Iran Journal of Food Sciences and Industries, No. 146, Volume 21, April 2024

Journal of Food Science and Technology (Iran)

Homepage: www.fsct.modares.ir

Scientific Research

Effect of storage conditions on color and weight of dried Iranian seedless barberry packaged in three types of packaging films

K Novini Bianlojeh[1] and M Esmaiili[2*], Iraj Bernosi

1-Graduated Master of Food Science and Technology of Urmia University.

2-Professor and faculty member of Department of Food Science and Technology, Faculty of Agriculture, Urmia University.

ARTICLE INFO

Article History:

Received:2019/9/15

Accepted: 2023/11/14

Keywords:

color,
seedless barberry,
storage conditions,
packaging films

DOI: 10.22034/FSCT.21.146.1

*Corresponding Author E-Mail:
m.esmaiili@urmia.ac.ir

ABSTRACT

The aim of this study was to evaluate the effect of storage conditions “relative humidity”, “temperature” and “light”, each one at two levels (high and low), on the weight and color of dried seedless barberry after 120 days' storage. The effect of conditions was statistically analyzed in a completely randomized design experiment based on factorial. After adjusting the moisture content barberry color were measured for both samples. The samples in weights of 100g in the bags made of low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene cast (CPP) were packaged and coded. Then samples were placed in a given storage conditions. Based on the results, all the hue angle and a/b ratio have not changed in all the packaging samples of films in the condition of “high relative humidity, low temperature and darkness” and “high relative humidity, low temperature and brightness” after 120 days of storage. The lowest difference in weight was observed in both samples packaged in bags of LDPE and HDPE films, at the same conditions. Also, in all the packaging samples at the “high relative humidity × low temperature” state, the lowest hue angle, lowest chroma and highest a/b ratio were observed, whilst at the similar state, the lowest difference in weight in samples packaged in polypropylene cast film bags was observed.

1. Introduction

All over the world, the different types of barberries are known for their many benefits, for example medicinal, ornamental and food uses. For producing the fruit, Iranian seedless barberry (*B. vulgaris var. Asperma* or *Berberis integerrima* 'Bidaneh') is cultivated in Iran, especially in South Khorasan province [1]. Due to their high anthocyanin and phenolic content, barberry fruits are a good source of biologically active phytochemicals [2]. Anthocyanins (from Ancient Greek ánthos meaning 'flower', and kuanoûs meaning 'dark blue') as water-soluble colors are the most important pigments of vacuolar plants. These pigments are responsible for the bright orange, pink, red, purple and blue colors in the flowers and some fruits, and with having antioxidant activity higher than vitamin C and E, they play a vital role in preventing neurological, cardiovascular, cancer and diabetic diseases [3]. Color plays a very chief role in food acceptance. Consumers first judge the quality of a food product by its color, and color has used for centuries to improve or restore the original appearance of foods and or to ensure uniformity of food quality in the food industry [4]. Because color is, in addition to nutrition, taste, and consistency, one of the most important qualitative parameters properties of foods, the quality and quantity of food dyes must be controlled [5]. The stability of anthocyanins in fruits, vegetables and their products during preparation, processing and storage is affected by pH, temperature, light, oxygen, metal ions, enzymes and sugars [6]. The bright red color of fresh barberry gradually turns into dark red through the loss of water, and with the destruction and change of compounds in the pigments in barberry, especially anthocyanins, due to improper processing and storage conditions, it turns brown to dark brown. The change and alteration of pigments as well as improper packaging by reducing the appearance quality of barberry is one of the most important factors in the stagnation of the export of this product [7]. The application of the CIELAB colorimetric system is very valuable in measuring and characterizing the color properties of anthocyanins, and also the color value is related to the concentration of pigments and physicochemical properties of food [8].

In relation with the effect of temperature, Laleh et al. (2006) studied the effect of temperature on anthocyanin content in four barberry varieties (*B. integerima*, *B. vulgaris*, *B. khorasanica* & *orthobotrys*) at temperatures of 5, 15, 25 and 35 °C and reported that anthocyanin content decreases with increasing temperature of storage [9]. Sinela et al. (2017) showed that the storage temperature has a strong effect on the degradation of anthocyanins, so that after 60 days of storage at 37 °C, almost all the anthocyanins in the pasteurized aqueous extract of *Hibiscus sabdariffa* were destroyed [10]. It has been reported that changes in anthocyanin content and color parameters of pasteurized pomegranate juice packed in Tetra Packs at 4 °C were relatively less, but significant at 20 and 37 °C [11]. Wang et al. (2015) concluded that the color of strawberry juice kept at refrigerator temperature for a period of 60 days remained stable compared to the juice kept at room temperature (30±5 °C) and parameters a* and L* was maintained, while at room temperature the color of the juices gradually faded and the parameters a* and L* values decreased by 34.88 and 14.28%, respectively [12]. Ochoa et al. (1999) showed that the highest color stability and the best visual appearance of pasteurized raspberry pulp concentrate were at 4°C and anthocyanins disappeared at 37°C after 50 days of storage [13]. Bakhshayeshi et al. (2006) observed that anthocyanin pigments extracted from 4 varieties of Malus fruit at pH 2 and temperature of 25 °C

[DOI: 10.22034/FSCT.21.146.1]

decreased more in the storage period in the presence of light [14].

The relative humidity of the location is a main factor for food stability due to the direction of moisture migration to reach equilibrium moisture in the food matrix [15]. Laverde et al. (2013) in examining the changes in color parameters and anthocyanin content in freeze-dried strawberry slices kept at relative humidity of 11, 43 and 75% for 120 hours at 45°C, concluded that with increasing relative humidity, Hue angle and anthocyanin degradation increased and *a value decreased, so that at 75% relative humidity, the lowest *a value and total anthocyanin degradation were observed [15]. Laverde et al. (2013) In examining changes in color and anthocyanin content parameters in dried strawberry slices, kept in relative humidity 11, 43 and 75 % for 120 hours at 45 °C, concluded that with increased relative humidity, Hue angle and anthocyanin destruction increased and a* value decreased, with relative humidity being 75 %, lowest a* value and destruction of anthocyanin were observed [16]. Laverde et al. (2011) observed that the rate of browning in dried pear and melon slices is a function of relative humidity. The highest speed occurred in the relative humidity where the water behaves as a solvent, and in low relative humidity, depending on the monolayer, the rate of browning is relatively low [17]. In the storage of dried powder from Bayberry juice in relative humidity 11 to 44 %, the highest relative humidity resulted in the highest loss in anthocyanin content. At a_w 0.44 at 40 ° C, 94 % of anthocyanins decreased after six months of storage [18].

Based on the review of literature, there is not enough information on the simultaneous effect of storage conditions (relative humidity, temperature and light) on the quality attributes of barberry, including color and weight changes. Therefore, the aim of this study was to evaluate the effect of storage conditions on the color and weight losses of dried Iranian seedless barberry packed in packaging films during 120 days of storage period.

2-Materials and Methods

Initial material

Dried barberry (puffy type) was purchased from Birjand city. For packaging the samples, three types films including low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene cast (CPP) from Kermanshah Tavan Sanat Company were purchased. The thickness of the films was determined by the Mitutoyo micrometer (Model CD-15CPX) Japan, resulting the thickness of the LDPE film 0.093±0.001, HDPE 0.074±0.002 and the CPP 0.097±0.002 mm. The sealing of the pouches was done with the thermal sealing machine (Power press - Iran). In order to create a given environmental condition, eight polypropylene containers (Türkiye) with dimensions 27x29x39 cm were prepared and colorless glass containers were used to store the control sample. Anhydrous sodium chloride salts with a purity of 99.5% and anhydrous calcium chloride with a purity of more than 90% from Merck, Germany were used to adjust high and low relative humidities in polypropylene containers, respectively. The treatments were carried out at two temperature levels, the ambient temperature was 25±2 °C as high temperature and 7±1 °C as low temperature (in Arg Yazd industrial refrigerator, Iran). Thick aluminum foils were used to make darkness condition, and German Parafilm was used to seal the containers.

Adjusting the moisture content, water activity (a_w) and relative humidity (RH)

The initial wet basis moisture content of barberries was set between 16-20 percent [1-19]. The

[DOI: 10.22034/FSCT.21.146.1]

moisture content of the purchased barberry was 19.19±0.15% (equivalent to a_w 0.54±0.01 at a temperature of 25±2 °C), which was placed in large glass plates in the oven (Memmert, Germany) at a temperature of 45±2 °C for 45 minutes in order to adjust the moisture content 16.47±0.15% (equivalent to a_w 0.40±0.01 at a temperature of 25±2 °C). Using the following formulas and according to data in Table 1, saturated solution of sodium chloride salt was used to provide high relative humidity and saturated solution of calcium chloride salt was used for low relative humidity [20]. The barberry sample with high moisture content was placed in the condition of high relative humidity and the barberry sample with low moisture value was placed in the condition of low relative humidity.

$$Ln\ aw = {}^{228.92}/_{T} - 1.04 \quad \text{NaCl} \quad (1)$$

$$Ln\ aw = {}^{893.03}/_{T} - 4.149 \quad CaCl_2 \quad (2)$$

where T is absolute temperature (K).

Table 1 Percentage of relative humidity created

Saturation solution	7±1℃	25±2℃
NaCl	80.01±0.23	76.16±0.39
$CaCl_2$	38.23±0.44	31.54±0.63

Measurement of moisture content and water activity

The moisture content of the samples was measured with a Kern & Sohn Moisture Analyzer. Water activity was determined with NOVASINA ms1 Water Activity Meter.

Determination of the difference in weight and sample packaging

AND precision balance (model HS-300S) with accuracy of ± 0.001 was used to weigh the samples. Then, 100 grams of barberry were poured into each film pouches and glass container, and the opening of the pouches was double-sealed with a thermal sealing machine. After 120 days of storage, the weight difference of the samples was calculated as a percentage of the initial weight difference.

Evaluation of color parameters

Changes in the color of the samples were determined using CIELAB parameters by a Minolta colorimeter (Minolta-CR-400, Japan). First, the device was calibrated using a standard white plate. Using the parameters L (lightness), a* (redness) and b* (yellowness), indices Hue angle (h), Chroma (C*) and the total difference color (ΔE*) were calculated through equations 3, 4 and 5 [21-22]. The ratio of b*/a* was also determined [23].

$$h = arc\ tan\ \left(\frac{b}{a}\right) \quad (3)$$

$$C^* = \sqrt{a^2 + b^2} \quad (4)$$

$$\Delta E^* = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2} \quad (5)$$

Statistical analysis of the results

The results of this research were statistically analyzed based on the statistical design of the factorial method on a completely random basis in two repetitions to evaluate the weight difference percentage and in 12 repetitions to evaluate the color parameters. Means were compared using Duncan's test at the 95% level.

3- Results and discussion

Evaluation of weight difference percentage

Based on the results, a significant difference was observed in the effect of "relative humidity × temperature × lightness" (Table 2) on the weight difference percentage of the samples packed in both types of polyethylene film with low and high

[DOI: 10.22034/FSCT.21.146.1]

density (p<0.05). The greatest weight difference (negative) in the conditions of "low relative humidity × high temperature × lightness", in the samples packed in HDPE film, and in LDPE film in the same conditions and also in the darkness was observed. The lowest weight difference (positive) was observed in both films in the conditions of "high relative humidity × low temperature × darkness" and in the same conditions of illumination. No significant difference was observed between the samples packed in CPP film and the control sample under the same conditions (p < 0.05).

There was no significant difference between the control sample and the sample packaged in CPP film in the combined effect of "temperature × lightness" and "relative humidity × lightness" (p > 0.05) (Table 3). While the effect of "relative humidity × temperature" had a significant difference on both samples (p<0.05). In the sample packed in CPP film, the highest weight difference (negative) was observed in "low relative humidity × high temperature" and the lowest weight difference (positive) was observed in "high relative humidity × low temperature". While in the control sample, the highest weight difference (positive) was observed in "high relative humidity × high temperature" and the lowest weight difference (negative) was observed in "low relative humidity × low temperature".

Table 2 Investigating the effect of “Relative humidity×temperature×light” on percentage weight difference of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	-0.186 ± 0.004^{f}	-0.166 ± 0.018^{c}	-0.112 ± 0.019^{ns}	-2.214 ± 0.036^{ns}
L(RH)×L(T)×Light	-0.229 ± 0.004^{e}	-0.115 ± 0.003^{d}	-0.125 ± 0.009^{ns}	-2.484 ± 0.099^{ns}
L(RH)×H(T)×Dark	-0.572 ± 0.014^{b}	-0.541 ± 0.000^{a}	-0.319 ± 0.012^{ns}	-3.158 ± 0.060^{ns}
L(RH)×H(T)×Light	-0.667 ± 0.001^{a}	-0.573 ± 0.016^{a}	-0.364 ± 0.042^{ns}	-3.260 ± 0.097^{ns}
H(RH)×L(T)×Dark	$+0.083\pm0.017^{g}$	$+0.055\pm0.005^{e}$	$+0.003\pm0.00^{ns}$	$+6.508\pm0.445^{ns}$
H(RH)×L(T)×Light	$+0.077\pm0.009^{g}$	$+0.034\pm0.000^{e}$	$+0.013\pm0.00^{ns}$	$+6.663\pm0.456^{ns}$
H(RH)×H(T)×Dark	$+0.462\pm0.021^{d}$	$+0.380\pm0.021^{b}$	$+0.131\pm0.005^{ns}$	$+8.258\pm0.401^{ns}$
H(RH)×H(T)×Light	$+0.558\pm0.004^{c}$	$+0.390\pm0.002^{b}$	$+0.167\pm0.030^{ns}$	$+9.513\pm0.301^{ns}$

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

In general, comparing the average weight differences of the control sample and the samples wrapped in films, the highest percentage of weight differences was observed in the control sample and the lowest percentage in the CPP film. Also, according to the significant effect of the interactions in (Tables 2 and 3), the greatest effect of these interactions in films is due to the effect of the main factors, namely "low relative humidity" and "high temperature" in creating the largest weight difference and "high relatively humidity" and "low temperature" were attributed to create the lowest weight difference and in the control sample, the largest weight difference was observed in the effect of "high relative humidity" and the lowest weight difference was observed in "low relative humidity". No significant difference was observed in the effect of light (p<0.05).

The results of the difference in weight with the findings of Castellanos et al. (2016) in the investigation of the weight loss of feijoa fruits packed in cast polypropylene film in Equilibrium Modified Atmosphere Packaging conditions with

[DOI: 10.22034/FSCT.21.146.1]

relative humidity of 85% and without packaging, kept for 14 days at 17°C, were consistent, so that the weight loss in unpacked samples was significantly high, which can be attributed to the greater difference in partial pressure of water in unpacked fruits and the storage compartment (68% relative humidity). Also, temperature had the greatest effect on fruit weight loss, because weight loss at 17°C was greater than at 6 and 12°C [24]. Tu et al. (2000) in investigating the effect of relative humidity of 30, 65 and 95% on apples stored at 20°C, reported the highest rate of weight loss at 30% relative humidity [25].

Table 3 Investigating the effects of "Relative humidity, temperature and light" and interaction effects "Relative humidity × temperature", "temperature× light" and "Relative humidity× light" on percentage weight difference of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)	-0.413±0.079^{a}	-0.349±0.079^{a}	-0.230±0.044^{a}	-2.779±0.170^{b}
H(RH)	+0.295±0.082^{b}	+0.215±0.065^{b}	+0.079±0.028^{b}	+7.735±0.491^{a}
L(T)	0.144±0.025^{b}	0.092±0.020^{b}	0.063±0.021^{b}	4.467±0.811^{ns}
H(T)	0.564±0.028^{a}	0.417±0.033^{a}	0.245±0.038^{a}	6.047±1.090^{ns}
Dark	0.326±0.075^{ns}	0.285±0.071^{ns}	0.141±0.043^{ns}	5.034±0.934^{ns}
Light	0.382±0.090^{ns}	0.278±0.081^{ns}	0.167±0.049^{ns}	5.480±1.067^{ns}
L(RH)× L(T)	-0.207±0.012^{c}	-0.140±0.016^{c}	-0.118±0.009^{c}	-2.349±0.089^{d}
L(RH)× H(T)	-0.619±0.028^{a}	-0.557±0.011^{a}	-0.341±0.022^{a}	-3.209±0.055^{c}
H(RH)× L(T)	+0.080±0.008^{d}	+0.044±0.006^{d}	+0.008±0.003^{d}	+6.585±0.264^{b}
H(RH)× H(T)	+0.510±0.029^{b}	+0.385±0.009^{b}	+0.149±0.016^{b}	+8.885±0.416^{a}
L(T)×Dark	0.134±0.031^{ns}	0.110±0.033^{ns}	0.058±0.032^{ns}	4.361±1.253^{ns}
L(T)× Light	0.153±0.044^{ns}	0.075±0.023^{ns}	0.069±0.032^{ns}	4.573±1.221^{ns}
H(T)×Dark	0.517±0.033^{ns}	0.460±0.047^{ns}	0.225±0.055^{ns}	5.708±1.482^{ns}
H(T)×Light	0.612±0.031^{ns}	0.481±0.053^{ns}	0.265±0.060^{ns}	6.386±1.810^{ns}
L(RH)×Dark	-0.379±0.112^{a}	-0.353±0.109^{ns}	-0.216±0.060^{ns}	-2.686±0.274^{ns}
L(RH)×Light	-0.448±0.126^{a}	-0.344±0.132^{ns}	-0.244±0.071^{ns}	-2.872±0.231^{ns}
H(RH)×Dark	+0.272±0.110^{b}	+0.217±0.094^{ns}	+0.067±0.037^{ns}	+7.383±0.561^{ns}
H(RH)×Light	+0.317±0.139^{b}	+0.212±0.103^{ns}	+0.090±0.046^{ns}	+8.088±0.852^{ns}

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

Evaluation of color parameters

Hue angle

Based on the results of the interaction of "relative humidity × temperature × light" on the Hue angle parameter in the control sample, a significant difference was observed (p<0.05) (Table 4). The lowest Hue angle was observed in the conditions of "high relative humidity × low temperature × darkness" and "high relative humidity × low temperature × lightness". At high storage

[DOI: 10.22034/FSCT.21.146.1]

temperature, in both low and high relative humidity, both in the light and in the dark, the highest Hue angle was observed. Contrary to expectation, the Hue angle increased in "low relative humidity × low temperature × darkness" condition.

Table 4 Investigating the effect of "Relative humidity × temperature × light" condition on hue angle of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	25.17±0.78 ns	24.03±0.79 ns	23.10±0.90 ns	26.46±0.59 a
L(RH)×L(T)×Light	25.00±0.70 ns	24.25±0.65 ns	23.45±0.74 ns	23.56± 0.69 b
L(RH)×H(T)×Dark	27.26±0.97 ns	26.93± 0.70 ns	28.30± 0.77 ns	26.32±0.66 a
L(RH)×H(T)×Light	28.25±1.25 ns	27.87± 1.10 ns	28.40± 0.75 ns	28.33±0.97 a
H(RH)×L(T)×Dark	19.48±0.87 ns	18.74± 0.38 ns	18.43± 0.31 ns	18.32 ± 0.35 c
H(RH)×L(T)×Light	18.90±0.69 ns	17.46± 0.75 ns	19.32± 0.64 ns	20.01± 0.67 c
H(RH)×H(T)×Dark	26.72±1.07 ns	26.50± 0.86 ns	28.55± 1.23 ns	26.21± 1.031 a
H(RH)×H(T)×Light	28.91±0.75 ns	29.46± 0.91 ns	27.78± 1.00 ns	26.82± 0.75 a

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

As can be seen in Table 5, in the samples packed in LDPE film, the interaction effect of "temperature x light" on the Hue angle showed a significant difference (p<0.05), so that the lowest angle Hue was observed at low temperature both in the dark and in light, and at high temperature in both dark and light environment, the highest angle of Hue was observed in the stored samples. In the rest of the samples, no significant difference was observed in the Hue angle in the same conditions (p>0.05). The interaction effect of "relative humidity x temperature" on Hue angle in packaged samples showed a significant difference (p<0.05). The lowest Hue angle was observed in "high relative humidity × low temperature" and the highest Hue angle was observed in high temperature in both low and high relative humidities. In the examination of all samples, the destructive effect on red color (higher hue angle) was attributed to the effect of "low relative humidity" and "high temperature", therefore "high relative humidity" in "low temperature" led to the lowest hue angle. "Light" did not show a significant effect on Hue angle (p>0.05). Crecente-Campo et al. (2012) observed that the surface color of organic strawberries tending to red, has a lower Hue angle [23]. As the value of Hue angle approaches zero, the color of the sample will be redder.

Chroma

In the effect of "relative humidity × temperature × lightness" on the chroma of the samples (Table 6), no significant difference was observed (p > 0.05), while "relative humidity × temperature" showed a significant effect on all samples (p<0.05) (Table 7). The lowest chroma was observed in "high relative humidity × low temperature" and the highest chroma was observed in "low relative humidity × low temperature" condition. At high temperature, no significant changes in chroma were observed in any of low and high relative humidity (p<0.05). The interaction effect of "relative humidity × light" in the sample packed in LDPE film caused significant changes in chroma (p<0.05), so that in low relative humidity both in the dark and in the light, the highest chroma, and at high relative humidity both in the dark and in the light, the lowest chroma was observed. In the rest of the samples, the interaction of "relative humidity x light" and "temperature x light" did not create a significant difference in chroma ($p<0.05$). According to Table 7, in all samples, the highest chroma was observed in "low relative humidity" and the lowest chroma in "high relative humidity".

Table 5 Investigating the effects of “Relative humidity, temperature and light” and intraction effects “Relative humidity×temperature”, “temperature× light” and “Relative humidity× light” on hue angle of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)	26.42±0.50[a]	25.77±0.47[a]	25.81±0.53[a]	26.17±0.44[a]
H(RH)	23.50±0.76[b]	23.04±0.82[b]	23.52±0.80[b]	22.84±0.65[b]
L(T)	22.14±0.57[b]	21.12±0.55[b]	21.07±0.46[b]	22.09±0.54[b]
H(T)	27.79±0.51[a]	27.69±0.47[a]	28.26±0.46[a]	26.92±0.44[a]
Dark	24.66±0.64[ns]	24.05±0.59[ns]	24.59±0.74[ns]	24.33±0.61[ns]
Light	25.27±0.72[ns]	24.76±0.79[ns]	24.74±0.66[ns]	24.68±0.60[ns]
L(RH)× L(T)	25.09±0.51[b]	24.14±0.50[b]	23.27±0.57[b]	25.01±0.54[b]
L(RH)× H(T)	27.76±0.78[a]	27.40±0.65[a]	28.35±0.53[a]	27.33±0.61[a]
H(RH)× L(T)	19.19±0.55[c]	18.10±0.43[c]	18.87±0.36[c]	19.16±0.41[c]
H(RH)× H(T)	27.82±0.68[a]	27.98±0.69[a]	28.17±0.78[a]	26.52±0.63[ab]
L(T)×Dark	22.33±0.82[ns]	21.38±0.70[b]	20.76±0.67[ns]	22.39±0.91[ns]
L(T)× Light	21.95±0.80[ns]	20.86±0.86[b]	21.38±0.64[ns]	21.78±0.60[ns]
H(T)×Dark	26.99±0.71[ns]	26.72±0.54[a]	28.42±0.71[ns]	26.27±0.60[ns]
H(T)×Light	28.58±0.71[ns]	28.66±0.72[a]	28.09±0.61[ns]	27.57±0.62[ns]
L(RH)×Dark	26.22±0.65[ns]	25.48±0.60[ns]	25.70±0.79[ns]	26.39±0.43[ns]
L(RH)×Light	22.63±0.78[ns]	26.06±0.73[ns]	25.93±0.73[ns]	25.94±0.76[ns]
H(RH)×Dark	23.10±1.01[ns]	22.62±0.93[ns]	23.49±1.22[ns]	22.27±0.98[ns]
H(RH)×Light	23.91±1.16[ns]	23.46±1.38[ns]	23.55±1.06[ns]	23.41±0.86[ns]

Means followed by the same letter within a column are not significantly different ($p<0.05$). L: Low, H: High, T: Temperature, RH: Relative Humidity

Table 6 Investigating the effect of “Relative humidity × temperature × light” on chroma of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	20.42±1.18[ns]	20.79±0.58[ns]	0.97 [ns]± 19.79	[ns] 22.83±1.73
L(RH)×L(T)×Light	19.41±1.16[ns]	18.28±0.62[ns]	0.83 [ns]± 18.87	[ns] 20.33±0.82
L(RH)×H(T)×Dark	17.63±1.00[ns]	17.75±0.90[ns]	0.73 [ns]± 18.01	[ns] 0.38 ±16.74
L(RH)×H(T)×Light	17.87±1.49[ns]	17.23±0.72[ns]	0.55 [ns]± 17.74	[ns] 1.26 ±20.28
H(RH)×L(T)×Dark	11.89±0.76[ns]	11.56±0.77[ns]	0.64 [ns]± 13.32	[ns] 13.52±1.03
H(RH)×L(T)×Light	12.02±0.46[ns]	13.58±1.04[ns]	12.86±0.40[ns]	[ns] 12.78±0.76
H(RH)×H(T)×Dark	15.18±0.78[ns]	16.19±0.96[ns]	17.57±1.16[ns]	[ns] 16.62±0.44
H(RH)×H(T)×Light	16.73±1.34[ns]	16.89±1.20[ns]	0.64 [ns]± 15.58	[ns] 17.03±0.63

[DOI: 10.22034/FSCT.21.146.1]

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

Table 7 Investigating the effects of "Relative humidity, temperature and light" and interaction effect**s** "Relative humidity × temperature", "temperature× light" and "Relative humidity× light" on chroma of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)	18.84±0.61[a]	18.51±0.40[a]	18.60±0.40[a]	20.05±0.65[a]
H(RH)	13.95±0.53[b]	14.55±0.58[b]	14.83±0.46[b]	14.98±0.45[b]
L(T)	15.94±0.74[ns]	16.05±0.65[ns]	16.21±0.58[ns]	17.36±0.84[ns]
H(T)	16.85±0.59[ns]	17.01±0.47[ns]	17.23±0.41[ns]	17.67±0.43[ns]
Dark	16.28±0.65[ns]	16.57±0.63[ns]	17.17±0.56[ns]	17.43±0.71[ns]
Light	16.51±0.70[ns]	16.49±0.52[ns]	16.27±0.45[ns]	17.60±0.63[ns]
L(RH)× L(T)	19.92±0.82[a]	19.53±0.49[a]	19.33±0.63[a]	21.58±0.97[a]
L(RH)× H(T)	17.75±0.88[b]	17.49±0.57[b]	17.88±0.45[ab]	18.51±0.74[b]
H(RH)× L(T)	11.95±0.43[c]	12.57±0.67[c]	13.09±0.37[c]	13.15±0.63[c]
H(RH)× H(T)	15.95±0.78[b]	16.54±0.76[b]	16.58±0.68[b]	16.82±0.38[b]
L(T)×Dark	16.16±1.12[ns]	16.17±1.07[ns]	16.55±0.88[ns]	18.17±1.38[ns]
L(T)× Light	15.72±0.98[ns]	15.93±0.77[ns]	15.87±0.77[ns]	16.55±0.96[ns]
H(T)×Dark	16.41±0.67[ns]	16.97±0.67[ns]	17.79±0.67[ns]	16.68±0.28[ns]
H(T)×Light	17.30±0.99[ns]	17.06±0.69[ns]	16.66±0.47[ns]	18.65±0.77[ns]
L(RH)×Dark	19.03±0.81[ns]	19.27±0.61[a]	18.90±0.62[ns]	19.79±1.08[ns]
L(RH)×Light	18.64±0.94[ns]	17.75±0.48[a]	18.31±0.50[ns]	20.30±0.73[ns]
H(RH)×Dark	13.53±0.63[ns]	13.88±0.77[b]	15.44±0.79[ns]	15.07±0.64[ns]
H(RH)×Light	14.38±0.85[ns]	15.23±0.85[b]	14.22±0.47[ns]	14.90±0.65[ns]

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

a/b ratio

Based on the results, the effect of "relative humidity × temperature × light" on the a/b ratio of the control sample and the sample packed in LDPE film (Table 8) was significant (p<0.05). The highest a/b ratio was observed in the control sample at "high relative humidity × low temperature × darkness" and in the sample packed in LDPE film at the same illumination. The lowest a/b ratio was observed in the control sample and the sample packed in LDPE film, in high temperature, in high and low relative humidities in both light and dark conditions. Contrary to expectation, in "low relative humidity × low temperature × darkness" the lowest a/b ratio was observed in the control sample.

"Relative humidity × temperature" showed a significant effect on the a/b ratio (Table 9) in the samples packed in CPP film and HDPE (p<0.05). The highest a/b ratio was observed in the condition of "high relative humidity × low temperature" and the lowest ratio was observed at high temperature in both relative humidities.

[DOI: 10.22034/FSCT.21.146.1]

Table 8 Investigating the effect of “Relative humidity×temperature×light” on a/b ratio of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	2.15±0.07^{ns}	2.27±0.08^{c}	2.38±0.10^{ns}	2.02±0.05^{d}
L(RH)×L(T)×Light	2.17±0.07^{ns}	2.24±0.07^{c}	2.33±0.08^{ns}	2.32±0.08^{c}
L(RH)×H(T)×Dark	1.97±0.09^{ns}	1.98±0.06^{d}	1.87±0.06^{ns}	2.04±0.06^{d}
L(RH)×H(T)×Light	1.90±0.09^{ns}	1.93±0.09^{d}	1.86±0.06^{ns}	1.88±0.08^{d}
H(RH)×L(T)×Dark	2.89±0.13^{ns}	2.96±0.06^{b}	3.01±0.05^{ns}	3.03±0.06^{a}
H(RH)×L(T)×Light	2.97±0.11^{ns}	3.25±0.15^{a}	2.89±0.10^{ns}	2.78±0.10^{b}
H(RH)×H(T)×Dark	2.03±0.10^{ns}	2.03±0.07^{cd}	1.88±0.09^{ns}	2.07±0.10^{d}
H(RH)×H(T)×Light	1.83±0.06^{ns}	1.79±0.06^{d}	1.93±0.08^{ns}	2.00±0.06^{d}

Means followed by the same letter within a column are not significantly different ($p<0.05$). L: Low, H: High, T: Temperature, RH: Relative Humidity

Table 9 Investigating the effects of “Relative humidity, temperature and light” and intraction effects “Relative humidity×temperature”, “temperature× light” and “Relative humidity× light” on a/b ratio of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)	2.05±0.04^{b}	2.11±0.04^{b}	2.11±0.05^{b}	2.06±0.04^{b}
H(RH)	2.43±0.09^{a}	2.51±0.10^{a}	2.43±0.09^{a}	2.47±0.08^{a}
L(T)	2.54±0.07^{a}	2.68±0.08^{a}	2.65±0.06^{a}	2.54±0.07^{a}
H(T)	1.93±0.04^{b}	1.93±0.04^{b}	1.89±0.04^{b}	2.00±0.04^{b}
Dark	2.26±0.07^{ns}	2.31±0.07^{ns}	2.29±0.08^{ns}	2.29±0.07^{ns}
Light	2.21±0.08^{ns}	2.30±0.10^{ns}	2.25±0.07^{ns}	2.24±0.06^{ns}
L(RH)× L(T)	2.16±0.05^{b}	2.25±0.05^{b}	2.36±0.06^{b}	2.17±0.06^{b}
L(RH)× H(T)	1.94±0.06^{c}	1.96±0.05^{c}	1.87±0.04^{c}	1.96±0.05^{c}
H(RH)× L(T)	2.93±0.09^{a}	3.10±0.08^{a}	2.95±0.06^{a}	2.91±0.06^{a}
H(RH)× H(T)	1.93±0.06^{c}	1.91±0.05^{c}	1.90±0.06^{c}	2.03±0.06^{bc}
L(T)×Dark	2.52±0.11^{ns}	2.62±0.09^{a}	2.70±0.09^{ns}	2.53±0.11^{ns}
L(T)× Light	2.57±0.11^{ns}	2.74±0.13^{a}	2.61±0.09^{ns}	2.55±0.08^{ns}
H(T)×Dark	2.00±0.07^{ns}	2.01±0.05^{b}	1.88±0.05^{ns}	2.05±0.06^{ns}
H(T)×Light	1.86±0.05^{ns}	1.86±0.06^{b}	1.90±0.05^{ns}	1.94±0.05^{ns}
L(RH)×Dark	2.06±0.06^{ns}	2.13±0.06^{ns}	2.13±0.08^{ns}	2.03±0.04^{b}
L(RH)×Light	2.03±0.06^{ns}	2.08±0.07^{ns}	2.10±0.07^{ns}	2.10±0.07^{b}
H(RH)×Dark	2.46±0.12^{ns}	2.50±0.11^{ns}	2.44±0.13^{ns}	2.55±0.11^{a}
H(RH)×Light	2.40±0.13^{ns}	2.52±0.17^{ns}	2.41±0.12^{ns}	2.39±0.10^{a}

Means followed by the same letter within a column are not significantly different ($p<0.05$). L: Low, H: High, T: Temperature, RH: Relative Humidity

According to Table 9, in all samples, the highest a/b ratio (redder color) was observed under the influence of "high relative humidity" and "low temperature" and the lowest a/b ratio was observed under the influence of "low relative humidity" and "high temperature". No significant difference was observed in the effect of "light" ($p > 0.05$).

Total difference color

The effect of "relative humidity × temperature × light" on the total color difference of the packaged samples was not significant (p > 0.05) (Table 10). No clear trend was observed in the nonsignificant changes of the total color difference of the control sample with similar storage conditions. According to Table 11, the effect of "relative humidity × temperature" on the total difference color of control sample was significant, so the lowest total color difference of the control sample in high relative humidity at both high and low temperatures, and the largest total color difference in "low relative humidity × low temperature" was observed (p<0.05). No significant difference was observed in the effect of "relative humidity x temperature", "relative humidity x light", "temperature x light", "temperature" and "light" factors in the total color difference of any of the packaged samples. p> 0.05). Therefore, in "low relative humidity" the total color difference increased and "high relative humidity" showed a decrease in the total color difference. In this regard, Venir et al. (2007) in examining the total color difference of freeze-dried apple cubes in different relative humidities reported that with increasing water activity up to 0.5, the total color difference increases and then decreases with increasing water activity [26]. In dried pear and melon slices during the storage period, the total color difference (as a result of browning) increases up to relative humidity of 75 and 85%, respectively, and then decreases with increasing relative humidity [17].

Table 10 Investigating the effect of “Relative humidity×temperature×light” on total colour difference of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	8.21±1.26^{ns}	8.64±0.67^{ns}	8.19±1.01^{ns}	11.06±1.98 ^{a}
L(RH)×L(T)×Light	8.03±1.03^{ns}	6.27±0.63^{ns}	6.67± 0.96^{ns}	8.59 ±0.90 ^{a}
L(RH)×H(T)×Dark	6.67±1.06^{ns}	7.01±1.02^{ns}	7.17± 0.76^{ns}	4.68 ± 0.34 ^{b}
L(RH)×H(T)×Light	7.73±1.57^{ns}	7.09±0.91^{ns}	7.15±0.74 ^{ns}	9.00 ±1.37 ^{a}
H(RH)×L(T)×Dark	4.37±0.63^{ns}	5.04±0.72 ^{ns}	3.36±0.59 ^{ns}	4.27 ±0.60 ^{b}
H(RH)×L(T)×Light	3.70±0.65^{ns}	3.93±0.74^{ns}	3.06 ±0.27 ^{ns}	3.65 ±0.40 ^{b}
H(RH)×H(T)×Dark	4.45±0.58^{ns}	4.60±0.69^{ns}	5.33±1.40 ^{ns}	4.84 ±0.48 ^{b}
H(RH)×H(T)×Light	5.92±1.04^{ns}	5.26±1.16^{ns}	4.01±0.33^{ns}	4.34 ±0.44 ^{b}

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

Table 11 Investigating the effects of “Relative humidity, temperature and light” and interaction effects “Relative humidity × temperature”, “temperature × light” and “Relative humidity × light” on total color difference of samples

Treatment	HDPE	LDPE	CPP	Control
L(RH)	7.66±0.61^{a}	7.25±0.42^{a}	7.29±0.43^{a}	8.33±0.71^{a}
H(RH)	4.61±0.38^{b}	4.71±0.42^{b}	3.94±0.40^{b}	4.28±0.24^{b}
L(T)	6.08±0.54^{ns}	5.97±0.42^{ns}	5.32±0.49^{ns}	6.89±0.71^{ns}
H(T)	6.19±0.57^{ns}	5.99±0.49^{ns}	5.91±0.47^{ns}	5.72±0.47^{ns}
Dark	5.92±0.51^{ns}	6.32±0.45^{ns}	6.01±0.55^{ns}	6.21±0.66^{ns}
Light	6.34±0.60^{ns}	5.64±0.46^{ns}	5.22±0.40^{ns}	6.40±0.55^{ns}

[DOI: 10.22034/FSCT.21.146.1]

L(RH)× L(T)	8.12±0.80[ns]	7.45±0.51[ns]	7.43±0.70[ns]	9.82±1.09[a]
L(RH)× H(T)	7.20±0.93[ns]	7.05±0.67[ns]	7.16±0.52[ns]	6.84±0.83[b]
H(RH)× L(T)	4.03±0.45[ns]	4.48±0.52[ns]	3.21±0.32[ns]	3.96±0.36[c]
H(RH)× H(T)	5.19±0.60[ns]	4.93±0.66[ns]	4.67±0.72[ns]	4.59±0.32[c]
L(T)×Dark	6.29±0.80[ns]	6.84±0.61[ns]	5.78±0.76[ns]	7.66±1.23[ns]
L(T)× Light	5.87±0.75[ns]	5.10±0.53[ns]	4.86±0.62[ns]	6.12±0.71[ns]
H(T)×Dark	5.56±0.64[ns]	5.80±0.65[ns]	6.25±0.80[ns]	4.76±0.29[ns]
H(T)×Light	6.82±0.94[ns]	6.18±0.75[ns]	5.58±0.51[ns]	6.67±0.86[ns]
L(RH)×Dark	7.44±0.82[ns]	7.83±0.62[ns]	7.68±0.63[ns]	7.87±1.19[ns]
L(RH)×Light	7.88±0.92[ns]	6.68±0.55[ns]	6.91±0.59[ns]	8.80±0.81[ns]
H(RH)×Dark	4.41±0.42[ns]	4.82±0.49[ns]	4.35±0.77[ns]	4.55±0.38[ns]
H(RH)×Light	4.81±0.64[ns]	4.59±0.69[ns]	3.54±0.23[ns]	4.00±0.30[ns]

Means followed by the same letter within a column are not significantly different ($p<0.05$). L: Low, H: High, T: Temperature, RH: Relative Humidity

The effect of different storage conditions on color parameters compared to the color of the first-time samples

In order to choose the best storage conditions for the samples in terms of color parameters, the average responses were compared with the quantitative average of the parameters measured in the primary barberry samples (Tables 12 & 13). The results showed that the Hue angle and the a/b ratio of all the packaged and stored samples were preserved in the conditions of "high relative humidity × low temperature × darkness" and "high relative humidity × low temperature × lightness". A similar result was also observed for the control sample, except that the a/b ratio was maintained only in the conditions of "high relative humidity × low temperature × darkness" compared to the samples of the first time.

Table 12 Investigating the effect of different storage conditions on hue angle of samples compared to the first time

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	25.17±0.78[b]	24.03± 0.79 [c]	23.10± 0.90 [b]	26.46± 0.59 [a]
L(RH)×L(T)×Light	25.00±0.70[b]	24.25± 0.65 [c]	23.45± 0.74 [b]	23.56± 0.69 [b]
L(RH)×H(T)×Dark	27.26±0.97[ab]	26.93± 0.70 [b]	28.30± 0.77 [a]	26.32± 0.66 [a]
L(RH)×H(T)×Light	28.25±1.25[a]	27.87± 1.10 [ab]	28.40± 0.75 [a]	28.33± 0.97 [a]
H(RH)×L(T)×Dark	19.48±0.87[c]	18.74± 0.38 [d]	18.43± 0.31 [c]	18.32 ± 0.35 [c]
H(RH)×L(T)×Light	18.90±0.69[c]	17.46±0.75 [d]	19.32± 0.64 [c]	20.01± 0.67 [c]
H(RH)×H(T)×Dark	26.72±1.07[ab]	26.50± 0.86 [bc]	28.55± 1.23 [a]	26.21± 1.03 [a]
H(RH)×H(T)×Light	28.91±0.75[a]	29.46± 0.91 [a]	27.78± 1.00 [a]	26.82± 0.75 [a]
hue angle of sample with low moisture first time	17.64±0.79 [c]	17.64±0.79 [d]	17.64±0.79 [c]	17.64±0.79 [c]
hue angle of sample with high moisture first time	17.91± 0.45 [c]	17.91± 0.45 [d]	17.91± 0.45 [c]	17.91± 0.45 [c]

[DOI: 10.22034/FSCT.21.146.1]

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

Table 13 Investigating the effect of different storage conditions on a/b ratio of samples compared to the first time

Treatment	HDPE	LDPE	CPP	Control
L(RH)×L(T)×Dark	2.15±0.07[b]	2.27±0.08[b]	2.38±0.10[c]	2.02±0.05[d]
L(RH)×L(T)×Light	2.17±0.07[b]	2.24±0.07[bc]	2.33±0.08[c]	2.32±0.08[c]
L(RH)×H(T)×Dark	1.97±0.09[bc]	1.98±0.06[cd]	1.87±0.06[d]	2.04±0.06[d]
L(RH)×H(T)×Light	1.90±0.09[bc]	1.93±0.09[d]	1.86±0.06[d]	1.88±0.08[d]
H(RH)×L(T)×Dark	2.89±0.13[a]	2.96±0.06[a]	3.01±0.05[ab]	3.03±0.06[a]
H(RH)×L(T)×Light	2.97±0.11[a]	3.25±0.15[a]	2.89±0.10[b]	2.78±0.10[b]
H(RH)×H(T)×Dark	2.03±0.10[bc]	2.03±0.07[bcd]	1.88±0.09[d]	2.07±0.10[d]
H(RH)×H(T)×Light	1.83±0.06[c]	1.79±0.06[d]	1.93±0.08[d]	2.00±0.06[d]
a/b ratio of sample with low moisture first time	3.17±0.14[a]	3.17±0.14[a]	3.17±0.14[a]	3.17±0.14[a]
a/b ratio of sample with high moisture first time	3.10±0.09[a]	3.10±0.09[a]	3.10±0.09[ab]	3.10±0.09[a]

Means followed by the same letter within a column are not significantly different (p<0.05). L: Low, H: High, T: Temperature, RH: Relative Humidity

Result of color parameters

The interaction effect of "high relative humidity x low temperature" in the samples packed in films led to the lowest hue angle, the lowest chroma and the highest a/b ratio. In addition, in the conditions of "high relative humidity x low temperature" in light and dark, Hue angle and a/b ratio were maintained over time. At ambient temperature, in both high and low relative humidity conditions, no significant changes were observed in hue angle, chroma and a/b ratio (p>0.05). Hue angle, chroma and a/b ratio of the samples at high temperature in both high and low relative humidity conditions did not differ significantly (p>0.05), but the highest hue angle and the lowest a/b ratio were observed in these conditions. which can be related to the effect of temperature on color degradation. In this case, Lavelli and Corti (2011) observed that in apple puree powder (dried by vacuum method at 40°C) stored for 9 months at relative humidity of 11 to 75% and temperature of 30°C in water activity 0.54 and 0.75, anthocyanin cyanidin-3-O galactoside could not be detected [15]. In the dry powder of Acai fruit juice kept in conditions of relative humidity of 32.8 and 52.9% and temperature of 25 and 35 °C for 120 days, temperature and water activity had a negative effect on the stability of anthocyanin, that the effect of temperature on the amount of anthocyanin degradation of the samples kept at higher relative humidity was higher, which can be pointed to the greater molecular mobility of water inside the food and facilitating the degradation of physicochemical reactions [27]. In this study, the interaction effect of "low relative humidity × high temperature" also led to color degradation. Patras et al. (2010) also reported that increasing the content of soluble solids increases the rate of degradation of anthocyanins due to the proximity of reactive molecules [6].

4- Conclusion

According to the results, packaging and storage conditions played an important role in preventing barberry weight changes, so that the samples packed in LDPE and HDPE films in the conditions of "high relative humidity × low temperature × light" and "high relative humidity × low

[DOI: 10.22034/FSCT.21.146.1]

temperature × darkness" and samples packaged in CPP film in the conditions of "high relative humidity x low temperature" showed the least weight differences. In all the packaged samples in the conditions of "high relative humidity × low temperature × light" and "high relative humidity × low temperature × darkness", the hue angle and a/b ratio were maintained and did not show any significant difference with the sample of the first time. High temperature, both in high relative humidity and in low relative humidity, caused the color of the sample to deteriorate. Therefore, it is possible that in addition to the effect of temperature, in the conditions of high relative humidity, more molecular mobility and in the conditions of low relative humidity, the proximity of reacting molecules plays a role in color degradation. Finally, the quality of the product can be maintained by adjusting the moisture content of barberry and using proper packaging and storage at low temperature.

5-Resources

[1] Alemardan, A., Asadi, W., Rezaie, M., Tabrizi, L., & Mohammadi, S., 2013, Cultivation of Iranian seedless barberry (Berberis integerrima'Bidaneh'): A medicinal shrub (Review). Industrial Crops and Products, 50:276-287

[2] Yildiz, H., Ercisli, S., Sengul, M., Topdas, EF., Beyhan, O., Cakir, O., Narmanlioglu, HK., & Orhan., E., 2014, Some Physicochemical Characteristics, Bioactive Content and Antioxidant Characteristics of Non-Sprayed Barberry (*Berberis vulgaris L.*) Fruits from Turkey. Erwerbs-Obstbau (Springer), 56:123-129

[3] Castañeda-Ovando, A., de Lourdes Pacheco-Hernández, M., Elena Páez-Hernández, M., Rodríguez, JA., & Andrés Galán-Vidal, C., 2009, Chemical studies of anthocyanins (A review). Food Chemistry, 113: 859–871

[4] Veberic, R., Slatnar, A., Bizjak, J., Stampar, F., & Petkovsek, MM., 2015, Anthocyanin composition of different wild and cultivated berry species. LWT- Food Science and Technology, 60:509-517

[5] Kovács, M., Dóka, O., Bicanic, D., & Ajtony, Z., 2017, Application of laser-based photoacoustic spectroscopy and colorimetry for quantification of anthocyanin in hard boiled candy. Microchemical Journal, 135:100-104

[6] Patras, A., Brunton, N.P., O´Donnell, C., & Tiwari, B.K., 2010, Effect of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation (review). Trends in Food Science & Technology, 21: 3-11

[7] Valipoormotlagh, N., Hamed Mosavian, MT., & Mortazavi, SA., 1388, The Effect of Polyethylene Packages Containing Micrometer-Sized Silver Particles on the microbial and apparent characteristics of Barberry in compare to general Polyethylene Packages (Persian). Journal of Food Industry Research, 2:75-87

[8] Heredia, FJ., Francia-Aricha, EM., Rivas-Gonzalo, JC., Vicario, IM., & Santos-Buelga, C., 1998, Chromatic characterization of anthocyanins from red grapes—I. pH effect. Food Chemistry, 4:491-498

[9] Laleh, GH., Frydoonfar, H., Heidary, R., Jameei, R., & Zare, S., 2006, The Effect of light, temperature, pH and species on stability of anthocyanin pigments in four *Berberis* species. Pakistan Journal of Nutrition, 5(1):90-92

[10] Sinela, A., Rawat, N., Mertz, C., Achir, N., Fulcrand, H., & Dornier, M., 2017, Anthocyanins degradation during storage of Hibiscus sabdariffa extract and evolution of its degradation products. Food Chemistry, 214:234-241

[11] Alighourchi, H., & Barzegar, M., 2009, Some physicochemical characteristics and degradation kinetic of anthocyanin of reconstituted pomegranate juice during storage. Journal of Food Engineering, 90:179-185

[12] Wang, Z., Zhang, M., & Wu, Q., 2015, Effects of temperature, pH, and sunlight exposure on the color stability of strawberry juice during processing and storage. LWT - Food Science and Technology, 60:1174-1178

[13] Ochoa, MR., Kesseler, AG., Vullioud, MB., & Lozano, JE., 1999, Physical and

Chemical Characteristics of Raspberry Pulp: Storage Effect on Composition and Color. Lebensm.-Wiss. u.-Technol, 32:149-153

[14] Bakhshayeshi, MA., Khayami, M., Heidari, R., & Jamei, R., 2006, The Effect of Light, Storage Temperature, pH and Variety on Stability of Anthocyanin Pigment in Four Malus Varieties. Pakistan Journal of Biological Sciences 9(3):428-433

[15] Lavelli, V & Corti, S., 2011, Phloridzin and other phytochemicals in apple pomace: Stability evaluation upon dehydration and storage of dried product. Food Chemistry, 129:1578-1583

[16] Laverde, LMA., Schebor, C., & Buera, MDP., 2013, Water content effect on the chromatic attributes of dehydrated strawberries during storage, as evaluated by image analysis, LWT Food Science and Tecknology, 52:157-162

[17] Laverde, LMA., Acevedo, NC., Schebor, C., & Buera, MDP., 2011, Integrated approach for interpreting browning rate dependence with relative humidity in dehydrated fruits. LWT - Food Science and Technology, 44:963-968

[18] Fang, Z., & Bhandari, B., 2011, Effect of spray drying and storage on the stability of bayberry polyphenols. Food Chemistry, 129:1139-1147

[19] National Iranian standard, No: 3337, 1386, Barberries, Specifications and test methods, 1st.Revision

[20] Labuza, T.P., Kaanane, A. & Chen, J.Y., 1985, Effect of temperature on the moisture sorption isotherms and water activity shift of two dehydrated foods. Journal of Food Science 50(2):385 – 392

[21] Yang, Z., Han, Y., Gu, Z., Fan, G., & Chen, Z., 2008, Thermal degradation kinetics of aqueous anthocyanins and visual color of purple corn (Zea mays L.) cob. Innovative Food Science and Emerging Technologies, 9: 341–347

[22] Rosso, VV de & Mercadante, AZ., 2007, Evaluation of colour and stability of anthocyanins from tropical fruits in an isotonic soft drink system.Innovative Food Science and Emerging Technologies, 8:347-352

[23] Crecente-Campo, J., Nunes-Damaceno, M., Romero-Rodríguez, MA., & Vázquez-Odériz, ML., 2012, Color, anthocyanin pigment, ascorbic acid and total phenolic compound determination in organic versus conventional strawberries (Fragaria×ananassa Duch, cv Selva). Journal of Food Composition and Analysis, 28:23-30

[24] Castellanos, DA., Polanía, W., & Herrera, AO., 2016, Development of an equilibrium modified atmosphere packaging (EMAP) for feijoa fruits and modeling firmness and color evolution. Postharvest Biology and Technology, 120:193-203

[25] Tu, K., Nicolaï, B., & De Baerdemaeker, J., 2000, Effects of relative humidity on apple quality under simulated shelf temperature storage. Scientia Horticulturae, 85: 217–229

[26] Venir, E., Munari, M., Tonizzo, A., & Maltini, E., 2007, Structure related changes during moistening of freeze dried apple tissue. Journal of Food Engineering, 81: 27–32

[27] Tonon, RT., Brabet, C., & Hubinger, MD., 2010, Anthocyanin stability and antioxidant activity of spray-dried acai (Euterpe oleracea Mart.) juice produced with different carrier agents. Food Research International, 43:907-914

[DOI: 10.22034/FSCT.21.146.1]

مجله علوم و صنایع غذایی ایران

سایت مجله: www.fsct.modares.ac.ir

مقاله علمی_پژوهشی

تاثیر شرایط نگهداری بر رنگ و وزن خشک‌کرده زرشک بی‌دانه ایرانی بسته‌بندی شده در سه نوع فیلم بسته‌بندی

خدیجه نوینی بیانلوجه[۱]، محسن اسمعیلی*[۲]، ایرج برنوسی

۱- دانش آموخته کارشناسی ارشد گروه علوم و صنایع غذایی دانشگاه ارومیه.

۲- استاد و عضو هیات علمی گروه علوم و صنایع غذایی دانشگاه ارومیه.

۳- دانشیار گروه مهندسی تولید و ژنتیک گیاهی دانشگاه ارومیه.

اطلاعات مقاله | **چکیده**

تاریخ های مقاله :

تاریخ دریافت: ۱۳۹۸/۳/۲۵

تاریخ پذیرش: ۱٤۰۲/۸/۲۳

کلمات کلیدی:

رنگ،

زرشک بی‌دانه،

شرایط محیطی،

فیلم بسته‌بندی.

DOI: 10.22034/FSCT.21.146.1

* مسئول مکاتبات:

m.esmaiili@urmia.ac.ir

هدف از این پژوهش بررسی تاثیر شرایط متفاوت محیطی «رطوبت نسبی» ، «دما» و «نور» هر کدام در دو سطح (بالا و پایین) به مدت ۱۲۰ روز تیمار بر تغییرات درصد اختلاف وزن و شاخص‌های پارامترهای رنگ خشک کرده زرشک بود. تاثیر شرایط مذکور در قالب طرح آماری کاملاً تصادفی بر پایه فاکتوریل مورد ارزیابی قرار گرفت. پس از تنظیم درصد رطوبت زرشک خریداری شده، رنگ سنجی بر هر دو نوع نمونه انجام گرفت. سپس نمونه‌ها به تفکیک درصد رطوبت در کیسه‌های فیلم‌های پلی‌اتیلن با دانسیته پایین (LDPE)، پلی‌اتیلن با دانسیته بالا (HDPE) و پلی‌پروپیلن کست (CPP) در اوزان ۱۰۰ گرمی بسته‌بندی و کد گذاری شدند و بر اساس کد مربوطه در شرایط متفاوت محیطی قرار گرفتند. بر اساس نتایج حاصل در نمونه‌های بسته‌بندی شده در تمامی فیلم‌ها در شرایط «رطوبت نسبی بالا × دمای پایین × تاریکی» و «رطوبت نسبی بالا × دمای پایین × روشنایی» بعد از ۱۲۰ روز نگهداری زاویه هیو و نسبت a/b حفظ شد. کمترین اختلاف وزنی در نمونه‌های بسته‌بندی شده در فیلم پلی اتیلنی با دانسیته بالا و پایین در شرایط مشابه مشاهده شد. همچنین در تمامی نمونه‌های بسته‌بندی شده در شرایط «رطوبت نسبی بالا × دمای پایین» کمترین زاویه هیو، کمترین کروما و بیشترین نسبت a/b مشاهده گردید و کمترین اختلاف وزنی در نمونه بسته‌بندی شده در فیلم پلی‌پروپیلن کست در این شرایط مشاهده شد.