 13, 2090-2104.

Osuna-Garcia, J.A., Wall, M.M., Waddell, C.A. (1997). Natural Antioxidants for Preventing Color Loss in Stored Paprika. Journal of Food Science, 62,5, 1017-1021.

Jeong, W. Y., Jin, J. S., Cho, Y. A., Lee, J. H., Park, S., Jeong, S. W., Kim, Y. H., Lim, C. S., El-Aty, A. M., Kim, G. S., Lee, S. J., Shim, J. H., Shin, S. C. (2011). Determination of polyphenols in three Capsicum annuum L. (bell pepper) varieties using high-performance liquid chromatography-tandem mass spectrometry: Their contribution to overall antioxidant and anticancer activity. Journal of Separation Science, 34, 21, 2967-2974.

Kaymak-Ertekin, F. (2002). Drying and rehydrating kinetics of green and red peppers. J. Food Sci., 67(1), 168-175.

Kim, J. S., Ahn, J., Lee, S. J., Moon, B. K., Ha, T. Y. & Kim, S. (2011). Phytochemicals and antioxidant activity of fruits and leaves of paprika (*Capsicum annuum* L., var. special) cultivated in Korea. Journal of Food Science, 76(2), 193–198.

Koç, A. B., Toy, M., Hayoğlu, İ., Vardin, H. (2004). Kırmızı Biber Kurutmada Kullanılan Güneş Enerjili bir Kurutucu Performansı. HR. Ü.Z.F.Dergisi, 8 (2), 57-65.

Krishnappa, N. P., Basha, S. A., Negi, P. S., Prasada Rao U. J. S. (2017). Phenolic acid composition, antioxidant and antimicrobial activities of green gram (*vigna radiata*) exudate, husk, and germinated seed of different stages. J Food Process Pres, 41(6), e13273. doi: 10.1111/jfpp.13273.

Lewicki, P. (2006). Design of hot air-drying for better foods. Trends in Food Sci. Technol., 17, 153- 163.

Lou, S. N., Hsu, Y. S., & Ho, C. T. (2014). Flavonoid compositions and antioxidant activity of calamondin extracts prepared using different solvents. Journal of food and drug analysis, 22(3), 290-295.

Mouratoglou, E., Malliou, V., Makris, D. P., 2016. Novel Glycerol-Based Natural Eutectic Mixtures and Their Efficiency in the Ultrasound-Assisted Extraction of Antioxidant Polyphenols from Agri-Food Waste Biomass. Waste Biomass Valor, 6(7), 1377–1387.

Osuna-Garcia, J. A., Wall, M. M. (1998). Pre-storage moisture content affects color loss of ground paprika (*Capsicum annuum L.*) under storage. Journal of food quality, 21, 251-259.

Osuna-Garcia, J. A., Wall, M. M., Waddell, C. A. (1997) Natural antioxidants for preventing color loss in stored Paprika. Journal of Food Science, 62, 1017- 1021.

Oyaizu, M. (1986). Studies on products of browning reaction: Antioxidative activities of products of browning reaction prepared from glucosamine Japanese Journal of Nutrition, 44, 307-315.

Papageorge, L. M., McFeeters, R. F., Fleming, H. P. (2003). Factors influencing texture retention of salt-free, acidified, red bell peppers during storage. J. Agric. Food Chem., 51(5), 1460-1463.

Raybaudi-Massilia, R., Suárez, A. I., Arvelo, F., Zambrano, A., Sojo, F., Calderón-Gabaldón, M. I., & Mosqueda-Melgar, J. (2017). Cytotoxic, antioxidant and antimicrobial properties of red sweet pepper (*Capsicum annuum* L. Var. Llanerón) extracts: in vitro study. International Journal of Food Studies, 6(2), 222–231.

Sánchez-Moreno, C., Plaza, L., de Ancos, B., Cano, M. P. (2003). Quantitative bioactive compounds assessment and their relative contribution to the antioxidant capacity of commercial orange juices. J. Sci. Food Agric., 83, 430–439.

Sayin, K., Arslan, D. (2015). Antioxidant Properties, Ascorbic Acid and Total Carotenoid Values of Sweet and Hot Red Pepper Paste: A Traditional Food in Turkish Diet. World Academy of Science, Engineering and Technology International Journal of Nutrition and Food Engineering, 9 (7), 834-837.

Shelembe, J., Bester, M. J., Minaar, A. (2012). Characterization of phenolic acids, flavonoids, proanthocyanidins and antioxidant activity of water extracts from seed coats of marama bean [*Tylosema esculentum*] - An underutilized food legume. International Journal of Food Science & Technology, 47(3), 648-655.

Simal, S., Garau, C., Femenia, A., Rossello, C., Sopee, M. S. M., Azlan, A., Khoo, H. E. (2019). Comparison of antioxidants content and activity of Nephelium mutabile rind extracted using ethanol and water. Journal of Food Measurement and Characterization, 13(3), 1958-1963.

Singh, S., Bawa, A.S., Riar, C. S., Saxena, D. C. (2006). Effect of Pretreatments on Drying and Rehydration Kinetics and Color of Sweet Potato Slices. Drying Technology 24(11), 1487-1494.

Srinivasan, K., (2016). Biological Activities of Red Pepper (*Capsicum annuum*) and Its Pungent Principle Capsaicin: A Review. Critical Reviews in Food Science and Nutrition 56(9), 1488-1500.

Tripathi, S., Mishra, H. N. (2009). Nutritional Changes in Powdered Red Pepper Upon in vitro Infection of Aspergillus Flavus. Brazilian Journal of Microbiology, 40, 139-144.

Tunde-Akintunde, T. Y. (2010). Effect of pretreatment on drying time and quality of Chilli Pepper. Journal of Food Processing and Preservation, 34, 595-608.

Wang, J., Yang, X. H., Mujumdar, A. S., Wang, D., Zhao, J. H., Fang, X. M., Zhang, Q., Xie, L., Gao, Z. J., Xiao, H. W. (2017). Effects of Various Blanching Methods on Weight Loss, Enzymes Inactivation, Phytochemical Contents, Antioxidant Capacity, Ultrastructure and Drying Kinetics of Red Bell Pepper (*Capsicum annuum*, L.). LWT - Food Sci. Technol., 77, 337–347.

Wang, J., Yang, X.H., Mujumdar, A. S., Fang, X. M., Zhang, Q., Zheng, Z. A., Gao, Z. J., Xiaoa, H. W. (2018). Effects of high-humidity hot air impingement blanching (HHAIB) pretreatment on the change of antioxidant capacity, the degradation kinetics of red pigment, ascorbic acid in dehydrated red peppers during storage. Food Chemistry, 259, 1, 65-72.

Vega-Gálvez, A., R. Lemus-Mondaca, Bilbao-Sáinz, C., .Fito, P., Andrés, A. (2008). Effect of drying temperature on the quality of rehydrated dried red bell pepper (var. Lamuyo). J. Food Eng., 85, 42-50.

Zaki, N., Hakmaoui, A., Ouatmane, A., Hasib, A., Fernández-Trujillo, J. P. (2013). Bioactive components and antioxidant activity of Moroccan Paprika (Capsicum annuum L.) at different period of harvesting and processing. Journal of Biology, Agriculture and Healthcare, 3(8), 1-8.