Turkish Journal of Food and Agriculture Sciences

7(1): 80-91 (2025)

Research Article

DOI: https://doi.org/10.53663/turjfas.1646626

Changes in water-soluble vitamins and bioactive compounds of cranberry (*Cornus mas* L.) nectar under different storage conditions

Fatma MENZEK[1], Çetin KADAKAL[1], Pınar ŞENGÜN[1*]

[1] Pamukkale University, Faculty of Engineering, Department of Food Engineering, Denizli, Türkiye

ARTICLE INFO

HISTORY

Received: 25 February 2025
Revised: 13 March 2025
Accepted: 18 April 2025
Online Published: 30 June 2025

KEYWORDS

Cranberry
Nectar
Resveratrol
Storage
Sugar
Vitamins

* CONTACT

psengun13@posta.pau.edu.tr

A B S T R A C T

Cranberry is a fruit known for its high content of bioactive compounds, particularly polyphenols, flavonoids, and organic acids. In this study, physical and chemical changes were investigated during 6 months storage of cranberry nectar at different temperatures (4, 22, 30 and 40 °C). The water-soluble dry matter value remained approximately the same throughout storage. The decrease in the pH value during the preservation of the nectars increased the acidity of titration. Total phenolic content (TPC) and antioxidant activity (AA) increased during storage temperature. Storage period had little effect on TPC and AA values. Sugar, water-soluble vitamin and *trans*-resveratrol analyzes were analyzed by high performance liquid chromatography (HPLC). As a result of storage at high temperatures, the a* value in cranberry nectar decreased. The least change in color values was measured in cranberry nectars stored at 4°C. Cranberry nectars were initially rich in sucrose, but as storage progressed, both glucose and fructose amounts increased. The ascorbic acid content of cranberry nectar was detected to be high. *Trans*-resveratrol level in cranberry nectar dropped from 0.9518 mg L^{-1} to 0.6478 mg L^{-1} over 6 months of storage at 40 °C. The least loss in *trans*-resveratrol content was seen in cranberry nectars stored at 4 °C and 22 °C. TPC value decreased as storage temperature increased. While the AA value did not show any change depending on the storage time, it decreased with increasing storage temperature. The highest physical and chemical change during storage occurred at 40°C.

Citation: Menzek, F., Kadakal, Ç. & Şengün, P. (2025). Changes in water-soluble vitamins and bioactive compounds of cranberry (*Cornus mas* L.) nectar under different storage conditions. *Turkish Journal of Food and Agriculture Sciences*, 7(1), 80-91.

ORCID> 0000-0001-5300-787X (FM), ORCID> 0000-0002-6608-3887 (ÇK), ORCID> 0000-0002-1801-721X (PŞ)

1. Introduction

Cranberry (*Cornus mas* L.) is a fruit species belonging to the *Cornaceae* family of the *Umbelliflorae* order. Cranberry is a perennial plant that typically grows as a bush or small tree, reaching a height of 7 to 8 meters. It is deciduous, shedding its leaves during the winter months, and is well adapted to a variety of climates, thriving in acidic, boggy soils. The plant produces small, white to pink flowers and is best known for its bright red berries, which are rich in bioactive compounds (Nemzer et al., 2022). Acid, sugar, and aroma compounds give the unique taste of cranberry fruit (Demir and Kalyoncu, 2003; Xia et al., 2021;). In cranberry fruit, which has a high content of bioactive compounds; there are high amounts of organic acids, tannin, vitamin C, phenolic substances, pectin, triterpenoid, and anthocyanin. There are also easily digestible sugars, fructose, glucose, glycoside, fructose, salicylic acid and aromatic compounds in cranberry fruit (Eser, 2010).

Cranberry nectar production generally consists of two stages, pulp production and nectar production. Pulp: Pulp; it is a viscous product obtained by removing parts of the fruit, such as the stem, peel, and core, and then mechanically crushing the remaining flesh fruit using a hydraulic press or mechanical grinder. Nectar production follows the pulp stage, where the pulp is typically diluted with water and sweetened with sugar or other sweeteners (Şahin, 2012).

It is reported that cranberry fruit contains phenolic acid, ascorbic acid, flavanol, anthocyanin, tannin, and sugar (Demir and Kalyoncu, 2003; Pantelidis et al., 2007). Cranberry is an important fruit for health due to the bioactive components it contains. It has been reported that this fruit is rich in bioactive compounds, has anti-cancer, curative effects against heart diseases, and has antihistamine, anti-inflammatory and antibacterial effects due to its high polyphenol content (Uğur, 2020). Because of its very bitter and sour taste, cranberry is not preferred as a fresh fruit, mostly compote, jelly, jam, syrup, marmalade, and fruit nectar are made from its fruits (Mizgier et al., 2016; Moldovan et al., 2016). Due to the fact that cranberry contains a large amount of fiber, using in the food industry is increasing due to its positive effects such as increasing the water holding capacity of dietetic fibers, modifying the texture, reducing formulation costs, reducing cooking losses, improving storage stability and preventing lipid oxidation with its antioxidant properties (Uran, 2018; Khalil et al., 2021).

Cranberry fruit, which is of great importance in terms of health, has been the subject of many researches in our country in recent years due to its bioactive components, rich in vitamin and mineral content. The amount of these bioactive components and vitamins, which are of plant origin, decreases during the nectar processing and storage of fruits and vegetables. This study, changes in some physical and chemical properties, water-soluble vitamins, *trans*-resveratrol, TPC and AA values of cranberry fruit were investigated during processing into cranberry nectar and storage at 4, 22, 30 and 40 °C for 6 months. In addition, the effects of storage temperature and duration on product quality were evaluated, and possible deteriorations in sensory properties and critical quality criteria determining shelf life were analyzed. The study also aimed to develop recommendations to minimize quality losses during the storage process. Studies in the literature have focused on the effects of processing on quality parameters in cranberry products, providing limited information on long-term storage stability under different temperature conditions. This study aims to comprehensively analyze the effects of storage time and temperature on the degradation of basic bioactive compounds, changes in sensory properties, and overall product quality. The findings will enable the development of strategies to minimize quality losses.

2. Materials and methods

2.1. Plant materials

In this study, cranberry fruit was used as raw material. Cranberry fruit was obtained from Çivril district of Denizli, Türkiye. Cranberry fruits were processed into cranberry nectar under laboratory conditions. For this purpose, after being sorted and washed, cranberry fruits were boiled for 5 min. The fruits were then sieved. Sugar syrup (66% prepared) was added so that the content of the obtained cranberry pulp was 35% fruit pulp and 15% water-soluble dry matter. It was filled into sterilized 250 mL glass bottles and pasteurized at 90°C for 15 min, after which it was stored at 4°C, 22°C, 30°C, and 40°C for 6 months.

2.2. Methods

2.2.1. Determination of pH, titration acidity, water soluble dry matter (°Bx)

The pH, titration acidity, and °Bx analyses of cranberry nectars stored under different conditions were performed according to the Association of Official Analytical Chemists (AOAC) (1990) method. pH values were measured with Hanna brand (Model HI 211, Romania) pH meter. For titratable acidity analysis, the cranberry nectars were first diluted with water and filtered. Then 20 mL of the filtrate was taken and titrated with NaOH until a pH of 8.1 was reached. The titratable acidity was determined in terms of malic acid equivalents. The titratable acidity was determined in terms of malic acid equivalents. A digital refractometer was used for °Bx measurement.

2.2.2. Determination of color change

Hunter Lab Color Miniscan XE (Model No:45/0-L, USA) device was used for color measurements of cranberry nectars. Prior to measurement, calibration of the instrument was performed with black and white plates. In order to make an accurate measurement, the nectars were filled in transparent containers and covered with a transparent glass layer so that there were no air bubbles. Color intensity values of L* (0= black, 100= white), a* (a+= red, a-= green) and b* (b+ = yellow, b- = blue) were read on a white background (William, 1987; Cemeroglu, 1992).

2.2.3. Sugar analysis

Sugar analysis of cranberry nectars was performed according to the method proposed by Karkacier (2003). After adding distilled water at a ratio of 1:2 to the samples, they were homogenized in the homogenizer. The samples were then centrifuged at 10000 rpm for 15 min at 4 °C, after which they were filtered through filter paper (No: 91). The filtrate was passed through a 0.45 µm microfilter. The characteristics of the HPLC device used in the analysis and the chromatography conditions used in the sugar analysis are given in Table 1. Glucose, fructose and sucrose standards used as reference in sugar analysis were supplied by Sigma-Aldrich. Standards were prepared at different concentrations and injected into the device. Calibration curve was drawn from the obtained areas.

Table 1. Properties of the HPLC device and chromatography conditions used in the analysis

	Sugar	Ascorbic Acid	Niacin	Pyridoxine	Pantothenic acid	Thiamine	Riboflavin	Resveratrol
Column	Bio Rad Animex HPX-87 ion exclusion column (300x7.8 mm)	ACE C18 Column (7.8x300 mm)	ACE C18 Column (7.8x300 mm)	ACE C18 Column (7.8x300 mm)	ACE C18 Column (7.8x300 mm)	ACE C18 Column (7.8x300 mm)	Macherey-Nagel Amino Column (4.6x250 mm)	ACE C18 Column (7.8x300 mm)
Column Oven and Operating Temperature	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 25°C	Shimadzu CTO-20A Column Oven, 35°C
Detector Operating Conditions	190 nm	254 nm	261 nm	324 nm	210 nm	324 nm	266 nm	306 nm
Flow Rate	1.4 mL min^{-1}	0.7 mL min^{-1}	0.7 mL min^{-1}	0.7 mL min^{-1}	0.7 mL min^{-1}	0.7 mL min^{-1}	1.0 mL min^{-1}	1.0 mL min^{-1}
Mobile Phase	Isocratic Acetonitrile: ultrapure water (75:25, v:v)	Isocratic, 0,1 M KH_2PO_4 (pH=7)	Isocratic, 0,1 M KH_2PO_4 (pH=7)	Isocratic, 0,1 M KH_2PO_4 (pH=7)	Isocratic, 0,1 M KH_2PO_4 (pH=7)	Isocratic, 0,1 M KH_2PO_4 (pH=7)	Isocratic, 0,1 M KH_2PO_4 (pH=7)	Isocratic, Methanol: 10mM KH_2PO_4: Acetonitrile

2.2.4. Water-soluble vitamin analysis

The method recommended by Ekinci and Kadakal (2005) was performed for the analysis of water-soluble vitamins. Cranberry nectars stored under different conditions were homogenized with the help of a homogenizer by adding ultrapure water at a ratio of 1:2. Then it was centrifuged at 10000 rpm at 4 ℃ for 10 min (Nüve NF800R, Türkiye). The samples removed from the centrifuge were filtered with the help of coarse filter paper (No:91) and the filtrate was passed through a 0.45 µm microfilter. Ascorbic acid, niacin, pyridoxine, pantetonic acid and thiamine standards used in the analysis were obtained from Sigma-Aldrich company. Standards were prepared at different concentrations and injected into the HPLC device. The conditions of the HPLC device used in the analysis of water-soluble vitamins are given in Table 1.

2.2.5. *Trans*-resveratrol analysis

The analysis method developed by Sing and Pai (2014) was used to determine the amount of *trans*-resveratrol in cranberry nectars. Cranberry nectars were diluted using a methanol water mixture (90% methanol:10% water) in a ratio of 1:3. Samples were centrifuged at 4 °C and 10000 rpm for 10 minutes (Nüve NF800R, Türkiye). The samples removed from the centrifuge were filtered with the help of coarse filter paper, and the filtrate was passed through a 0.45 µm micro filter. The *trans*-resveratrol standard to be used in the HPLC device was obtained from Sigma-Aldrich. Standard solutions prepared at different concentrations were injected into the device and the calibration curve was drawn. The operating conditions of the HPLC device used in the *trans*-resveratrol analysis are given in Table 1.

2.2.6. TPC analysis

TPC analysis of cranberry nectars stored under different storage conditions was performed according to the spectrophotometric method developed by Singleton and Rossi (1965). 300 µL of cranberry extracts prepared with methanol:water (90:10) were taken and 1500 µL of Folin-Ciocalteu solution (1:10, Folin-Ciocalteu reagent; Ultra-pure water) was added to them. Then, 1200 µL of 7.5% sodium bicarbonate solution was added to this mixture and kept in the dark for 2.0 h. At the end of the period, the samples were read at 760 nm absorbance in a spectrophotometer device (PG Instruments T80 UV/VIS, UK). In the calculation of the TPC value, a standard curve was prepared with gallic acid solutions having different concentrations. The results obtained were expressed in mg GAE 100 g^{-1} dw units.

2.2.7. AA analysis

AA analysis was performed according to the DPPH method suggested by Thaipong (2006). Extraction of cranberry nectars was done with a mixture of methanol:water (90:10). The absorbance of the DPPH solution was adjusted to 1.1 at a wavelength of 515 nm. A volume of 150 µL from the prepared cranberry extracts was taken, and 2850 µL of DPPH solution was added. The prepared mixture was incubated at room temperature in the dark for 1.0 h. Then, absorbance values were read at 515 nm wavelength in the spectrophotometer device. In the calculation of the AA value, a standard curve was drawn with Trolox solutions having different concentrations. Antioxidant activity results were calculated and reported as mmol Trolox equivalent (mmol TE) per 100 mL.

2.2.8. Statistical analysis

Statistical analysis of the data was performed using IBM SPSS statistical analysis software for Windows version 23.0 (IBM Corp. 2015). One-way ANOVA and Tukey tests were applied to compare mean the values. Mean values were compared at a significance level of $p < 0.05$.

3. Results and discussion

3.1. Changes in pH, titration acidity, water-soluble dry matter (°Bx) values during storage at different temperatures

The changes in pH, titration acidity and °Bx content of cranberry nectar during different storage conditions are given in Table 2. As the storage time at different temperatures increased, a decrease in pH values was observed.

Titration acidity and pH value of cranberry nectar are the basic quality parameters affecting chemical stability and sensory properties. Increase in temperature during storage causes deterioration in acidity and pH balance. Changes in titration acidity and pH values can directly affect sensory quality and shelf life, leading to differences in sour/astringent taste balance. The pH values of nectars stored at 4°C and 22°C showed no significant variation during storage, whereas a significant decline was observed in the pH of nectars kept at 40°C ($p<0.05$). Okatan (2016) reported that the pH value of different cranberry species range from 2.60 to 4.02. Tiptiri-Kurpeti et al. (2019) reported the pH value of cranberry juice as 3.27. When the titration acidity values of cranberry nectars stored at different temperatures and times were examined, an increase in titration acidity was observed due to the increase in storage time and temperature. The least increase in titration acidity was in nectars stored at 4°C and maximum at 40°C. Titration acidity of nectars differed statistically according to temperature and time ($p<0.05$). Tural and Koca (2008) reported the titration acidity value of cranberry fruit in the range of 1.10-2.53%. Didin et al. (2000) reported the titration acidity in cranberry nectars in the range of 0.55-0.64%. In a study investigating the storage of pomegranate juices at 4°C and 20°C for 6 months, it was reported that the titration acidity, which was 0.95 % at the beginning, increased to 2.66% at 4°C and 2.72% at 20°C. No significant difference was detected in the °Bx values of cranberry nectars stored at 4°C and 22°C during the storage period ($p>0.05$). In another study, it was reported that the brix value of cranberry nectars varied between 13-14.50 (Didin et al., 2000). Gomes et al. (2017) reported the water-soluble dry matter of cranberry juice as 17.4-17.7, Moldovan and David (2020) as 10 °Bx. The initial brix value of apricot nectars, which was 12.79 at 4°C and 20°C, was measured between 12.77-12.79 at the end of 6 months (Bakan, 2012).

Table 2. Changes in pH, titration acidity, water-soluble dry matter (°Bx) values during storage at different temperatures

Parameter	Duration phase (Mont)	Temperate storage (°C)			
		4	22	30	40
pH	1	3.25±0.02^{Aa}	3.25±0.02^{Aa}	3.25±0.02^{Aa}	3.25±0.02^{Aa}
	2	3.25±0.01^{Aa}	3.24±0.02^{Aa}	3.23±0.04^{ABa}	3.23±0.01^{Aba}
	3	3.24±0.01^{Aa}	3.24±0.02^{Aa}	3.22±0.01^{ABCa}	3.21±0.01^{BCa}
	4	3.25±0.03^{Aa}	3,23±0.02^{Aa}	3.23±0.01^{ABa}	3.21±0.05^{BCa}
	5	3.25±0.02^{Aa}	3.22±0.00^{Aab}	3.21±0.01^{BCab}	3.19±0.01^{CDb}
	6	3.24±0.02^{Aa}	3.22±0.01^{Aab}	3.19±0.02^{Cbc}	3.17±0.01^{DEc}
Titratable Acidity (%)	1	0.60±0.01^{Aa}	0.60±0.01^{Ba}	0.60±0.01^{Ba}	0.60±0.01 ^{Ca}
	2	0.60±0.01^{Ab}	0.62±0.01^{ABab}	0.63±0.01^{ABab}	0.65±0.02^{BCa}
	3	0.61±0.01^{Ab}	0.64±0.01^{Aab}	0.65±0.01^{Aa}	0.67±0.01^{ABa}
	4	0.60±0.01^{Ab}	0.64±0.02^{Aa}	0.66±0.01^{Aa}	0.67±0.01^{ABa}
	5	0.61±0.00^{Ac}	0.63±0.01^{ABbc}	0.65±0.01^{Ab}	0.70±0.02^{ABa}
	6	0.63±0.01^{Ab}	0.64±0.01^{Ab}	0.66±0.02^{Ab}	0.69±0.01^{ABa}
°Bx	1	14.90±0,04^{Aa}	14.90±0.04^{Aa}	14.90±0.04^{Ca}	14.90±0.04^{Ca}
	2	14.90±0.04^{Ac}	14.90±0.01^{Ac}	14.96±0.03^{Bb}	15.02±0.05^{Ba}
	3	14.91±0.02^{Ac}	14.93±0.02^{Abc}	14.97±0.02^{Bb}	15.02±0.02^{Ba}
	4	14.91±0.03^{Ab}	14.93±0.02^{Ab}	14.96±0.03^{Bb}	15.07±0.03^{ABa}
	5	14.89±0.04^{Ac}	14.92±0.02^{Ac}	15.00±0.01^{ABb}	15.10±0.02^{Aa}
	6	14.90±0.01^{Ac}	14.93±0.01^{Ac}	15.03±0.01^{Ab}	15.09±0.01^{Aa}

*Values shown with different capital letters in the same column and with different lowercase letters in the same row are different from each other ($p<0.05$). (±: Standard deviation)

3.2. Determination of color changes

As a sensory attribute, color is an essential quality criterion for fruit juices. The characteristic red color of cranberry nectar is largely due to natural pigments such as anthocyanins. The stability of anthocyanins is affected by factors such as pH, temperature, oxygen availability, light exposure and enzymatic activities.

Storage at high temperatures can accelerate the thermal degradation of anthocyanins, leading to color fading or browning. During storage at low temperatures, anthocyanins remain more stable, and color changes occur more slowly. When the color values of cranberry nectars stored under different conditions were examined, storage at high temperatures decreased a* value expressing the redness of the color. It was determined that the least changes were at 4°C. Nectars stored at 4°C maintained their initial colors throughout storage, but nectars stored at 40°C experienced a negative change in color values. The changes in color value of cranberry nectar as a result of different storage temperatures and times are given in Table 3. In a study investigating the properties of cranberry juice, the L* value was 27.1, a* value was 23.3, and the b* value was 8.1 (Tiptiri-Kourpeti et al., 2019). In another study on cranberry juice, the L* value was determined as 24.32, a* value as 12.33, and the b* value as 3.61 (Naderi et al., 2015).

Table 3. Changes in color values of cranberry nectar as a result of different storage temperatures and different storage times

Parameter	Duration phase (Mont)	Temperate storage (°C)			
		4	22	30	40
*L**	1	21.88 ± 0.12^{BCa}	21.88 ± 0.12^{Ca}	21.88 ± 0.12^{Ba}	21.88 ± 0.12^{BCa}
	2	21.74 ± 0.07^{Cc}	22.99 ± 0.10^{Aa}	22.42 ± 0.12^{Ab}	22.87 ± 0.04^{Aa}
	3	22.43 ± 0.44^{ABa}	22.07 ± 0.02^{BCa}	22.43 ± 0.15^{Aa}	22.39 ± 0.51^{Aba}
	4	22.09 ± 0.32^{ABCb}	22.65 ± 0.23^{Aa}	22.47 ± 0.25^{Aab}	22.64 ± 0.06^{Aa}
	5	22.04 ± 0.29^{ABCb}	22.82 ± 0.52^{Aa}	22.50 ± 0.13^{Aab}	21.31 ± 0.01^{CDc}
	6	22.58 ± 0.35^{Aab}	22.62 ± 0.08^{Aa}	21.94 ± 0.06^{Bb}	21.20 ± 0.53^{Dc}
*a**	1	22.85 ± 0.84^{Aa}	22.85 ± 0.84^{Aa}	22.85 ± 0.84^{Aa}	22.85 ± 0.84^{Aa}
	2	20.45 ± 0.06^{Ba}	17.45 ± 0.11^{Bb}	16.27 ± 0.10^{Bc}	11.63 ± 0.41^{Bd}
	3	20.15 ± 0.28^{Ba}	16.68 ± 0.22^{Bb}	14.44 ± 0.05^{Cc}	10.40 ± 0.05^{Cd}
	4	19.05 ± 0.47^{Ca}	15.46 ± 0.28^{Cb}	12.98 ± 0.27^{Dc}	10.05 ± 0.06^{Cd}
	5	18.00 ± 0.02^{Da}	14.99 ± 0.75^{Cb}	12.46 ± 0.20^{Dc}	9.73 ± 0.06^{CDd}
	6	17.86 ± 0.09^{Da}	14.51 ± 0.13^{CDb}	12.19 ± 0.01^{DEc}	9.06 ± 0.24^{DEd}
*b**	1	5.33 ± 0.17^{Aa}	5.33 ± 0.17^{BCa}	5.33 ± 0.17^{Ca}	5.33 ± 0.17^{Da}
	2	5.07 ± 0.03^{ABCc}	5.14 ± 0.21^{Cbc}	5.32 ± 0.05^{Cb}	6.67 ± 0.01^{Ca}
	3	5.37 ± 0.11^{Ac}	5.19 ± 0.02^{Cd}	5.84 ± 0.01^{Bb}	7.23 ± 0.09^{Ba}
	4	5.14 ± 0.23^{ABd}	5.60 ± 0.09^{BCc}	6.25 ± 0.07^{Ab}	7.83 ± 0.04^{Aa}
	5	4.86 ± 0.07^{BCd}	5.64 ± 0.50^{BCc}	6.27 ± 0.06^{Ab}	7.82 ± 0.06^{Aa}
	6	5.17 ± 0.13^{ABd}	5.82 ± 0.12^{ABc}	6.36 ± 0.04^{Ab}	7.75 ± 0.08^{Aa}

*Values shown with different capital letters in the same column and with different lowercase letters in the same row are different from each other ($p<0.05$). (±: Standard deviation)

3.3. Changes in sugar content

Sugar content in fruit-based beverages is an important quality parameter in terms of both taste profile and microbial stability. The main sugars found in cranberry nectar are glucose, fructose and sucrose, and may change during storage depending on factors such as temperature, pH and enzymatic activities. Increased storage temperature may cause sucrose to hydrolyze into glucose and fructose in an acidic environment. This conversion may accelerate, especially at high temperatures such as 30 °C and 40 °C, leading to an increase in the reducing sugar ratio.

Table 4 presents the variations in glucose, fructose, and sucrose contents of cranberry nectars stored at different temperatures for 6 months. It was determined that while the amount of glucose increased during storage, the amount of sucrose decreased. However, it was observed that there was no regular change in the amount of fructose. Moreover, higher storage temperatures led to a faster rise in glucose content. The acceleration of the decrease in the amount of sucrose with the increase in storage temperature can be explained by the inversion of sucrose with temperature. Didin et al. (2000), cranberry nectars reported the amount of total sugar in the range of 10.75-14.72 g 100 g^{-1}, the amount of sucrose in the range of 4.05-7.44 g 100 g^{-1}. In another study, the fructose content of cranberry fruits was reported as 3.7% and the glucose content as 5.4% (Tarko et al., 2014).

Table 4. Changes in sugar content of cranberry nectar as a result of different storage temperatures and different storage times

Parameter	Duration phase (Mont)	Temperate storage (°C)			
		4	22	30	40
Glucose (g 100 mL^{-1})	1	2.79±0.05^{CDa}	2.79±0.05^{Ea}	2.79±0.05^{Da}	2.79±0.05^{Ea}
	2	2.78±0.03^{CDc}	2.83±0.03^{Ebc}	2.87±0.04^{Db}	3.44±0.05^{Da}
	3	2.75±0.05^{Dd}	2.90±0.04^{DEc}	3.11±0.06^{Cb}	3.90±0.09^{Ba}
	4	2.81±0.01^{Cc}	3.07±0.22^{CDb}	3.19±0.02^{Cb}	3.99±0.07^{Ba}
	5	2,82±0.02^{Cd}	3.12±0.02^{Cc}	3.46±0.03^{Bb}	4.20±0.07^{Aa}
	6	3.01±0.02^{Bd}	3.40±0.03^{Bc}	3.60±0.11^{Ab}	4.32±0.06^{Aa}
Fructose (g 100 mL^{-1})	1	2.26±0.05^{Aa}	2.26±0.05^{Aa}	2.26±0.05^{Ba}	2.26±0.05^{Ea}
	2	2.19±0.05^{Ab}	2.22±0.06^{ABb}	2.19±0.03^{BCb}	2.34±0.02^{DEa}
	3	2.23±0.02^{Ab}	2.21±0.14^{ABb}	2.05±0.03^{Dc}	2.45±0.04^{Da}
	4	2.19±0.02^{Ab}	2.08±0.02^{BCc}	2.09±0.06^{CDbc}	2.91±0.06^{Ba}
	5	2.07±0.21^{Bbc}	1.97±0.10^{CDc}	2.16±0.04^{BCDb}	3.12±0.08^{Aa}
	6	1.93±0.02^{Cc}	1.92±0.04^{Dc}	2.38±0.17^{Ab}	3.01±0.04^{Aba}
Sucrose (g 100 mL^{-1})	1	4.09±0.02^{Aa}	4.09±0.02^{Aa}	4.09±0.02^{Aa}	4.09±0.02^{Aa}
	2	4.09±0.04^{Aa}	4.06±0.18^{Aa}	4.03±0.07^{ABa}	3.97±0.05^{Ba}
	3	4.07±0.09^{Aa}	4.00±0.04^{ABab}	3.93±0.04^{BCb}	3.90±0.03^{Bb}
	4	4.03±0.12^{Aa}	3.94±0.02^{BCb}	3.87±0.02^{Cc}	3.71±0.04^{Cd}
	5	4.02±0.05^{Aa}	3.90±0.23^{BCb}	3.77±0.03^{Dc}	3.54±0.13^{Dd}
	6	3.99±0.06^{Aa}	3.86±0.02^{Cb}	3.64±0.12^{Ec}	3.39±0.05^{Ed}

*Values shown with different capital letters in the same column and with different lowercase letters in the same row are different from each other ($p<0.05$). (±: Standard deviation)

3.4. Changes in water-soluble vitamins

There was a loss of water-soluble vitamin content of cranberry nectars stored at different storage temperatures and times. As storage temperature increased, ascorbic acid content decreased. A high loss occurred at 40 °C. While the initial value of ascorbic acid was 68.60 mg L^{-1}, the lowest value decreased to 37.889 mg L^{-1} at 40 °C in the 6th month. It has been reported in the literatures that storage conditions reduce the amount of ascorbic acid during the storage of fruit juices (Klimaczak et al., 2007; Ros Chumillas et al., 2007). Emelyanoc et al. (2013) determined the ascorbic acid content of cranberry juice as 41.8 mg100 g^{-1}. Hassanpour et al. (2012) reported 240-360 mg 100 g^{-1} dw ascorbic acid content of cranberry. A statistically significant decrease in thiamine content was determined during storage ($p<0.05$). The lowest concentration among all water-soluble vitamins was determined as thiamine with 1.105 mg L^{-1}. When the riboflavin content of cranberry nectar stored under different conditions was examined, the increase in storage time and temperature increased riboflavin loss. The maximum decrease in riboflavin amount occurred at the end of 6 months storage at 40°C, and the least loss occurred at 4 °C. Duman (2014) reported the amount of riboflavin in rosehip nectar as 15.7 mg L^{-1}. As a result of drying the cranberry fruit under different conditions, riboflavin values ranged between 64-76 µg g^{-1} (Nemzer et al., 2018). During storage, the amount of niacin decreased at 4 °C, 22 °C storage temperatures, and could not be detected in the 5th and 6th months of 30 °C and 40 °C temperatures. Niacin content exhibited a significant decrease throughout storage ($p<0.05$). Emelyanov et al., (2013) examined the changes in bioactive substances during cranberry processing and determined the amount of niacin in cranberry juice as 0.22 mg 100 g^{-1}. Results were similar for pantothenic acid and pyridoxine. The increase in storage time and temperature increased the loss of pantothenic acid and pyridoxine. Goverd and Carr (1974) determined the pantothenic acid content in different apple juices between 47-116 µg 100 mL^{-1} at maximum apricot 40 °C. Changes in the water-soluble vitamin levels of cranberry nectars, stored for 6 months under different temperature conditions, are shown in Table 5.

Table 5. Changes in water-soluble vitamins of cranberry nectar as a result of different storage temperatures and different storage times

Parameter	Temperate storage (°C)				
	Duration phase (Mont)	4	22		4
Ascorbic acid (mg L^{-1})	0	68.60±0.53^{Aa}	68.60±0.53^{Aa}	68.60±0.53^{Aa}	68.60±0.53^{Aa}
	1	65.85±1.1^{ABa}	63.03±0.68^{Bb}	61.99±1.32^{Bbc}	59.78±1.72^{Bc}
	2	63.80±1.14^{BCa}	61.13±0.89^{Bb}	59.05±0.92^{Cc}	56.45±0.58^{Cd}
	3	61.25±0.66^{CDa}	61.14±1.53^{Ba}	58.21±1.31^{Cb}	55.00±1.42^{Cc}
	4	60.02±2.21^{Da}	57.64±1.25^{Ca}	54.25±1.39^{Db}	49.67±0.49^{Dc}
	5	58.76±1.13^{Da}	54.98±1.12^{Db}	50.46±1.14^{Ec}	43.96±.1.27^{Ed}
	6	55.03±0.85^{Ea}	51.10±1.34^{Eb}	46.45±1.35^{Fc}	37.89±1.68^{Fd}
Thiamine (mg L^{-1})	0	1.10±0.25^{Aa}	1.10±0.25^{Aa}	1.10±0.25^{Aa}	1.10±0.25^{Aa}
	1	1.07±0.68^{Aa}	1.042±0.71^{ABa}	1.03±0.64^{Aa}	0.96±0.50^{Bb}
	2	1.05±0.75^{Aa}	1.03±0.90^{ABa}	0.96±0.52^{Aa}	0.85±0.35^{Cb}
	3	1.03±0.90^{Aa}	0.98±0.67^{ABa}	0.84±1.05^{Ba}	0.60±0.74^{Db}
	4	1.01±0.62^{Aa}	0.89±0.43^{ABa}	0.64±0.21^{Cb}	Nd.
	5	0.98±0.43^{Aa}	0.80±0.46^{Ba}	Nd.	Nd.
	6	0.92±0.43^{Aa}	0.65±0.37^{Cb}	Nd.	Nd.
Riboflavin (mg L^{-1})	0	15.72±7,24^{Aa}	15.72±7,24^{Aa}	15.72±7,24^{Aa}	15.72±7,24^{Aa}
	1	15.15±0.43^{ABa}	14.64±0.37^{ABa}	14.52±0.78^{ABa}	13.81±0.86^{Ba}
	2	15.06±0.31^{ABa}	14.18±1.09^{ABab}	13.81±0.61^{BCab}	12.64±0.93^{BCb}
	3	14.72±1.03^{ABa}	13.15±0.66^{BCab}	12.288±0.99^{CDb}	11.33±0.96^{CDb}
	4	14.35±0.49^{ABa}	11.89±0.97^{CDb}	11.49±0.50^{DEb}	9.85±0.49^{Dc}
	5	13.28±1.15^{Ba}	11.74±0.83^{CDab}	10.25±0.53^{EFb}	7.68±0.47^{Ec}
	6	12.91±1.83^{Ba}	10.37±0.26^{Db}	9.13±0.65^{Fb}	6.99±0.54^{Ec}
Niacin (mg L^{-1})	0	1.20±0.40^{Aa}	1.20±0.40^{Aa}	1.20±0.40^{Aa}	1.20±0.40^{Aa}
	1	1.15±0.57^{ABa}	1.10±0.50^{Ba}	0.96±0.62^{Bb}	0.91±0.22^{Bb}
	2	1.11±0.38^{BCa}	1.09±0.22^{Ba}	0.94±0.54^{Bb}	0.82±0.23^{Cc}
	3	1.05±0.26^{CDa}	1.00±0.33^{Ca}	0.82±0.40^{Cb}	0.73±0.44^{Dc}
	4	0.99±0.28^{DEa}	0.99±0.28^{Ca}	0.66±0.44^{Db}	0.55±0.49^{Ec}
	5	0.98±0.25^{DEa}	0.92±0.34^{Cb}	Nd.	Nd.
	6	0.95±0.24^{Ea}	0.77±0.52^{Db}	Nd.	Nd.
Pantothenic acid (mg L^{-1})	0	11.48±0.38^{Aa}	11.48±0.38^{Aa}	11.48±0.38^{Aa}	11.48±0.38^{Aa}
	1	11.13±0.21^{Aa}	10.96±0.21^{ABa}	10.34±0.64^{ABab}	9.55±0.50^{Bb}
	2	10.95±0.71^{ABa}	10.32±0.76^{ABCab}	10.00±0.62^{Bab}	8.92±0.65^{BCb}
	3	10.60±0.69^{ABCa}	10.00±0.39^{ABCDab}	9.29±0.54^{BCb}	8.11±0.36^{Cc}
	4	9.82±0.56^{BCa}	9.64±0.40^{BCDa}	9.18±0.67^{BCa}	7.76±0.72^{CDb}
	5	9.65±0.57^{Ca}	8.98±0.85^{CDa}	8.55±1.02^{CDa}	6.58±0.81^{Db}
	6	9.44±0.26^{Ca}	8.59±1.12^{Dab}	7.68±0.18^{Db}	5.14±0.45^{Ec}
Pyridoxine (mg L^{-1})	0	4.22±0.61^{Aa}	4.22±0.61^{Aa}	4.22±0.61^{Aa}	4.22±0.61^{Aa}
	1	4.00±0.23^{ABa}	3.78±0.42^{ABa}	3.51±0.24^{ABa}	3.16±0.64^{ABa}
	2	3.91±0.38^{ABa}	3.56±0.24^{ABab}	3.30±0.33^{ABab}	2.99±0.60^{Bb}
	3	3.78±.39^{ABa}	3.19±0.17^{ABCa}	3.11±0.64^{Bab}	2.42±0.21^{BCb}
	4	3.60±0.35^{ABa}	3.00±0.49^{BCab}	2.97±0.62^{BCab}	2.05±0.52^{BCDb}
	5	3.42±0.31^{ABa}	2.74±0.57^{BCa}	2.59±0.37^{BCab}	1.63±0.60^{CDb}
	6	3.14±0.65^{Ba}	2.44±0.48^{Cab}	1.94±0.24^{Cbc}	1.31±0.07^{Dc}

*Values shown with different capital letters in the same column and with different lowercase letters in the same row are different from each other ($p<0.05$). (±:Standard deviation), *Nd.: not detection

3.5. Change in *Trans*-resveratrol

The *trans*-resveratrol content of cranberry nectars stored at different temperatures and times are given in Table 6. The *trans*-resveratrol concentration, initially 0.9518 mg 100 mL^{-1}, decreased to 0.8613, 0.8018, 0.7439, and 0.6317 mg 100 mL^{-1} after 6 months of storage at 4, 22, 30, and 40 °C, respectively. Wang et al., (2002) determined the total resveratrol content in cranberry juice as 1.07 nmol g^{-1}. Borowska et al. (2019) reported the amount of resveratrol in cranberry fruit between 598.2-712.3 ng g^{-1}.

Table 6. Changes in total phenolic matter and antioxidant actividty of cranberry nectar as a result of different storage temperatures and different storage times

Parameter	Temperate storage (°C)				
	Duration phase (Mont)	4	22	30	40
Trans-resveratrol (mg L^{-1})	1	0.95 ± 1.16^{Aa}	0.95 ± 1.76^{Aa}	0.95 ± 1.76^{Aa}	0.95 ± 1.76^{Aa}
	2	0.94 ± 0.30^{Aa}	0.92 ± 0.04^{ABab}	0.92 ± 0.91^{Bab}	0.91 ± 0.89^{Bb}
	3	0.93 ± 0.16^{Aa}	0.92 ± 1.38^{ABab}	0.90 ± 1.26^{Bbc}	0.88 ± 1.40^{Cc}
	4	0.93 ± 0.12^{Aa}	0.90 ± 0.28^{BCa}	0.86 ± 0.69^{Cb}	0.83 ± 0.71^{Db}
	5	0.91 ± 0.17^{ABa}	0.87 ± 0.25^{CDb}	0.81 ± 1.17^{Dc}	0.76 ± 1.13^{Ed}
	6	0.88 ± 0.12^{BCa}	0.84 ± 1.46^{Db}	0.81 ± 0.93^{Dc}	0.70 ± 0.58^{Fd}

*Values shown with different capital letters (A-E) in the same column and with different lowercase letters (a-c) in the same row are different from each other ($p<0.05$). (±:Standard deviation)

3.6. Changes in TPC and AA

A negative correlation was found between storage temperature and TPC value, with the maximum total phenolic content recorded in nectars stored at 4 °C. Spanos and Wrolstad (1990) suggested that the reduction in TPC during nectar storage might result from the degradation or condensation of phenolic compounds. Klimczak et al. (2007) reported that the increase in TPC during storage could be due to some compounds reacting with the folin reagent. Although the AA value of cranberry nectars did not show a regular time-dependent change, the AA value decreased with increasing storage temperature (Table 7). Harrison et al. (2012) found that the AA value of cranberry juice was 64-75 mg TE g^{-1}.

Table 7. Changes in *trans*-resveratrol of cranberry nectar as a result of different storage temperatures and different storage times

Parameter	Temperate storage (°C)				
	Duration phase (Mont)	4	22	30	40
Total phenolic matter (mg GAE/100)	1	324.46 ± 3.44^{Aa}	324.46 ± 3.44^{Aa}	324.46 ± 3.44^{Aa}	324.46 ± 3.44^{Aa}
	2	272.50 ± 2.13^{Ba}	241.56 ± 1.82^{Bb}	188.50 ± 4.82^{Bc}	177.30 ± 0.43^{Bd}
	3	235.10 ± 4.38^{Ca}	187.60 ± 4.39^{CDb}	176.02 ± 5.83^{Cc}	150.26 ± 5.61^{Cd}
	4	198.53 ± 5.29^{Ca}	183.99 ± 2.78^{Db}	168.77 ± 1.74^{CDc}	138.34 ± 2.66^{Dd}
	5	188.88 ± 1.63^{Ea}	180.74 ± 4.13^{Da}	161.07 ± 5.22^{Db}	140.11 ± 4.88^{Cc}
	6	194.19 ± 1.15^{DEa}	185.01 ± 4.78^{CDb}	163.89 ± 1.37^{Dc}	149.37 ± 1.75^{Dd}
Antioxidant activity (mg TE/100ml)	1	155.21 ± 3.11^{Aa}	155.21 ± 3.11^{Aa}	155.21 ± 3.11^{Aa}	155.21 ± 3.11^{Aa}
	2	142.09 ± 1.91^{Ba}	121.52 ± 2.64^{Bb}	106.05 ± 1.51^{Bc}	95.67 ± 1.11^{Bd}
	3	111.17 ± 3.39^{CDa}	100.21 ± 2.76^{CDb}	83.11 ± 1.40^{DEc}	73.51 ± 1.62^{Dd}
	4	105.17 ± 4.53^{Da}	105.16 ± 5.83^{Ca}	92.02 ± 1.61^{Cb}	75.69 ± 0.21^{Dc}
	5	116.96 ± 1.39^{Ca}	98.28 ± 1.67^{CDb}	86.55 ± 1.20^{Dc}	82.57 ± 1.31^{Cd}
	6	106.49 ± 3.02^{Da}	95.25 ± 2.56^{Db}	80.83 ± 1.38^{Ec}	76.39 ± 0.44^{Dd}

*Values shown with different capital letters in the same column and with different lowercase letters in the same row are different from each other ($p<0.05$). (±:Standard deviation)

4. Conclusion

In this study, physical and chemical properties of cranberry nectars were analyzed during 6 months of storage at 4, 22, 30 and 40 °C. An increase in titration acidity was observed due to the decrease in pH value during storage at different temperatures. During the 6 months of storage of cranberry nectars, a* value decreased at each temperature. Cranberry nectars initially contained mostly sucrose; however, over the storage period, glucose and fructose increased, and sucrose levels dropped. The amount of water-soluble vitamins decreased with storage temperature and time. The predominant vitamin in cranberry nectars was determined to be ascorbic acid. Similarly, a decrease in *trans*-resveratrol content was observed during storage.

The degradation of water-soluble vitamins and *trans*-resveratrol was minimal in samples stored at 4 °C and most pronounced in those stored at 40 °C. In the light of the research findings, it was observed that the losses in the investigated components increased as the storage temperature and time increased in cranberry nectar. However, when the results obtained are evaluated; in terms of *trans*-resveratrol and water-soluble vitamins, it is thought that the best storage temperature of cranberry nectar is 4 °C. It is determined that there will be significant quality losses when the storage temperature of cranberry nectar rises to 40 °C. It is clear that reducing the storage temperature and time will be effective in reducing the losses in the components. The findings of this study have the potential to be applied in industrial production in terms of determining the optimum storage conditions to minimize quality losses and preserve sensory properties of cranberry nectar. However, further research and optimization of production processes may be required for widespread dissemination of such applications. In this context, further research on storage conditions and shelf life of cranberry nectar is recommended to increase the sustainability of the food industry. Future research should be aimed at developing more efficient methods for preserving bioactive components in cranberry nectar. For example, development of new packaging technologies or preservatives may minimize deterioration at higher temperatures. Furthermore, investigation of the use of cranberry fruits as a natural source of *trans*-resveratrol in other food and beverage products may expand the potential applications of cranberry-based products in the food industry.

Compliance with Ethical Standards

Conflict of Interest

The authors confirm that there are no conflicts of interest.

Authors' Contributions

Fatma MENZEK: Conceptualization, Data Curation, Laboratory analysis, Writing-original Draft, Investigation, Methodology, Formal analysis, Visualization, Writing-review and Editing. **Çetin KADAKAL**: Conceptualization, Data curation, Methodology, Review and Editing. **Pınar ŞENGÜN**; Laboratory analysis, Conceptualization, Methodology, Formal analysis, Writing-review and Editing.

Ethical approval

Not applicable.

Funding

This study was supported by Pamukkale University Scientific Research Project (Grant number: 2020FEBE050). Pınar Şengün is thankful to the YOK 100-2000 PhD scholarship program and Scientific and Technological Research Council of Türkiye (TUBITAK 2211-A National PhD program) for financial support.

Data availability

Not applicable.

Consent for publication

Not applicable.

References

Association of Official Agricultural Chemists, & Horwitz, W. (1960). Official methods of analysis (Vol. 12, p. 13). Washington, DC: Association of Official Agricultural Chemists.

Bakan, A., (2012). Meyve Sularında Raf Ömrü Süresince Antioksidan Aktivite Ve Kalite Değişimi, Doctoral Thesis, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Gıda Mühendisliği Anabilim Dalı, Ankara.

Borowska, E.J., Mazur, B., Kopciuch, R.G., & Buszewski, B. (2009). Polyphenol, anthocyanin and resveratrol mass fractions and antioxidant properties of cranberry cultivars. Food Technology and Biotechnology, 47, 56-61.

Cemeroğlu, B., (1992). Meyve ve Sebze İşleme Endüstrisinde Temel Analiz Metotları, Biltav Yayınları, Ankara, 381p.

Demir, F., & Kalyoncu, İ.H. (2003). Some nutritional, pomological and phycisal properties of cornelian cherry (*Cornus mas* L.). *Journal of Food Engineering, 60*, 335-341. https://doi.org/10.1016/S0260-8774(03)00056-6

Didin, M., Kızılaslan, A., & Fenercioğlu, H. (2000). Malatya'da yetiştirilen bazı kızılcık çeşitlerinin nektara işlenmeye uygunluklarının belirlenmesi üzerinde bir araştırma. *Gıda, 25*, 435-441.

Duman, T. (2014). Kuşburnu (*Rosa canina*) Nektarında Toplam Fenolik Madde Ve Suda Çözünen Vitaminlerin Isıl Parçalanma Kinetiği", Master's Thesis, Pamukkale Üniversitesi Fen Bilimleri Enstitüsü, Gıda Mühendisliği Anabilim Dalı, Denizli.

Ekinci, R., & Kadakal, C. (2005). Determination of seven water-soluble vitamins in tarhana, a traditional Turkish cereal food, by high-performance liquid chromatography. *ACTA chromatography, 15*, 289.

Emelyanov, A., Emelyanov, K., Kuznetcova, E. (2013). Cranberry bioactive substances composition change due to resources-saving. *Processing, Biochemistry and Biophysics, 1*(1), 1-6.

Eser, Z., (2010). Kızılcık Meyvesi Ve Marmelatının Bazı Kimyasal, Fiziksel Özellikleri İle Antioksidan Aktivitesi Ve Antosiyanin Profilinin Belirlenmesi, Master's Thesis, Atatürk Üniversitesi Fen Bilimleri Enstitüsü, Erzurum.

Gomes, W.F., Tiwari, B.K., Rodriguez, O., Brito, E.S., Fernandes, F.A.N., Rodrigues, S. (2017). Effect of ultrasound followed by high pressure processing on prebiotic cranberry juice. *Food Chemistry, 218*, 261-268. https://doi.org/10.1016/j.foodchem.2016.08.132 Goverd, K.A., & Carr J.G. (1974). The content of some B-group vitamins in single-variety apple juices and commercial ciders. *Journal of the Science of Food and Agriculture, 25*(9), 1185-1190. https://doi.org/10.1002/jsfa.2740250916

Harrison, J. E., Oomah, B. D., Diarra, M. S., & Ibarra-Alvarado, C. (2013). Bioactivities of pilot-scale extracted cranberry juice and pomace. *Journal of Food Processing and Preservation, 37*(4), 356-365. https://doi.org/10.1111/j.1745-4549.2011.00655.x

Hassanpour, H., Hamidoghli, Y., & Samizadeh, H., (2012). Some fruit characteristics of Iranian cornelian cherries (*Cornus mas* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca,40* (1), 247- 252. https://doi.org/10.15835/nbha4017385

Kalyoncu İ.H., (1996). Konya Yöresindeki Kızılcık (*Cornus mas* L.) Tiplerinin Bazı Özellikleri ve Farklı Nem Ortamlarındaki Köklenme Durumu Üzerine Bir Araştırma", Selçuk Üniversitesi Fen Bilimleri Enstitüsü, Doctoral Thesis

Karadeniz, T. (2002). Selection of native 'Cornelian' cherries grown in Turkey. *Journal of the American Pomological Society, 56*(3), 164.

Karkacier, M., Erbas, M., Uslu, M. K., & Aksu, M. (2003). Comparison of different extraction and detection methods for sugars using amino-bonded phase HPLC. *Journal of Chromatographic Science, 41*(6), 331-333. https://doi.org/10.1093/chromsci/41.6.331

Khalil, R. R., Mohammed, E. T., & Mustafa, Y. F. (2021). Various promising biological effects of cranberry extract: A. Review. *Clinical Schizophrenia & Related Psychoses, 15*(1). https://doi.org/10.3371/CSRP.KRET.113021

Klimczak, I., Małecka, M., Szlachta, M., & Gliszczyńska-Świgło, A. (2007). Effect of storage on the content of polyphenols, vitamin C and the antioxidant activity of orange juices. *Journal of Food Composition and Analysis, 20*(3-4), 313-322. https://doi.org/10.1016/j.jfca.2006.02.012

Mizgier, P., Kucharska, A. Z., Sokół-Łętowska, A., Kolniak-Ostek, J., Kidoń, M., & Fecka, I. (2016). Characterization of phenolic compounds and antioxidant and anti-inflammatory properties of red cabbage and purple carrot extracts. *Journal of Functional Foods, 21*, 133-146. https://doi.org/10.1016/j.jff.2015.12.004

Moldovan, B., & David, L. (2020). Influence of different sweeteners on the stability of anthocyanins from cornelian cherry juice. *Foods, 9*(9), 1266. https://doi.org/10.3390/foods9091266

Naderi, B., Maghsoudlou, Y., Aminifar, M., Ghorbani, M., & Rashidi, L. (2015). Investigation on the changes in color parameters and turbidity of cornelian cherry (*Cornus mas* L) produced by microwave and conventional heating. *Nutrition and Food Sciences Research, 2*(4), 39-46.

Nemzer, B. V., Al-Taher, F., Yashin, A., Revelsky, I., & Yashin, Y. (2022). Cranberry: chemical composition, antioxidant activity and impact on human health: overview. *Molecules, 27*(5), 1503. https://doi.org/10.3390/molecules27051503

Nemzer, B., Vargas, L., Xia, X., Sintara, M., & Feng, H. (2018). Phytochemical and physical properties of blueberries, tart cherries, strawberries, and cranberries as affected by different drying methods. *Food Chemistry, 262*, 242-250. https://doi.org/10.1016/j.foodchem.2018.04.047

Okatan, V., Güçlü, S. F., Çolak, A. M., Korkmaz, N., & Aşkin, M. A. (2016). Some physico-chemical characteristics of currant genotypes from Turkey. *LUCRĂRI ŞTIINŢIFICE SERIA HORTICULTURĂ*, 59 (1), 245-250.

Pantelidis, G. E., Vasilakakis, M., Manganaris, G. A., & Diamantidis, G. R. (2007). Antioxidant capacity, phenol, anthocyanin and ascorbic acid contents in raspberries, blackberries, red currants, gooseberries and Cornelian cherries. *Food Chemistry, 102*(3), 777-783. https://doi.org/10.1016/j.foodchem.2006.06.021

Ros-Chumillas, M., Belissario, Y., Iguaz, A., & López, A. (2007). Quality and shelf life of orange juice aseptically packaged in PET bottles. *Journal of Food Engineering, 79*(1), 234-242. https://doi.org/10.1016/j.jfoodeng.2006.01.048

Şahin, G. (2013). Dondurarak ve açık havada kurutarak muhafazanın kuşburnu meyvesinin bazı kalite özelliklerine etkisi, Master's Thesis Gaziosmanpaşa Üniversitesi, Tokat.

Singh, G., & Pai, R. S. (2014). A Rapid Reversed-Phase HPLC Method for Analysis of Trans-Resveratrol in PLGA Nanoparticulate Formulation. *International Scholarly Research Notices, 2014*(1), 248635.

Singleton, V. L., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. American journal of Enology and Viticulture, 16(3), 144-158. https://doi.org/10.5344/ajev.1965.16.3.144

Spanos, G. A., & Wrolstad, R. E. (1990). Influence of variety, maturity, processing and storage on the phenolic composition of pear juice. *Journal of Agricultural and Food Chemistry, 38*(3), 817-824. https://doi.org/10.1021/jf00093a049

Tarko, T., Duda-Chodak, A., Satora, P., Sroka, P., Pogoń, P., & Machalica, J. (2014). Chaenomeles japonica, Cornus mas, Morus nigra fruits characteristics and their processing potential. *Journal of Food Science and Technology, 51*, 3934-3941. https://doi.org/10.1007/s13197-013-0963-5

Thaipong, K., Boonprakob, U., Crosby, K., Cisneros-Zevallos, L., & Byrne, D. H. (2006). Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. *Journal of Food Composition and Analysis, 19*(6-7), 669-675. https://doi.org/10.1016/j.jfca.2006.01.003

Tiptiri-Kourpeti, A., Fitsiou, E., Spyridopoulou, K., Vasileiadis, S., Iliopoulos, C., Galanis, A., ... & Chlichlia, K. (2019). Evaluation of antioxidant and antiproliferative properties of *Cornus mas* L. fruit juice. *Antioxidants, 8*(9), 377. https://doi.org/10.3390/antiox8090377

Tural, S., & Koca, I. (2008). Physico-chemical and antioxidant properties of cornelian cherry fruits (*Cornus mas* L.) grown in Turkey. *Scientia Horticulturae, 116*(4), 362-366. https://doi.org/10.1016/j.scienta.2008.02.003

Uğur, Y. (2020). Kizilcik (*Cornus mas* L.) meyve ekstraktlarinin fenolik içeriklerinin hplc ile belirlenmesi ve sitotoksik etkilerinin araştirilmasi (Doctoral dissertation, Doktora Tezi, İnönü Üniversitesi, Sağlık Bilimleri Enstitüsü, 184 s, Malatya).

Uran, H. (2018). Kızılcık ilave edilerek üretilmiş salamların çeşitli kalite özelliklerinin incelenmesi.

Wang, Y., Catana, F., Yang, Y., Roderick, R., & van Breemen, R. B. (2002). An LC-MS method for analyzing total resveratrol in grape juice, cranberry juice, and in wine. *Journal of Agricultural and Food Chemistry, 50*(3), 431-435. https://doi.org/10.1021/jf010812u

William, L., Aurand, L. W., Woods, A. E. and Welli, M. R. (1987). Food composition and analysis, An Avi Book, New York, 690p.

Xia, J. Y., Yang, C., Xu, D. F., Xia, H., Yang, L. G., & Sun, G. J. (2021). Consumption of cranberry as adjuvant therapy for urinary tract infections in susceptible populations: A systematic review and meta-analysis with trial sequential analysis. *PLoS One, 16*(9), e0256992. https://doi.org/10.1371/journal.pone.0256992