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Degradation Kinetics of Anthocyanins in Red Meat Radish Juice

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Abstract

The aim of this work is to examine the effect of temperature on the anthocyanins in red meat radish and the kinetics of the degradation of the anthocyanins. For this purpose, radish juice was obtained from red meat radish and stored at 60, 70 and 80 °C for 84 hours and the amounts of anthocyanins in the samples were determined. As a result of the investigation, it was determined that the anthocyanins well fit first order kinetic model and the R2 values ranged from 0.974 to 0.995. The activation energy was calculated using the Arrhenius model and was determined to be 18682 Joule/mol. The half-life of the anthocyanins was determined as 24.75 1/hour, 19.25 1/hour and 16.90 1/hour at 60, 70 and 80 °C, respectively. In addition, Total phenolic compounds and antioxidant activity values of radish juice were observed to be at a good level.

Keywords: Red meat radish Juice, anthocyanin, kinetics content

1. INTRODUCTION

Radish (*Raphanus sativus* L.) belongs to the Brassicaceae (Cruciferae) family and is widely produced in China, Japan, Korea and South Asia (Wang and He, 2005). According to Turkish Statistical Institute (TUIK) data for 2020, a total of 223,394 tons of radishes were produced in Turkey (Anonymus, 2020). Approximately 72% of the radishes produced are produced in Osmaniye. Radishes are an important vegetable that generally meets the needs of people for fresh vegetables, rich in nutrients and beneficial to human health. In radishes, the root part consumed is of different shape, color and size. Hazelnut for radishes to those with small and red roots; chestnut for the white ones (red meat radish); black ones are called horseradish (Vural et al., 2000). Color, brightness, shape and size are among the leading qualitative characteristics of radishes. Radishes grown in Europe are widely consumed fresh. In Asian countries, the tubers of large radishes are consumed by cooking, used for making pickles, and used by drying. It is stated that black radishes are used for medicinal purposes in South America, to prevent gallstone formation and to reduce the level of fat in the blood (Wang and He, 2005; Castro-Torres et al., 2012; Afacan and Sönmezdağ, 2020). Red meat radish contains a significant amount of anthocyanins and has antioxidant properties. Anthocyanins are water-soluble natural coloring substances that form a variety of colors of fruits, vegetables and flowers as pink, red, viole, blue and purple tones. (Kelebek et al., 2006; Bozdogan and Canbaş, 2009; Garcia-Alonso et al., 2009; Shih et al., 2010).

The acceptability of a product depends on its color characteristics. The color of food is one of the most important quality parameters affecting the consumer. Since color is the first noticed characteristic of foods, consumers are evaluating the quality of a food product by looking at the color. The color of a food is also influential for perception of its flavor, taste and texture

The most important factor that causes the anthocyanins to break down is temperature. The high temperature applied whether during storage or product is processed causes the anthocyanins to break down (Giusti and Wrolstad, 2001).

The aim of this work is to examine the effect of temperature on the anthocyanins in red meat radish and the kinetics of the degradation of the anthocyanins.

2. MATERIALS AND METHODS

Red meat radish from Kadirli was obtained from local market in Osmaniye. The studies were carried out at Osmaniye Korkut Ata University Food Engineering Laboratory (Osmaniye, Turkey). Red meat radish was washed with distilled water at room temperature. The outer layer (Skin containing white) was removed manually with the help of a peeler.

The Radish was carefully pressed with a juice extractor (Arçelik, Turkey). Then the juice was settled at 4 °C for 6 h, racked and filtered using a cotton bag filter. After filtration, radish juices were obtained.

Samples were stored at 3 different temperatures (60, 70, and 80 °C) for 84 hours. Experiments were carried out in two replicates

2.1. Total Phenolics Analysis

Analysis of total phenol compounds in radish juice was made according to Ough and Amerine (1988). Results are given in gallic acid.

2.2. DPPH (2,2-diphenyl-1-picrylhydrazyl) Assay

Total antioxidant analysis was performed according to the DPPH (2,2-diphenyl-1-picrylhydrazyl) method(Brand-Williams et al., 1995).

2.3.Total Anthocyanin Analysis

The total anthocyanin content was determined according to the pH- differential method (Giusti and Wrolstad, 2001), using two buffer systems: sodium acetate 0.4 M at pH 4.5, and potassium chloride 0.025 M at pH 1. Absorbance was read at 510 and 700 nm. Anthocyanin concentration was reported as milligrams cyanidin 3- glucoside equivalent.

2.4.Kinetics model

The first-order reaction rates, constants (k) and half-lives ($t_{1/2}$), and the time needed for 50% degradation of anthocyanins were calculated with the following equations:

Where C_0 is the initial anthocyanin content (mg/L),

$$C = C_0 .\exp(-kt) \quad (1)$$

$$t_{1/2} = \ln_2/k \quad (2)$$

and C is the anthocyanin content (mg/L) after t minute heating at a given temperature.

The activation energy is calculated according to the

$$\ln C = - kt + \ln Co, \quad (1)$$

$$t_{1/2} = \ln_2/k \quad (2)$$

Arrhenius equation (3)

$$k= k_0.exp(-Ea/RT) \quad (3)$$

Where, Ea is the Arrhenius activation energy (kJ/mole), k_0 is a pre-exponential factor; R is the universal gas constant (8.314 J/mole K), and T is absolute temperature.

3. RESULTS AND DISCUSSION

Phenolic compounds are compounds that contribute to the color and sensory properties of plants. They are important compounds because of their contribution to human health and their multiple biological effects, such as antioxidant activity, antimutagenic, anticarcinogenic activities, and anti-inflammatory action. (Kelebek et al., 2006; Donovan et al., 1998; Del Caro et al., 2004; Bozdoğan and Canbaş, 2009).

Total phenol compounds and antioxidant activity analyzes were made in Red meat radish juice. Total amount of phenolic compounds was found to be 1742.27 GAE mg/L. In addition, the antioxidant activity value was determined as 88.97%. Sabuncu

(2019) determined the total amount of phenolic compounds in Chinese Radishes grown in Turkey as 3407.9 mg GAE/1000g.

Anthocyanins are compounds that give fruits and vegetables their red color. Anthocyanins in fruits and vegetables pass into the product at varying rates depending on the temperature of the environment, pH value, amount of oxygen, enzyme application, pressing process, and amount in the raw material. (Mazza and Brouillard, 1987; Bozdogan and Canbaş, 2006; Bozdogan and Canbas, 2009).

Amounts of anthocyanin were determined at 3 different temperatures (60°C, 70°C, 80°C) and for 84 hours. Anthocyanin degradation followed a first-order reaction model. The first-order reaction rate constants (k) and half-lives (t1/2), the time needed for 50% degradation of anthocyanins, were calculated by the following equations:

$$C = C_0 .\exp(-kt) \quad (1)$$

$$t_{1/2} = \ln_2/k \quad (2)$$

where C_0 is the initial anthocyanin content and C is the anthocyanin content after t hour heating at a given temperature

As can be see in Figure 1 and Table 1. According to this formula, the R2 values ranged from 0.974 to 0.995, and the results were found to be first-degree kinetic. Similar to our study, it has been reported in previous studies that the degradation kinetics of anthocyanins fit the 1st order kinetic model (Garzon and Wrolstad, 2002; Kırca et al., 2007; Cao et al., 2011; Bozdoğan and Yaşar, 2019).

Harborne et al. (2008) investigated the degradation of currant anthocyanins in the model fruit juice solution at a temperature range of 4-140°C. The researchers determined that the degradation of anthocyanins fit the 1st order kinetic model. Kırca et al. (2007) expressed the degradation of anthocyanins in black carrot juice at 70, 80 and 90°C with a 1st degree kinetic model. Bozdoğan and Yaşar (2019) reported that the degradation of anthocyanins in Shalgam beverages at 65, 75 and 85°C fits to the 1st order kinetic model

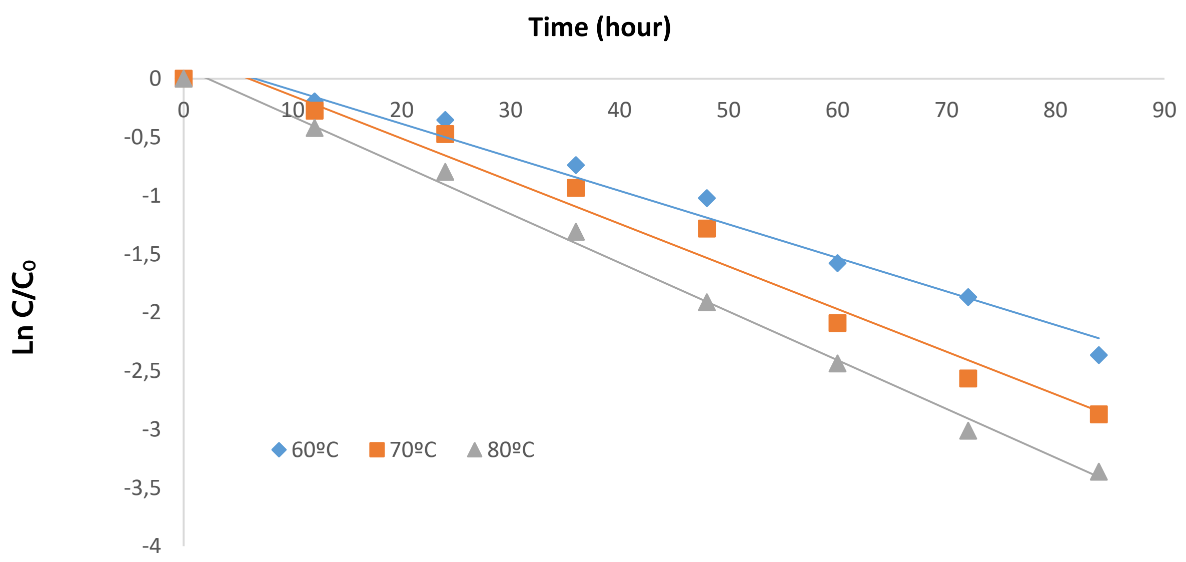

Figure 1. Degradation kinetics of Radish anthocyanins

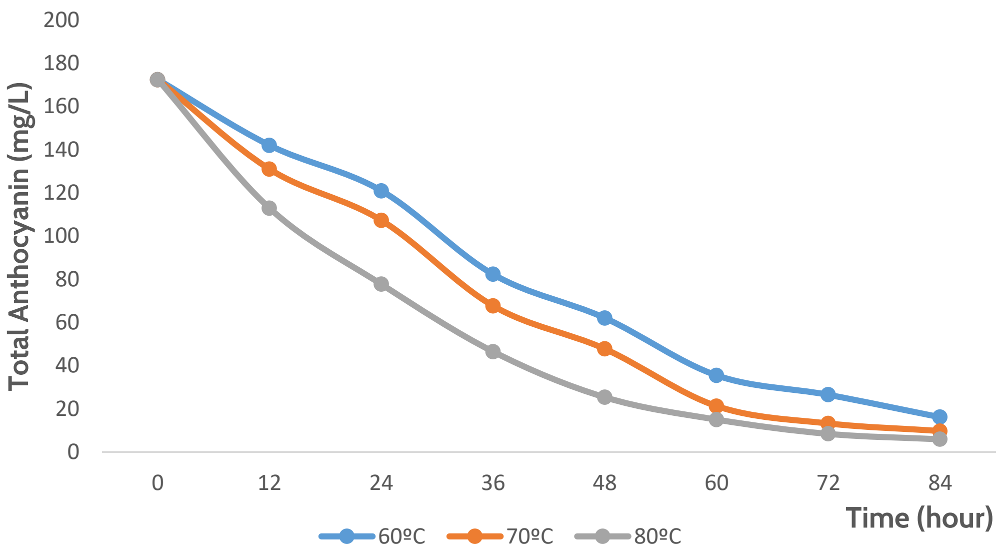

Figure 2. Temporal variation of anthocyanin concentration of Radish

Table 1. Degradation kinetics of anthocyanins

T(◦C)	k	R^2	$t_{1/2}$	Ea
60	0.028	0.976	24.75	
70	0.036	0.974	19.25	18682
80	0.041	0.995	16.90	

T: Temperature (°C) , k: Reaction rate constant (1/hour), $t_{1/2}$: Half-lives (hour), ***Ea:*** *Acticvation Energy (Joule/mol), R^2: Determination Coefficients.*

Temporal variation of anthocyanin concentration of Radish was given Figure 2. It is seen that anthocyanins breakdown significantly as the temperature increases. At temperatures of 60 ° C, 70 ° C and 80 ° C, it is found that the half-lives of the anthocyanins were 24.75, 19.25 and 16.90 hours, respectively(Table 1). According to the half-lives, it was observed that as the temperature increased, the degradation increased and anthocyanins remained more stable at low temperature. Kırca et al. (2007) determined that the half-life of anthocyanins was 25.1, 12.6 and 5.6 hours, respectively, at temperatures of 70°C, 80°C and 90°C.

The activation energy is calculated according to the Arrhenius equation $\ln k=(-Ea/RT)+\ln k_o$ The activation energy was determined to be Ea=18682 Joule/mol. Kırca et al. (2007) found the activation energy value in carrot juice as 78100 Joule / mol. Cao et al. (2011) determined the activation energy value of blood orange anthocyanins as 55810 Joule/mol.

4. CONCLUSIONS

The degradation kinetics of Red meat Radish anthocyanin at 60, 70 and 80 °C were investigated. The results from the present study provide detailed information regarding the changes in kinetic stability of Red meat Radish anthocyanin in juice during heating.

The present data shows that degradation of Red meat Radish anthocyanins follows first order reaction model. Variation of degradation rate constants with temperature obeyed the Arrhenius model. It was observed that anthocyanins were significantly degraded as the storage temperature increased. Therefore, it has been determined that anthocyanins remain more stable in low temperature storage.

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